Advances in Asian Human-Environmental Research

Noboru Ishikawa
Ryoji Soda *Editors*

Anthropogenic Tropical Forests

Human–Nature Interfaces on the Plantation Frontier

Springer

Advances in Asian Human-Environmental Research

Aims and Scope

The series aims at fostering the discussion on the complex relationships between physical landscapes, natural resources, and their modification by human land use in various environments of Asia. It is widely acknowledged that human-environment interactions become increasingly important in area studies and development research, taking into account regional differences as well as bio-physical, socioeconomic and cultural particularities.

The book series seeks to explore theoretic and conceptual reflection on dynamic human-environment systems applying advanced methodology and innovative research perspectives. The main themes of the series cover urban and rural landscapes in Asia. Examples include topics such as land and forest degradation, glaciers in Asia, mountain environments, dams in Asia, medical geography, vulnerability and mitigation strategies, natural hazards and risk management concepts, environmental change, impacts studies and consequences for local communities. The relevant themes of the series are mainly focused on geographical research perspectives of area studies, however there is scope for interdisciplinary contributions.

More information about this series at http://www.springer.com/series/8560

Noboru Ishikawa • Ryoji Soda
Editors

Anthropogenic Tropical Forests

Human–Nature Interfaces on the Plantation Frontier

Springer

Editors
Noboru Ishikawa
Center for Southeast Asian Studies
Kyoto University
Kyoto, Japan

Ryoji Soda
Graduate School of Literature and Human Sciences
Osaka City University
Osaka, Japan

ISSN 1879-7180 ISSN 1879-7199 (electronic)
Advances in Asian Human-Environmental Research
ISBN 978-981-13-7511-8 ISBN 978-981-13-7513-2 (eBook)
https://doi.org/10.1007/978-981-13-7513-2

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Acknowledgements

We dedicate our sincere gratitude to the people of Kemena and Tatau basin society who allowed us to ask questions and discuss things with them. A special note of thanks goes to academic institutions, government offices and business communities in Sarawak, Malaysia. For their unfailing support, we are grateful to the Bintulu Development Authority; Bintulu Resident Office; Bintulu District Office; the Department of Agriculture Sarawak; the Department of Irrigation and Drainage Sarawak; the Forest Department Sarawak; the Department of Statistics Malaysia, Sarawak; the Land and Survey Department, Sarawak Malaysia; Bintulu Division; the Sarawak Biodiversity Centre; the Sarawak Development Institute; Sarawak State Museum; Sebauh Sub-District Office; Sekolah Kebangsaan Kuala Binyo; Sekolah Kebangsaan Kuala Kebulu; the State Planning Unit Sarawak; Tatau District Office; Universiti Malaysia Sarawak; Universiti Putra Malaysia Bintulu Campus; WWF-Malaysia (Sarawak Office); Daiken Sarawak Sdn Bhd; Goodterm Trading Sdn Bhd; Grand Perfect Sdn Bhd; Keresa Plantations Sdn Bhd; Keresa Mill Sdn Bhd; Malaysian Palm Oil Board; Sarawak Forestry Corporation Sdn Bhd; Sarawak Oil Palm Plantation Owners Association; Sarawak Planted Forest Sdn Bhd; Tun Jugah Foundation; and Zedtee Sdn Bhd.

The field research for this book was conducted under the auspices of the State Planning Unit, Chief Minister's Department, State Government of Sarawak, with the authorisation granted to the project titled 'Multidisciplinary Study of Human–Nature Interactions in the Riverine Society of Sarawak' ((15) UPN/S/G1/1/10.1 Vol. 29). We would like thank those who saw academic value in our research and allowed us to conduct fieldwork in Sarawak.

Our research was supported financially by the Japan Society for the Promotion of Science (JSPS) under its Integrated Science and Innovative Science Scheme (new multidisciplinary fields) of the Grants-in-Aid for Scientific Research (S) No. 22221010 (2010–2014).

Our heartfelt thanks are due to the help we received from Ali Yusop, Joanes Unggang, Alex Jukie, Kazue Sakai, A. Kamalakumaran a/l Ayyaru, Abdul Aziz bin Zainal Abidin, Lelia Sim Ah Hua, Julaihi Abdu, Wong Ting Chung, Lucy Chong, Ipoi Datan, Melvin Goh, David Kala, Nyurak Keti, Peter M. Kedit, Dimbab

Ngidang, Elena Gregoria Chai, Lau Seng, Sanib Said, Andrew Alek Tuen, Khairuddin bin Ab. Hamid, Henry Chan, Wong Ing Yung, Yuji Aso, Lee Hua Seng and Joseph Jawa Kendawang. As a small token of appreciation, we would like to mention the commitment of Impress Creative & Editorial, where Gareth Richards and Helena Dodge-Wan dealt with this highly empirical and unusual book with 360 figures and tables and texts written by an international transdisciplinary research team.

Kyoto, Japan
1 August 2019

Noboru Ishikawa
Ryoji Soda

Contents

Part IV Commodification and Local Processes

Part V Coda

About the Editors and Contributors

Editors

Noboru Ishikawa is a professor of anthropology at the Center for Southeast Asian Studies, Kyoto University, Japan. He has conducted fieldwork in Sarawak and West Kalimantan over the past two decades, exploring the construction of national space in the borderland, highland–lowland relations, commodification of natural resource and labour, and the relationship between nature and non-nature. His publications include the following: *Between frontiers: nation and identity in a Southeast Asian borderland* (2010) and the edited volumes such as *Transborder governance of forests, rivers and seas* (2010) and *Flows and movements in Southeast Asia: new approaches to transnationalism* (2011).

Ryoji Soda is a professor in geography at the Graduate School of Literature and Human Sciences, Osaka City University, Japan. He has conducted field research in Sarawak and other Asian countries focusing on human mobility of ethnic minorities. His recent interest is in human–nature interactions and environmental humanities. His publications include the following: *People on the move: rural–urban interactions in Sarawak* (2007); The diversity of small-scale oil palm cultivation in Sarawak, Malaysia, *The Geographical Journal* 182 (2015); and Culture and acceptance of disasters: supernatural factors as an explanation of riverbank erosion, *Ngingit* 9 (2017).

Contributors

Abdul Rashid Abdullah is a social anthropologist with an interest in the study of Borneo's indigenous societies. His research focuses on areas such as the articulation of traditional societies with the market economy, the adoption of new technologies and organisation of production and the sustainability of traditional land-use systems.

Mitsuhiro Aizu is a research fellow in conservation genetics at the Research Institute of Environment for Sustainability, Faculty of Engineering, Kyushu University, Japan. He has conducted genetic studies of cetaceans and other endangered species for their appropriate conservation. In addition, he has participated in fieldwork in Southeast Asia for several years and has applied environmental DNA metabarcoding to elucidate the fish fauna around Tsushima Island and other fields. He is the co-author of Genetic population structure of finless porpoise in Japanese coastal waters, *Journal of Cetacean Research and Management* (2013), and Reptile diversity in food markets in Laos, *Current Herpetology* 34 (2015).

Daniel Chew is a historian and independent researcher based in Adelaide, Australia. He has worked for research institutions in Singapore and Malaysia, and his last academic appointment was with the Institute of East Asian Studies, Universiti Malaysia Sarawak. His current research interests are the Chinese diaspora in Sarawak and Australia. Recent selected published papers include the following: His story, her story: Chinese-Iban intermarriages in Engkelili and Lubok Antu, *Borneo Research Bulletin* 45 (2014); The Timorese Hakka in Australia: community and the internet, *Global Hakka Studies* 2 (2014); A Hakka civil servant in Sarawak, *Global Hakka Studies* 6 (2016); and Between the new and old worlds: Hakka associations in Melbourne, Australia, *Hakka studies in Taiwan*, ed. W. Chang (2017).

Malcom Demies is a senior researcher at the Sarawak Forestry Corporation, Malaysia. His research interest lies in the forest ecology of the tropical rainforest in Sarawak, with a focus on tree diversity, composition, ecosystem dynamics and biodiversity survey methods. He is also involved in high conservation value forest assessment in natural and planted forests in Sarawak and has published reports on this. His other publications as co-author include the following: *Tropical peat swamp forests of Sarawak: sustainable use and biodiversity conservation in a changing environment* (2013) and Response of tree species diversity to disturbance in humid tropical forests of Borneo, *Journal of Vegetation Science* 27 (2016).

Bibian Diway is a researcher at the Botanical Research Centre, Sarawak Forestry Corporation. Her main interest is in forest ecology and population diversity, and she has conducted research on species diversity changes due to human interaction and population genetic studies. Her publications as co-author include the following: *Development of Lanjak Entimau Wildlife Sanctuary as a totally protected area: a study on the vegetation of Batang Ai National Park, Sarawak, Malaysia* (2004), *The development of DNA database for Gonystylus bancanus in Sarawak* (2010) and *Geographic pattern of genotypic variation of ramin in Sarawak* (2014). She currently leads a project on the establishment of permanent sample plot networks in Sarawak.

Shogoro Fujiki is a postdoctoral researcher at Kyoto University, Japan, and CEO at Biome Inc. His primary research interest is in the development of new remote sensing methods for supporting efforts to reduce emissions from deforestation and forest degradation in developing countries (REDD+) and sustainable development goals. His publications include the following: Estimation of the stand ages of tropical secondary forests after shifting cultivation based on the combination of WorldView-2 and time-series Landsat images, *Journal of Photogrammetry and Remote Sensing* 119 (2016); Large-scale mapping of tree-community composition as a surrogate of forest degradation in Bornean tropical rain forests, *Land* 5 (2016); and Estimation of the spatiotemporal patterns of vegetation and associated ecosystem services in a Bornean montane zone using three shifting-cultivation scenarios, *Land* 7 (2018).

Motoko Fujita is a researcher in bird ecology at the Center for Southeast Asian Studies, Kyoto University, Japan. She initially pursued research into nutrient transportation by urban birds in Japan, before extending her focus to the ecology of forest birds in tropical Southeast Asia. She has conducted fieldwork for over a decade. Her publications include the following: Roles of fragmented and logged forests for bird communities in industrial *Acacia mangium* plantations in Indonesia, *Ecological Research* 29 (2014), and an edited volume, *Catastrophe and regeneration in Indonesia's peatlands: ecology, economy and society* (2016).

Keitaro Fukushima is a researcher in ecosystem ecology at the Center for Ecological Research, Kyoto University, Japan. His research interests focus on the elucidation of factors controlling water chemistry from upstream forest to the sea and responses to various disturbances including forest clear-cut, understorey degradation by deer, land-use change, tsunami attacks after earthquakes and so on. His recent publications include the following: Effects of deer grazing on soil C and N dynamics in *Miscanthus sinensis* grassland and *Quercus serrata* forest in Ashiu research forest, Japan, *Journal of Forest Research* 22 (2017), and *Species biology of bamboos* (in Japanese, forthcoming).

Jason Hon is the programme leader for Sarawak for World Wide Fund for Nature-Malaysia. His main research interests focus on wildlife ecology, conservation spatial planning, forest management certification, peat ecology, environmental policies and protected area management. His recent publications as co-author include the following: A review on land use in the Malaysian state of Sarawak, Borneo and recommendations for wildlife conservation inside production forest environment, *Borneo Journal of Resource Science and Technology* 3 (2013); Predicted distribution of the collared mongoose *Herpestes semitorquatus* (Mammalia: Carnivora: Herpestidae) on Borneo, *The Raffles Bulletin of Zoology* 33 (2016); and Connecting science, policy, and implementation for landscape-scale habitat connectivity, *Conservation Biology* 30 (2016).

Tetsu Ichikawa is an associate professor of cultural anthropology and tourism studies at Nagoya City University, Japan. He has conducted research on the Chinese diaspora in Papua New Guinea, Malaysia and other Southeast Asian countries. His publications include the following: Mareshia Sarawaku shu ni okeru shukougeihin kenkyuu no tameno oboegaki: kanko to minzoku kankei no setsugo [Preliminary study of ethnic handicraft in Sarawak, Malaysia: articulation of tourism and ethnic relationship], *Rikkyo Daigaku Kankogakubu Kiyo* [Rikkyo University Bulletin of Studies in Tourism] 16 (2014), and Building houses and graves for their ancestors in their hometowns: homecoming practices of Papua New Guinean Chinese in their ancestral villages in China, *Journal of Humanities and Cultures* 27 (2016).

Mayumi Ishikawa is professor of anthropology at the Center for Global Initiatives, Osaka University, Japan. Her research interests include ethnographic studies of Borneo, as well as of universities and the globalisation of higher education. She is the author of The story of Nakoda Hitam: her life and ventures at maritime crossroads at the turn of the 20th century, *Sarawak Museum Journal* 61(82) (2005), and co-author of The paradox of autonomy: Japan's vernacular scholarship and the policy pursuit of 'super global', *Higher Education Policy* 29 (2016). She is coediting a book on global university rankings for University of Toronto Press (forthcoming).

Yuichi Kano is an associate professor of the Institute of Decision Science for a Sustainable Society, Kyushu University, Japan. He has conducted fieldwork in East Asia and Southeast Asia, including Sarawak, exploring freshwater fish diversity. He is the co-author of Waterfalls drive parallel evolution in a freshwater goby, *Ecology and Evolution* 2 (2012), and Impacts of dams and global warming on fish biodiversity in the Indo-Burma hotspot, *PLOS ONE* 11 (2016), and the author of *Oborerusakana, soratobusakana, kieyukusakana* [Exploring freshwater fishes in monsoon Asia] (2018).

Yumi Kato is an associate professor of anthropology at the Center for Arts and Sciences, Fukui Prefectural University, Japan. She has conducted fieldwork in Sarawak since 2003, exploring social change and interethnic relations of settled hunter-gatherer groups, especially the Sihan and the Lugat. Her publications include the following: Changes in resource use and subsistence activities under the plantation expansion in Sarawak, Malaysia, *Social–ecological systems in transition*, ed. Shoko Sakai and Chieko Umetsu (2014), and Resilience and flexibility: history of hunter-gatherers' relationships with their neighbors in Borneo, *Senri Ethnological Studies* 94 (2016).

Atsushi Kobayashi is a lecturer in international economics at the Department of Economics, Osaka Sangyo University, Japan. His research interests include trade development in modern Southeast Asia, with a particular focus on the role of Singapore as a hub for international and regional trade. His recent publications include the following: The role of Singapore in the growth of intra-Southeast Asian trade, *c.*1820s–1852, *Southeast Asian Studies* 2 (2013); Price fluctuations and growth patterns in Singapore's trade, 1831–1913, *Australian Economic History Review* 57 (2017); and International bimetallism and silver absorption in Singapore, 1840–73, *Economic History Review* (forthcoming).

Miyako Koizumi is a research administrator at Kyoto University, Japan. She has conducted fieldwork in Kalimantan and Sarawak since 2001, exploring natural resource use by hunter-gatherers, the nature of ethnobotanical knowledge and flora of Borneo. Her publications include the following: Penan Benalui wild-plant use, classification, and nomenclature, *Current Anthropology* 48 (2007); Hunter-gatherers' culture, a major hindrance to a settled agricultural like: the case of the Penan Benalui of East Kalimantan, *Forests, Trees and Livelihoods* 21 (2012); and Two new species and notes on Bornean *Praravinia* (Rubiaceae), *Acta Phytotaxonomica et Geobotanica* 67 (2016).

Osamu Kozan is an associate professor of hydrology at the Center for Southeast Asian Studies, Kyoto University, Japan. He has conducted hydrometeorological observation and modelling in China, Central Asia and Indonesia to understand water-related problems. He is the author of Rainfall and groundwater level fluctuations in the peat swamps, *Catastrophe and regeneration in Indonesia's peatlands: ecology, economy and society*, ed. Kosuke Mizuno et el. (2016), and coeditor of *In search of sustainable humanosphere: a new paradigm for humanity, biosphere and geosphere* (2010).

Jayl Langub is a retired civil servant and is currently an associate research fellow at the Institute of Borneo Studies, Universiti Malaysia Sarawak. His research interests focus on ethnic minorities in Sarawak and their adaptation to change. His recent publications include the following: Making sense of the landscape: Eastern Penan perspectives, *Sarawak Museum Journal* 69 (2011), and *Tamu*: institutionalized barter trade, the Penan and their encounter with the colonial and post-colonial state, *Borneo Research Bulletin* 44 (2013). He compiled *Sukĕt: Penan folk stories* (2001). He is currently an adviser for World Wide Fund for Nature-Malaysia.

Charles Leh was formerly a zoologist and curator of natural history at the Sarawak State Museum where he worked for 35 years and the scientific editor of *The Sarawak Museum Journal*. He has conducted research since 1985 on the natural science of swiftlets in caves and farmhouses and published several books including *A guide to birds' nest caves and birds' nests of Sarawak* (1993). He is currently an honorary curator at the World of Birdnest Museum, Singapore, and conducts classes for investors in swiftlet farming.

Mohd Khairulazman Sulaiman is a freshwater biologist and a programme officer under the Sarawak Conservation Programme at World Wide Fund for Nature Malaysia. He is also a PhD candidate at Universiti Malaysia Sarawak. His current work scope includes supporting engagement and conducting research with various stakeholders towards achieving a coordinated effort for the improved management and protection of priority ecosystems in key watersheds in Sarawak. He has also been trained in GIS applications for systematic conservation planning. His latest publication is Mitochondrial DNA diversity of river mahseers (Cyprinidae: *Tor* species) from the proposed Baleh National Park, Kapit Division, Sarawak (in press).

Kuniyasu Mokudai is an associate professor of physical geography at the Department of Regional Design, Tohoku Gakuin University, Japan. His field of specialisation is mountain geomorphology and nature conservation science. He is the coeditor and co-author of *Natural heritage of Japan: geological, geomorphological, and ecological aspects* (2018).

Daisuke Naito is a researcher at the Center for Southeast Asian Studies, Kyoto University, Japan, and a scientist at the Center for International Forestry Research, Indonesia. He has conducted fieldwork in Malaysia and Kalimantan, examining the effects of the implementation of market-driven natural resource management and the relationship between society and nature. His publications, as coeditor, include the following: *Nettai Asia no hitobito to shinrinkanriseido* [People and forest management in tropical Asia: local-level impacts of diverse governance systems] (2010), *Borneo no sato no kankyogaku* [Environmental studies on satoyama landscapes in Borneo] (2013) and *Kokusai shigen kanri ninsyo* [International certification schemes on natural resources] (2016).

Koji Noshita is a researcher in theoretical morphology at Precursory Research for Embryonic Science and Technology (PRESTO), Japan Science and Technology Agency (JST) and the Graduate School of Agricultural and Life Sciences, University of Tokyo, Japan. His interests are concerned broadly with morphometrics of animals, plants and artefacts. His publications include the following: Functional constraints on coiling geometry and aperture inclination in gastropods, *Paleobiology* 38 (2012); Quantification and geometric analysis of coiling patterns in gastropod shells based on 3D and 2D image data, *Journal of Theoretical Biology* 368 (2014); and Geometric analysis and estimation of the growth rate gradient on gastropod shells, *Journal of Theoretical Biology* 389 (2016).

Katsumi Okuno is a professor at the College of Intercultural Communication, Rikkyo University, Japan. He undertook anthropological fieldwork among the Kalis (one of the so-called Maloh ethnic group) of West Kalimantan, Indonesia, in 1994 and 1995, focusing on religious practices. He then moved on to do research among the indigenous populations in Sarawak, Malaysia. His current major area of research is multispecies anthropology.

Yucho Sadamichi is a consultant at Japan NUS Co. Ltd., an environmental consultancy company in Japan. He has conducted studies on lifecycle assessment of biomass products through industrial products in Japan and Southeast Asian countries over the past decade, exploring the development of a sustainability assessment methodology that takes into consideration not only environmental aspect but also the economic and social aspects of products. His publications include the following: Life cycle impact assessment of fuel procuring and electricity generating processes in Japan by using an 'LCA-NETS' scheme, *International Journal of Emerging Electric Power Systems* 7 (2006), and Sustainability assessment methodology of biomass utilization for energy in East Asian countries, *Journal of the Japan Institute of Energy* 91 (2012).

Hiromitsu Samejima is a senior researcher at the Institute for Global Environmental Strategies, Japan. His research explores ecology, sustainable forest management in Southeast Asia, international timber trade and forestry policy, including efforts to reduce emissions from deforestation and forest degradation in developing countries (REDD+). His publications include the following: Camera-trapping rates of mammals and birds in a Bornean tropical rainforest under sustainable forest management, *Forest Ecology and Management* 270 (2012); Biodiversity in peat swamp forest and plantations, *Catastrophe and regeneration in Indonesia's peatlands: Ecology, economy and society*, ed. Kosuke Mizuno et al. (2016); and Estimating animal density without individual recognition using information derivable exclusively from camera traps, *Journal of Applied Ecology* 55 (2017).

Logie Seman is a former assistant forest officer at the Forest Department Sarawak. He was trained in wood inspection, forest management and traditional ecological knowledge. He has conducted research with various stakeholders for making clear human–nature interactions in inland Sarawak. His publications as co-author include the following: Difference of rice farming practices of the Iban in a national boundary area in Borneo and its socio-economic background, *Tropics* 14 (2005); Soil characteristics under cash crop farming in upland areas of Sarawak, Malaysia, *Agriculture, Ecosystems & Environment* 129 (2009); and Life histories of migrants: *bejalai* experiences of the Iban in Sabah, Malaysia, *Journal of Geographical Studies* 86 (2011).

Shozo Shibata is a dual-appointment professor at the Graduate School of Global Environmental Studies and Graduate School of Agriculture, Kyoto University, Japan. His research focuses in particular on forest resource management, bamboo ecology and natural restoration engineering. He has published more than 20 books and over 120 research articles. His recent publications include the following: *Giant temperate bamboos (genus Phyllostachys) with low genetic diversity* (2016), *The state of timber resource use for Korean–Chinese traditional wooden houses and accessory structures* (2016) and *Impacts of sea cucumber farming on biogeochemical characteristics in the Yellow River estuary, northern China* (2017). He is also a president of the International Consortium of Landscape and Ecological Engineering.

Kaoru Sugihara is a programme director and professor at the Research Institute for Humanity and Nature in Kyoto, Japan. He has written widely on Japanese, Asian and global economic and environmental history. His publications as editor include the following: *Japan, China and the growth of the Asian international economy, 1850–1949* (2005) and *Labour-intensive industrialization in global history* (2013), and he is the author, most recently, of Monsoon Asia, intra-regional trade and fossil-fuel-driven industrialization, *Economic development and environmental history in the Anthropocene: Perspectives on Asia and Africa*, ed. Gareth Austin (2017). He is currently vice-chair of the Future Earth Committee at the Science Council of Japan.

Haruka Suzuki is a researcher at the Research Institute for Humanity and Nature, Japan. She is also a visiting assistant professor at Universitas Riau, Indonesia, and the Center for Southeast Asian Studies, Kyoto University, Japan. Her research explores long-term ecological resource use and local history in coastal communities in Indonesia. Her publications include the following: Forest conservation efforts by a pulp and paper company in Indonesia: the relationship between a company and NGO, *Journal of Forest Economics* 62 (2016) (in Japanese), and Social economic aspects of long-term timber use for sustainability of the tropical forest, *Proceedings of XIV World Forestry Congress* (2015).

Yayoi Takeuchi is a senior researcher at the Center for Environmental Biology and Ecosystem Studies, National Institute for Environmental Studies, Japan. She has conducted studies on plant ecology, empirical and theoretical community ecology and biodiversity conservation. Her main field site is Southeast Asian tropical forests, the location of major biodiversity hotspots. Her current research focuses on biodiversity and ecosystem services in a human-modified landscape in Sarawak, working towards the formulation of a conservation strategy integrated with indigenous practice. She adopts a multidisciplinary approach—conducting a biological survey on biodiversity and a sociological survey on resource use based on indigenous knowledge.

Naoko Tokuchi is a professor of forest ecology at the Field Science Education and Research Center, Kyoto University, Japan. She has studied nitrogen dynamics in forest ecosystems from the subarctic zone to tropical areas, including Siberia, Japan, Thailand, Malaysia and Myanmar. Her research focuses on the natural and anthropogenic disturbances including bamboo flowering events, insect damage, logging and atmospheric deposition. Her publications include the following: Nitrogen dynamics of nitrogensaturated and unsaturated deciduous forest ecosystems on Toyama Plain, Japan, *Journal of the Japanese Forest Society* 99 (2017), and Terrestrial-aquatic linkage in stream food webs along a forest chronosequence: multi-isotopic evidence, *Ecology* 97 (2016).

Fumikazu Ubukata is a professor of environmental policy and economics at the Graduate School of Environmental and Life Science, Okayama University, Japan. He has conducted fieldwork in Thailand, Vietnam and Sarawak over the past few decades, exploring the transformation of resource industries, institutional changes of communal resources management, commodification of natural resources and labour and market-driven environmental management schemes. His publications include the following: Forest sustainability and the free trade of forest products: cases from Southeast Asia, *Ecological Economics* 50 (2004), *The institutional formation process of communal forest management in northeast Thai villages* (2008) and *Getting villagers involved in the system: the politics, economics and ecology of production relations in the Thai pulp industry* (2009).

Motomitsu Uchibori is professor emeritus at Hitotsubashi University, Tokyo, and at the Open University of Japan. He was formerly the director of the Research Institute for Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies, Japan. His research interests are in social anthropology and Southeast Asian ethnology, with a particular focus on features of high biomass societies in tropical Asia with reference to Borneo, and family histories among the Iban of Sarawak. His publications include the following: On ethnic and/or cultural diversity, *Trends in the Sciences* 19 (2014), and Theoretical themes for an anthropology of resources, *Social Science Information* 50 (2011).

Takuma Watakabe is a graduate student at Kyoto University, Japan. His doctoral research involves quantifying soil production rates and the recurrence interval of shallow landslides on hillslopes underlain by granite and hornfels. His research interests focus on the evolution of bedrock rivers in mountainous watersheds. His publications include the following: Estimating bedrock-channel incision rates using terrestrial cosmogenic ^{10}Be: an example from the Oshika gorge, Tottori prefecture, Japan, *Transactions, Japanese Geomorphological Union* 35 (2014).

Yu Xin is a lecturer at the Anthropology Centre, Institute for Advanced Studies in Humanities and Social Science, Chongqing University, China. Originally trained in food science, her research interests focus on globalisation, the overseas Chinese in Southeast Asia, the anthropological study of food, material culture studies and economic anthropology. Her recent publications include the following: Birds' nest trading and maritime China: a reflection on earthbound China, *Journal of Southwest University for Nationalities* 1 (2016), and Two illusions of one coin reading: towards an anthropological theory of value, *North West Ethno-national Studies* (2014). She has translated the work of Bronisław Malinowski and Marcel Mauss from English to Mandarin.

Abbreviations and Acronyms

ACA	acacia plantations
ADB	Asian Development Bank
AIC	Akaike information criterion
ALOS PALSAR	Advanced Land-Observing Satellite Phased Array type L-band Synthetic Aperture Radar
AMFMU	Anap-Muput Forest Management Unit
ANOVA	analysis of variance
APKINDO	Asosiasi Panel Kayu Indonesia (Indonesian Wood Panel Producers Association)
AQSIQ	Chinese State Administration of Quality Supervision, Inspection and Quarantine
ASDU	Anap Sustainable Development Unit
AU	approximately unbiased
brglm	bias reduction in binomial-response GLM
C	carbon
CAR	corrective action request
CBD	Convention on Biological Diversity
CH_4	methane
CI	confidence interval
CO_2	carbon dioxide
CRF	communally reserved forest
dbh	diameter at breast height
DFR	Deramakot Forest Reserve
DIC	deviance information criterion
DOC	dissolved organic carbon
DOM	dissolved organic matter
EEM	excitation-emission matrix
ENSO	El Niño–Southern Oscillation
EU	European Union
EUTR	EU Timber Regulation
FAO	Food and Agriculture Organisation (United Nations)

FLAASH	Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes
FLEGT	Forest Law Enforcement, Governance and Trade Action Plan
FMU	forest management unit
FOA	Farmers' Organisation Authority
FOR	natural or mature secondary forests
FSC	Forest Stewardship Council
FSC P&C	Forest Stewardship Council Principles and Criteria
GDP	gross domestic product
GHG	greenhouse gas
GIS	geographic information system
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
GLM	generalised linear model
glm.nb	negative binomial GLM
GTZ	Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
ha	hectare
HCVF	high conservation value forest
IPCC	Intergovernmental Panel on Climate Change
ISCC	International Sustainability and Carbon Certification
ITCZ	intertropical convergence zone
ITTA	International Tropical Timber Agreement
ITTO	International Tropical Timber Organisation
JAS	Japan Agricultural Standard
LEI	Lembaga Ekolabel Indonesia (Indonesian Ecolabelling Institute)
LiDAR	light detection and ranging
LNG	liquefied natural gas
LOG	logged forests
LPF	licence for planted forest area
m	metre
M-NJWG	Malaysia–Netherlands Joint Working Group on Forestry
MC&I	Malaysian Criteria, Indicators, Activities and Standards of Performance for Forest Management Certification
MCMC	Markov chain Monte Carlo
MCMCglmm	MCMC generalised linear mixed model
MFMA	model forest management area
mm	millimetre
MPOB	Malaysian Palm Oil Board
MTC	Malaysia Timber Council
MTCC	Malaysian Timber Certification Council
MTCS	Malaysian Timber Certification Scheme
MTIB	Malaysia Timber Industry Board
MTR	mean trapping rate
N_2O	nitrous oxide
NCSFM	National Committee of Sustainable Forest Management

NDVI	normalised difference vegetation index
NGO	non-governmental organisation
NTCC	National Timber Certification Council
NTTA	Netherlands Timber Trade Association
OIL	oil palm plantations
ONI	Oceanic Niño Index
OPEC	Organisation of the Petroleum Exporting Countries
PARAFAC	parallel factor analysis
PEAT	tropical low-lying peatlands
PEFC	Programme for the Endorsement of Forest Certification
PETRONAS	Petroliam Nasional Berhad
PHPL	Pengelolaan Hutan Produksi Lestari (Sustainable Production Forest Management)
POC	particulate organic carbon
pvclust	hierarchical clustering with *p* values
REDD-plus	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RIL	reduced-impact logging
RSPO	Roundtable on Sustainable Palm Oil
RU	Raman unit
SALCRA	Sarawak Land Consolidation and Rehabilitation Authority
SCORE	Sarawak Corridor of Renewable Energy
SCS	Scientific Certification Systems
SEALPA	South-East Asia Lumber Producers' Association
SFC	Sarawak Forestry Corporation
SGS	Société Générale de Surveillance
SRTM	Shuttle Radar Topography Mission
SS	suspended sediment
STIDC	Sarawak Timber Industry Development Corporation
STLVS	Sarawak Timber Legality Verification System
SVLK	Sistem Verifikasi Legalitas Kayu (Timber Legality Verification System)
TRMM	Tropical Rainfall Measuring Mission
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNIMAS	Universiti Malaysia Sarawak
WWF-Malaysia	World Wildlife Fund-Malaysia

List of Figures

List of Tables

List of Appendices

Chapter 1
Commodification of Nature on the Plantation Frontier

Noboru Ishikawa and Ryoji Soda

Abstract The studies in this volume provide an ethnography of a plantation frontier located in the Kemena and Tatau river basin catchment in central Sarawak, Malaysian Borneo. Using a transdisciplinary approach that draws on the expertise of both natural scientists and social scientists, the key focus is on the commodification of nature that has turned the local landscape into anthropogenic forests. Looking into the interfaces between capitalism and the natural system, we document and analyse the transformation of a space of mixed landscapes and multiethnic and multispecies communities, for the most part driven by trade in forest products, logging and the cultivation of oil palm. How have new commodity chains emerged while older ones disappeared? What changes are associated with such shifts? How are material cycles and food webs altered as a result of large-scale land-use change? What are the relationships among these three elements—commodity chains, material cycles and food webs? Attempts to answer these questions lead us to go beyond the dichotomy of society and nature, and enable us to uncover complex relational entanglements of the two worlds abruptly and forcibly connected by human-induced changes.

Keywords Sarawak · Plantation frontier · Tropical biomass society · Commodification · Anthropogenic forests

---

The original version of this chapter was revised: This chapter was previously published as non-open access chapter. It has now been changed to open access under a CC BY NC ND 4.0 license. The correction to this chapter is available at https://doi.org/10.1007/978-981-13-7513-2_29

N. Ishikawa (✉)
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_1

1.1 An Ethnography of the Plantation Frontier

This volume is a multidisciplinary ethnography of a plantation frontier. We document and analyse the commodification of nature that has turned the local landscape into anthropogenic forests in central Sarawak, Malaysian Borneo. The primary catalysts transforming the web of life in this part of the tropics are forest produce trade, logging and, more recently, the cultivation of oil palm in plantations and by smallholders. We formed a multidisciplinary team of researchers that was able to transcend the boundary between the social and natural worlds, as well as the human and non-human. With our strength in empirical fieldwork and capacity to collectively uncover complex relational entanglements, we present a study of an emergent and compelling resource frontier landscape in maritime Southeast Asia.

The project that has resulted in this book involved the collaboration of researchers specialising in anthropology, geography, Southeast Asian history, global history, area studies, political ecology, environmental economics, plant ecology, animal ecology, forest ecology, hydrology, ichthyology, geomorphology and life-cycle assessment. From 2010 to 2014 researchers engaged in individual fieldwork as well as collaborative sub-projects in a basin catchment composed of two riverine systems, the Kemena and the Tatau in Bintulu Division, central Sarawak.

The basin catchment represents a space of mixed landscapes and multiethnic and multispecies communities. Our research conceptualises the riverine basin as a unitary social field. The space constitutes an organic whole—penetrated, connected and structured by a major stream axis as well as a number of its tributaries. These tributaries function as corridors for two-way traffic, for instance for the downward movement of labour and commodities to coastal and international markets and the upward movement of state development policies into the interior. By conducting multisited fieldwork in this unitary yet inherently heterogeneous socio-ecological space, we explore a microcosm of Sarawak society along three broad trajectories: the changing nature of the environment; multispecies interactions; and multiple socialities based on both industrial capitalism and the natural economy such as hunting and gathering and swidden cultivation.[1]

The project examines multifarious dimensions of change in a tropical region that has historically been deeply connected to both local marketplaces and international markets. They are the interfaces between capitalism and the natural system. We investigate a number of pressing questions. How have new commodity chains emerged while older ones disappeared? What changes are associated with such shifts? How are material cycles and food webs altered as a result of large-scale land-use change? What are the relationships among these three elements—commodity chains, material cycles and food webs?

[1] Scant attention has been given to such locales in the ethnography of Borneo, as researchers have been more concerned with the study of a single village community, an ethnic group, or a specific ecological niche. This study is thus an attempt to reformulate the unit of analysis to better comprehend the socio-ecological dynamic by shifting its reference away from closed units and expand it in time and space.

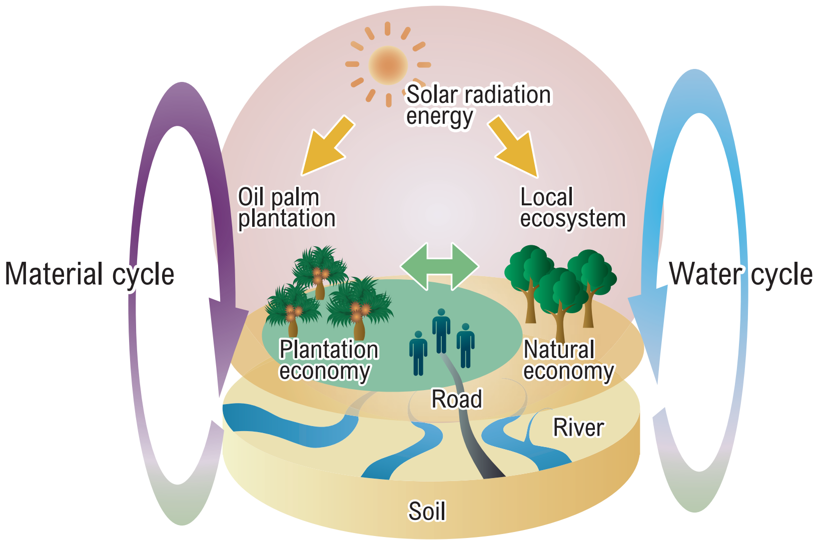


Fig. 1.1 Social and natural systems

Attempts to answer these questions lead us to go beyond the dichotomy of society and nature (see Fig. 1.1). The relations between the two worlds that have been abruptly and forcibly connected by human-induced change are the mainstay of our empirical inquiry. We look into multifaceted agents and drivers of change. We then track their flows and movements across social and natural systems, which are located within a local ecology yet part of a larger social milieu. In addition to humans, the focus of conventional ethnography, we attend to such mobile factors as energy, stream water, chemical components, mammals, birds, commodities, labour and capital.[2] Our attention to movements and flows also takes us to the interfaces of social space and the physical landscape. We scale up and down the units of analysis—from household, longhouse community, region, nation state and to the Global North, as well as from patches, landscapes and to spheres. This enables us to comprehend how the constituent parts of a system are related and distant places linked.[3]

Natural scientists deal with moving thresholds among mosaic landscapes, such as peat swamp forests, secondary forests, culturally preserved communal forests, swidden fields, reduced-impact logging sites and oil palm plantations. Social scientists look into changing boundaries between plains and hills, maritime and terrestrial domains, and urban and rural social formations in order to unveil the fundamental reconfigurations, adaptations and casualties at a plantation frontier. In

[2] For studies of transnational flows and movements of various social agents of change, see Ishikawa (2011).

[3] The diverse nature of our field research is closely related to our research agenda where we intend to cover *shinra banshō* (森羅万象)—*all things in nature*, literally meaning 'all-covering forests and ten thousand things'.

the field sites, we asked a series of questions for closing the nature/society divide. Some questions are addressed so as to envision the ways in which local communities, both human and non-human, are connected to the outside world.

- How do animals choose migration routes in and outside anthropogenic forests?
- How do biodiversity hotspots connect communities beyond their local ecology?
- How do new systems of agrarian production affect hydrologic cycles?
- How does the terrestrial road network change the movement of people?
- How does a rural–urban continuum emerge out of new flows of labour and capital?
- How are food webs articulated with regional and global commodity chains?
- In what ways do the plantation and local peasantry influence climate change?

In order to integrate such broad fields of inquiries and their findings, we seek a strategic combination of field sciences. The natural sciences deal with material flows, such as water, gases and minerals, that are physical and biological processes at work, in and out of anthropogenic forests. Meanwhile, the social sciences look into the articulations and disarticulations between the natural economy and plantation economy, the effects of road networks linking the interior land to cities as well as hills and plains. Attention to commodity chains also uncovers the reconfiguration of local–global relationships. All of us have made a deliberate attempt to work outside our own disciplinary comfort zones. In so doing, social scientists seek perspectives that go beyond the conventional human and non-human divide, while natural scientists go beyond *in situ* analyses of ecosystems and embrace historical perspectives.

1.2 River, Forest and Trade

We situate our research site in a riverine basin consisting of two river systems—the Kemena and the Tatau (Figs. 1.2 and 1.3). The basin is formulated in a triangular area carved out by the South China Sea, and the Rejang and Baram rivers.[4] The Kemena is the fourth largest basin with an area of 6105 km^2 and the Tatau is the fifth largest with an area of 5260 km^2 among the 21 river basins in Sarawak. We place special focus on the two tributary systems, where a variety of ethnic groups and diverse fauna and flora occupy a niche peculiar to their webs of life. The majority of social groups officially acknowledged by the state government of Sarawak can be found in the Kemena and Tatau basin catchment, making it a microcosm of Sarawak and widely representative of its ethnic composition and society at large. The basin is also one of the few remaining biodiversity hotspots in maritime Southeast Asia.

Historically, the Kemena and Tatau rivers have functioned as important social hubs for local communities (Langub and Ishikawa 2017). The river basin is the locus of economic exchange, information networks and kinship ties. Despite cultural

[4] For a social history of Rejang basin, see Fong (1996).

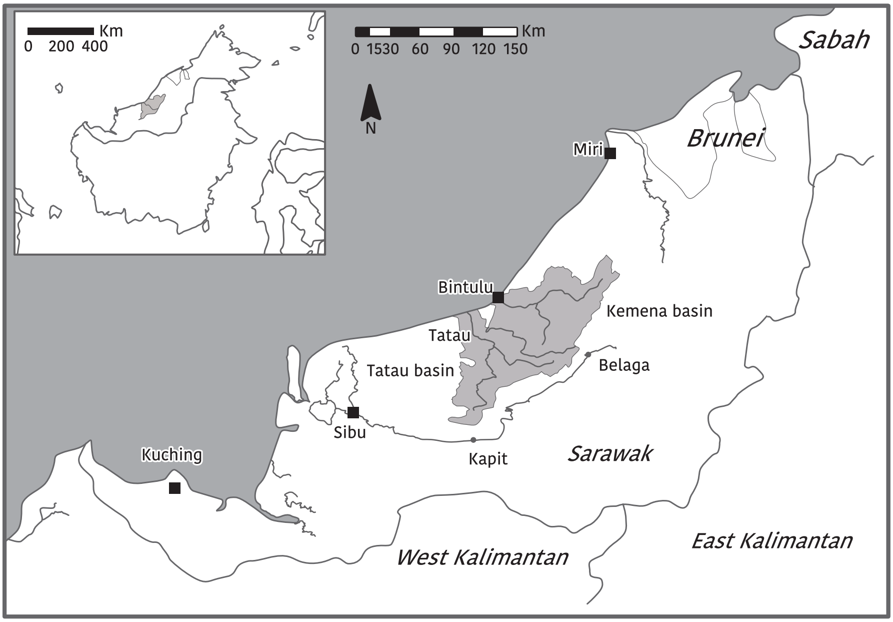


Fig. 1.2 Central Sarawak, Malaysia

differences, members of these river-based groups have a shared awareness of the strength and value of these interactions. River-based commons not only constitute a spatially specific geo-ecological unit but also a historically inscribed space where people's memories, social interactions, and conjugal and consanguineal ties accumulate to construct a historical memory and consciousness.

Contrary to the popular image of an out-of-reach hinterland in a dense tropical jungle, the riverine society under study has been connected to world commodity markets for generations. Under Brooke colonial rule (1841–1946), as a British Crown colony (1946–1963) and within the modern Malaysian nation state since 1963, local communities have been closely articulated with trading networks that derived from the extensive Chinese cultural complex in Asia as well as the West-cum-Global North. Abundant forest produce has been highly valued in both regional and international commodity markets (Ishikawa and Ishikawa, Chap. 6). The linkages to transnational commodity chains have long provided diverse income sources for local people (Ishikawa et al. 2013). The need to produce and store resources through settled agriculture has never been acute. Local communities have maintained multifaceted livelihood strategies, combining various modes of subsistence rather than solely depending on perennial cropping regimes with land ownership. People have, at different points in time, engaged in swidden cultivation, foraging, forest produce extraction and trade, crop cultivation during boom periods, wage labour (at logging camps and offshore oil fields) and so on (Soda 2007; Ishikawa 2010). By maintaining diversified economic portfolios, communities have upheld a

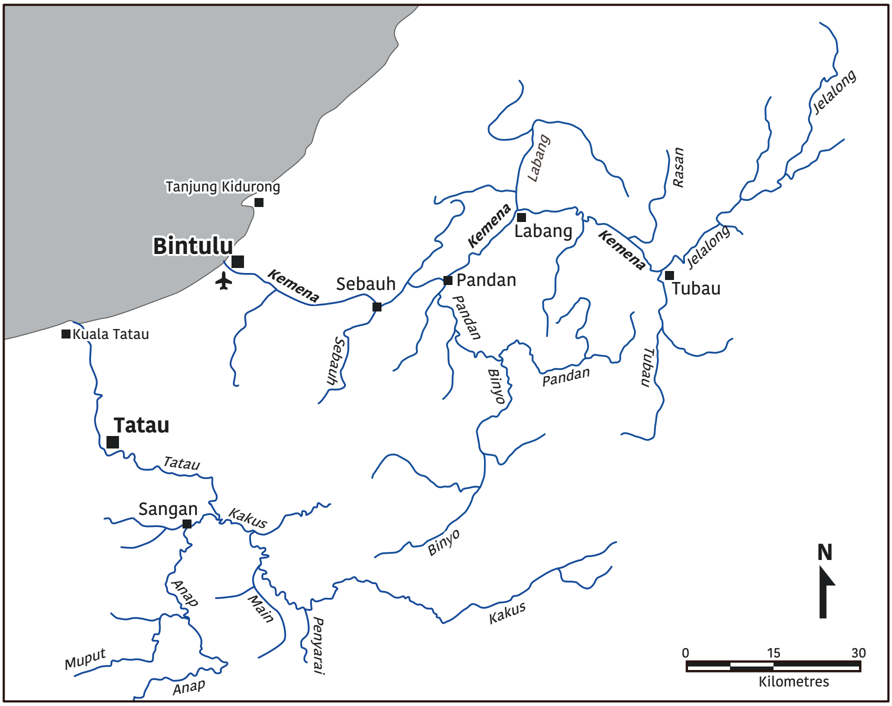


Fig. 1.3 Kemena and Tatau basins

distinctive non-sedentary character. People periodically move to access richer forests and rivers, where usufruct rather than land ownership functions as a basic mode of resource management (Langub and Ishikawa 2017).

The riverine basin in central Sarawak under study has a number of characteristics that have resulted in a peculiar riverine social formation. The first feature is the high level of biodiversity. Recent studies show that the research site in central Sarawak is located in one of the hotspots that possesses the highest level of plant biodiversity in the Sundaic region and records the existence of 639 plant species in seven families: Dipterocarpaceae, Ericaceae, Fagaceae, Lauraceae, Moraceae, Myristicaceae and Sapindaceae (Raes et al. 2013).[5] In addition to flora, the region has the highest terrestrial vertebrate endemism (Fitzherbert et al. 2008: 540).

The richness of fauna and flora has supported the trading of forest produce by local communities with Malay and Chinese merchants at bazaars established at river confluences and inland trading spots (Langub and Ishikawa 2017). River tributaries and confluences in the basin have long functioned as an interface between the interior peoples and traders, and connected distant peoples and landscapes. The tropical forests have yielded numerous commodities for regional and international con-

[5] The Sundaic region comprises the Malay Peninsula, Borneo, Java, Sumatra and their surrounding islands.

sumption, such as natural rubber for submarine cable insulation, latex used in foods as a clouding or glazing agent, ironwood for roofing and construction materials, edible birds' nests and bezoar stones as highly valued Chinese medicinal ingredients, rattan for furniture, handicrafts and even grenade basket cases during the First World War, to name just a few. Take rattan as an example. Rattan is part of species-rich taxa representing a high level of biodiversity. As our study shows, the highest species diversity of rattan is found in Borneo, where an estimated 150 species exist out of approximately 600 species belonging to 13 genera of the Palmae family. Sarawak alone contains the highest species diversity, with a record of 107 species. However, it is not only biodiversity that has supported local trade but also high biomass. Brooke colonial officers stationed in Bintulu district recorded some activities associated with the brisk rattan trade in 1909.

> These people are exceedingly busy carrying rattan sega overland from Belaga and while I was at Tubau some 10,000 bundles of this rattan were either in Tubau or on their way from Belaga. I found Tubau very badly in want of supplies the Bintulu Chinese keeping their agents there short of rice and other food stuffs. The whole of Tubau trade is with Belaga and thousands of dollars (silver) go over to Belaga as the price of rattan during the year and the consequence is a shortage of silver here. Dayaks keep large quantities of silver in their houses and always refuse copper in payment of rattan. (Owen 1909: 7)

This basin society with high biodiversity and biomass is also ethnically diverse. More than a dozen ethnic groups migrated into the river basin, living along the rivers. With the exception of multiethnic Bintulu town where all ethnic groups live side by side, particular ethnic groups occupy specific segments of the riverine settlements as if forming an ethnic gradation from the coast upriver to the interior. The Iban, the largest ethnic group in Sarawak, who now occupy almost all segments of the Kemena, are exceptions (Kato et al., Chap. 5; see Fig. 1.4).

It is important to note that such a riverine space with a mixed landscape and multiethnic communities is morphologically homogenous. The landform of northern Borneo mainly consists of soft mudstone, and the bedrock of the mudstone is well weathered. Despite the extremely high uplift rate, Borneo has remarkable physical weathering because of the large amount of rainfall and chemical weathering due to high temperatures and humidity, so that steep topography is uncommon and the stream gradient is relatively small.

In addition, most stretches of the major rivers in central Sarawak are parallel to the seam of the geological strata, and it is difficult for rapids and waterfalls to develop. Hardly any gravel exists in the beds of many large rivers. Therefore the erosion of rivers is weak, and the river channels and the terrain around them have been relatively stable over thousands of years.[6] Relatively sluggish streams with few rapids and waterfalls have become the most suitable communication corridors in the environment of thick forests where a lack of road networks made long-distance ter-

[6] On a timescale of decades, however, lateral erosion of major rivers has been progressing, which leads to a crisis of the collapse of riverside longhouses into the water (Soda 2017).

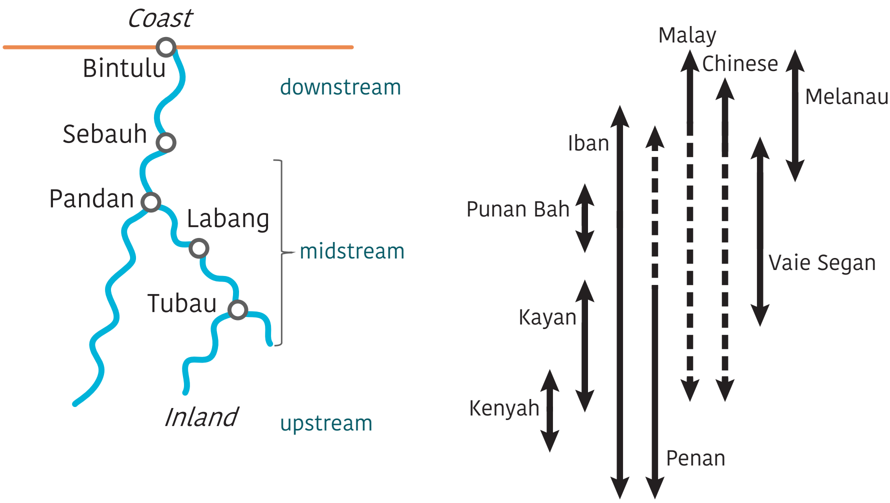


Fig. 1.4 Ethnic groups in the Kemena basin

restrial movement difficult. These features also mean, for the peoples living in the basin society, that there are similar geomorphological environments wherever they move. In addition to these geophysical features, vegetative and floral variations are not noticeable, so there is little change in geo-ecological settings in the riverine landscape. Local people settled and resettled anywhere without a fundamental change in their style of living and livelihoods (Mokudai et al., Chap. 2).

In such a morphologically homogenous basin, a web of riverine networks has long been established, connecting people with distant kin and traders from afar. As our expedition team found, there are currently eight major connecting points in central Sarawak, where different river systems divided by a mountain range are linked with small but well-travelled paths (Langub and Ishikawa 2017). They are one of the means by which people have maintained close contact with kin and traders. Our literature survey and field interviews identify other watershed connecting points that functioned in the past as trade and migration routes. These places were frequented for the purpose of social visits as well. They are usually located along district boundaries such as Belaga–Baram, Belaga–Bintulu, Belaga–Tatau, Kapit–Tatau, Bintulu–Baram and Bintulu–Miri (Langub and Ishikawa 2017). From these local connecting points, people could reach trading spots and bazaars with trader intermediaries who navigated up and down the rivers handling commodities. The proximity of Sarawak to Singapore as well as Brunei has enabled a synergy between Chinese *taukay* traders and Malay *nakodah* maritime traders who eventually connected the inland regions with coastal and international trade networks.

1.3 Tropical Biomass Society

The characteristics of the basin society in central Sarawak have led to the formation of what we propose to call a tropical biomass society.[7] Heuristically, a tropical biomass society is defined as a social formation typically found in a geo-ecological niche located in an equatorial zone classified as having a tropical rainforest climate. An equatorial zone possesses the most concentrated biome on the surface of the Earth due to a combination of abundant solar energy and high precipitation. Active hydrothermal circulation makes tropical rainforests fertile ground for the regeneration of biome. High biomass societies with high levels of biodiversity are generally found between the northern and southern tropics. In maritime Southeast Asia, tropical biomass societies are located in Borneo, the Malay Peninsula, Sumatra and the Philippines. They are social formations with a number of general characteristics.

First, a tropical biomass society is not an isolated frontier. It is a mercantile and capitalist space connected to global commodity chains. Due to the rapid pace of regeneration and the abundance of biomass, tropical biomass societies have historically engaged with various modes of biomass commodification. High biomass and high biodiversity have led to the (continuous or intermittent) extraction of forest produce for export, leading to the formation of commodity chains.

Second, a tropical biomass society is a multi-livelihood space whose inhabitants are capable of practising combined modes of subsistence. Local people are engaged in swidden cultivation, foraging, forest produce trade and off-farm wage labour (Cramb and Dian 1979; Morrison 1993). Livelihoods have been secured through diversified economic portfolios.[8]

Third, a tropical biomass society is non-agrarian. With low population pressure, both biodiversity and biomass are retained. As a result, the requirement for producing and securing stocks of resources by settled agriculture remains low. A tropical biomass society is essentially a society based on flow and exchange rather than stock derived from agricultural production. Agriculture, when practised, is supplementary and not the sole or major means of livelihood. While people may engage in subsistence farming, their access to commodity chains and off-farm labour markets enable diversified strategies of living.

Fourth, a tropical biomass society values biomass cover more than land itself. Rather than ownership, the usufruct operation of land and the maintenance of commons provide the foundations for its sustainability. As the chapters in this volume discuss in detail, the absence of private land ownership coupled with usufruct opera-

---

[7] A tropical biomass society is an ecosystem type of tropical rainforest with the richest forest cover formulated between the northern and southern tropics. In addition to Southeast Asia, similar geo-ecological formations with high biomass and biodiversity can also be found in New Guinea, Africa, South America, Central America and in many Pacific, Caribbean and Indian Ocean islands.

[8] There is a danger of equating a 'high biomass society' to the 'original affluent society' (Sahlins 1968). The notions of 'self-sufficiency' and 'affluence' can be considered as constructs made by colonialism and developmental autocracy.

tions and the maintenance of commons have inadvertently created the necessary conditions for inviting drastic and large-scale land-use change.

Fifth, a tropical biomass society exhibits a high degree of flexibility to accommodate and respond to changes brought about by outsiders. When such a flexible response generates too drastic a change, or moves beyond a certain tipping point, a regime shift may take place. As we shall see, many tropical biomass societies have been exposed to large-scale anthropogenic land-use change, and have entered a phase of massive transformation or regime shift. In these instances, an environment-dependent subsistence economy has been replaced by commodity production and rural–urban migration (see Ishikawa et al. 2013).

1.4 A Human-Induced Inflection Point of Succession

In the history of the resource frontier under study, there are two plants—one native and one imported—that have played a distinctive role in transforming local communities, both human and non-human. They are Dipterocarpaceae and oil palm. The individual characteristics of the two plants have contingent effects on the transformation of tropical biomass societies.

The Dipterocarpaceae (literally ‘two-winged fruits’) family of rainforest trees plays a dominant role in the ecology and economics of Asian forests in a way that no comparable family plays in other regions. Dipterocarp trees dominate forests in Borneo, Sumatra, Java, the Malay Peninsula and the wetter parts of the Philippines, where the majority of large trees are members of this one family and account for the majority of biomass. Outside this core area, dipterocarps gradually decline in diversity and abundance. In total, there are at least 500 Asian species. Since the 1960s, due to their ecological dominance, large diameter at breast height and excellent knot-free quality, dipterocarps have been marketed internationally as plywood and sawn timber. Philippine timber excelled in quality and long supported the production of thin plywood mainly for interior woodwork, while Sarawak has provided plywood for construction materials such as concrete-forming panels and floor base. Southeast Asia first became a site of logging operations for the Japanese market. Round log exports to Japan gradually shifted away from the Philippines, Indonesia and Sabah, and Sarawak has become the last frontier for logging operations (Samejima, Chap. 25; Taylor et al. 1994; Bevis 1995; King 1996; Parnwell and Taylor 1996).

At the beginning of the century, oil palm plantations arrived in a major way in the Kemena and Tatau river basin. The shift from selective tree cutting to oil palm cultivation marked a fundamental change in commodification, from a system based on the regeneration of biomass to one that depends on expansive production of planted vegetation on clear-cut land. In the history of the basin, we have witnessed a new inflection point of succession, where biome transformation goes beyond primary as well as secondary succession. In the process of the construction of oil palm plantations, pre-existing above-ground biome has gone and been replaced by a single domesticated crop.[9] We do not see interspecies competition but only intraspecies competition.

The quintessential nature of the plantation system also lies in the principles of economies of scale and scalability. When the organisational practice of making goods cheaper because more are being produced is applied to oil palm plantations, at least 3000–5000 ha of cultivation land are necessary for the efficient and economic operation of a single mill (Okamoto and Hayashida 2018). The expansive nature of plantations is based on the principle of scalability. A plantation is 'a scalable project where small projects can become big without changing the nature of the project'. Scalable projects are those that can expand without changing, where diversity is banished (Tsing 2012: 507; cf. Scott 1998). The effects of plantations on the ecology and landscape include the enclosure of space, the replacement and singularisation of the biomes, the fragmentation of the landscape and the emergence of a mosaic landscape.

We have seen precisely the emergence of such a highly fragmented, mosaic-like landscape in the Kemena and Tatau riverine basin (cf. Taylor et al. 1994). Using high-resolution satellite imagery, we analyse the land cover types and classify them into the following land uses:

- Good standing forests: 2.59%
- Degraded forests or forest clearings: 52.74%
- *Temuda* swidden agricultural practice: 21.85%
- Oil palm plantations: 15.92%
- Acacia plantations: 1.35%
- Log ponds: 0.4%
- Others: 5.12%

Forest covers most of the 62,133.8 ha project area, followed by fallow or secondary forest used for swidden agricultural practice (*temuda*), oil palm plantations and industrial tree plantations. The large extent of degraded forests implies that logging is the main economic activity in this region. Areas planted with oil palm have increased, especially along roads. Our results suggest there will be an increase in the area covered by oil palm plantations and this may soon surpass the extent of land currently categorised as *temuda* (Hon and Samejima, Chap. 3).

With the advent of inflection points of nature where heterogeneous landscapes are observable in sequence, and nature and non-nature or first nature and capitalist nature exist side by side,[10] we inquired into issues such as how new systems of agrarian production affect the hydrologic cycle, the ways plantations and the local peasantry influence material cycles, and how animals choose migration routes in and outside of anthropogenic forests (see Figs. 1.5 and 1.6).

---

[9] For a comparison between the impacts of selective logging and forest conversion to oil palm plantations, see Edwards et al. (2014).

[10] Anna Tsing defines 'first nature' as ecological relations (including human) and 'second nature' as capitalist transformations of the environment (Tsing 2015: viii).

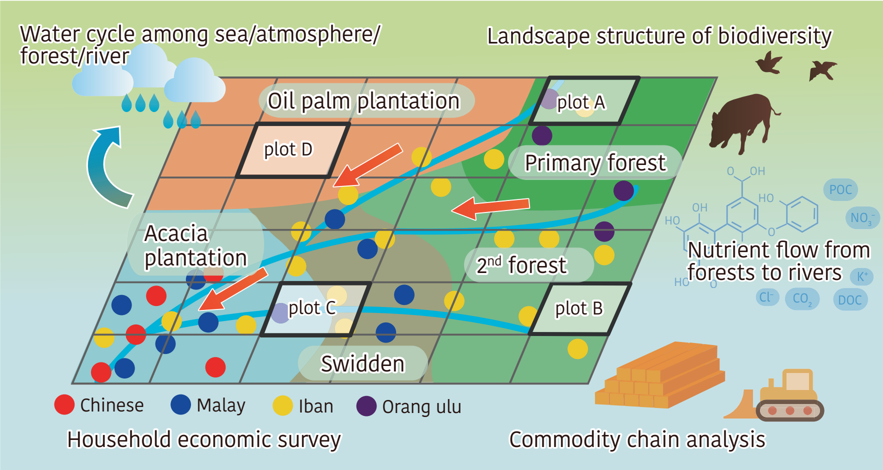


Fig. 1.5 Multidisciplinary research

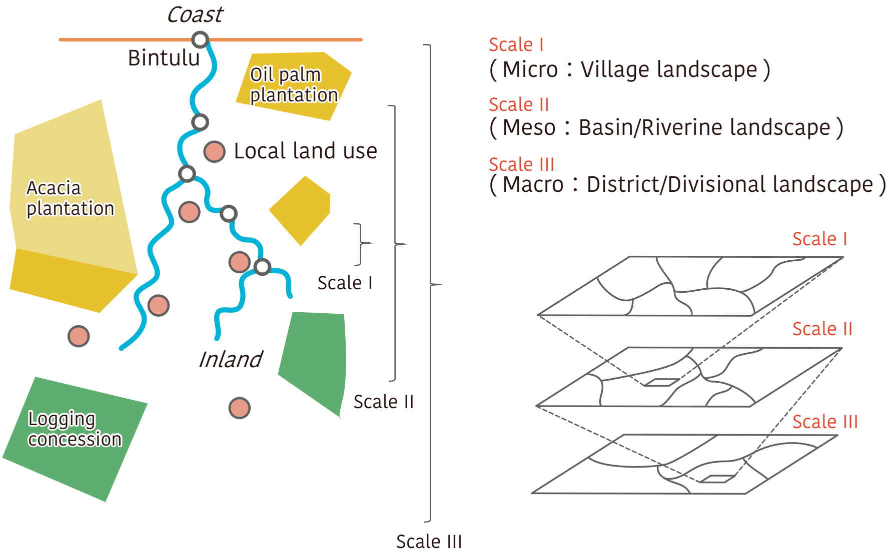


Fig. 1.6 Multiscale research

Our ecological research team analysed the ecosystems of natural and planted forests. For instance, multiple research plots were selected by animal ecologists in order to map the spatial structure of biodiversity. Hundreds of camera traps were set to monitor the movements of animals in and out of plantations as well as timber concessions for the purpose of examining habitat range and changes in the mixed landscape (Samejima et al., Chap. 10).

While a hydrologist looked into the water cycle in the ocean and atmosphere, and the forests and rivers at a mesoscale (Kozan, Chap. 4), ecosystem ecologists focused on the flows of nitrogen and particulate organic matter in the forests and rivers. They examined material cycles of nature, where the transfer of chemicals from biological to geological systems is observable in mixed landscapes. Rivers run through the fragmented mosaic landscapes, transporting chemical components derived from plantation agriculture. Forest ecologists examined the effects of agroindustrial operations on the forest ecosystem by taking numerous water samples along the rivers, while ichthyologists conducted a taxonomic evaluation of the freshwater community at each water sampling spot. The sampling points covered the whole river system including the landscapes of natural and logged-over forests, fallow land, and oil palm and acacia plantations (Tokuchi et al., Chap. 11; Fukushima et al., Chap. 12; Kano et al., Chap. 13).

The landscape being modified with the advent of plantations produces new food webs and commodity chains. With the expansion of planted forests, human relationships to other animals have changed, albeit in rather unexpected ways. After oil palm plantations are developed in the vicinity of longhouses, for example, it has become easier to hunt wild boar (*Sus barbatus*), because they eat oil palm seeds inside the plantations. By combining ecological data with anthropological information on local hunting practices, we examined how wild animals and local people have developed a new interface in the changing environs (Samejima and Hon, Chap. 8; Kato and Samejima, Chap. 14). Our research also confirmed that older logged-over forests in a forest concession that practises sustainable forest management contain greater numbers of carnivore species. As carnivores sit on top of the food chain, their presence indicates the general health of the forest, the importance of sustainable forest management and some of the roles logging companies can engage in towards the conservation of wildlife in a production forest environment (Hon et al., Chap. 9).

1.5 The Plantation as a Social Complex and Infrastructure

Just like the Dipterocarpaceae family, the very peculiar nature of oil palm also has a contingent effect on the social formation of the riverine society. As an industrial commodity, fresh fruit bunches need to be processed within 24 h so as to avoid oxidation which lowers the quality of the product. It is therefore essential that oil palm fruits are sterilised by heat treatment immediately after harvest and before oil extraction in order to deactivate the lipase, an enzyme naturally present in the seed. The oxidation process triggered by the lipase, a micro-change at the molecular level, is in fact a driving force of considerable social change in our research site. Traditional maritime and riverine society is being transformed to a landbound one with road networks for transportation of fruit bunches to processing mills. The advent of oil palm plantations stands not only for the introduction of a new mode of corporate production but also the establishment of spatial linkages between upriver cultivation sites with downriver production sites.[11]

Oil palm production requires an industrial complex comprising road networks and mills, and local people in the vicinity of plantations are simultaneously incorporated into the system. Our research witnessed and documented the very initial moment of the emergence of oil palm smallholders in the basin society. With the advent of road connections, many residents moved to the roadside, at some distance from their longhouses that are traditionally built along rivers. Now a long stretch of temporary huts (*langkau* in the Iban language) can be found, and oil palm seeds harvested by local people are brought to the refinery mills attached to plantation companies (Soda et al., Chap. 15).[12]

The emergence of the plantation as a social complex not only leads to the spatial reconfiguration of the basin society but also brings local communities into a profoundly contested situation. With the advent of the plantation complex, the object of appropriation has shifted from the extraction of biomass on land to land itself. As already noted, in the Kemena–Tatau basin catchment natural resources on the land surface, both timber and non-timber, have been valued for subsistence and trade activities for generations. Today the land and soil have become devices for production, where new biomass is cultivated through the domestication of plants.[13] This new mode of biomass generation, both in plantations as well as by smallholders, requires an operational condition in which labour mobilisation, capital investment and land as a commodity become essential for continued operations (Soda et al., Chap. 15). What we observe now in the basin society is the rapid development of plantations leading to so-called 'accumulation by dispossession', with indigenous communities having compromised access to land.[14]

---

[11] The notion of the plantation as a social complex is not new. A pioneering study of Puerto Rico by Julian Steward focuses on 'the levels of social integration' brought about by the plantation system (Steward and others 1956). The plantation is also seen as 'a socio-cultural type' (Mintz 1959: 42). Plantations always function as a corridor connecting local communities to national and international markets through labour mobilisation and commodity chains.

[12] Concerning the spatial configuration of plantation society in Puerto Rico, Eric R. Wolf notes: 'This class structure finds expression not only in the social terms but also in spatial relationships. Invariably the plantation creates new communities. In the highland areas of the New World it drew the Indians from their communities into life near the hacienda and made them *acasillados*. In the lowlands of the New World, it ringed the big house with the huts of African slaves. When population grew to a point where labor became plentiful, cheap and readily available, new settlements of laborers grew up in the vicinity of the fields, inhabited by men eager to find employment in cultivation and harvest' (Wolf 2001: 217).

[13] The Meratus Dayak of South Kalimantan have a notion of *bulu gumi*, which literally means 'the body hair of the earth'. 'It is all the living things, in the water, in the air, and on the surface of the earth: they are the body hair of the earth' (Tsing 2005; Haraway et al. 2016).

[14] This includes the commodification and privatisation of land, displacement of local peasants, turning various modes of ownership into exclusive private ownership, suppression of communal rights, commodification of labour, and suppression of non-capitalistic mode of production and consumption (Harvey 2003). For a discussion of land tenure and large-scale land acquisitions in Sarawak, see Bulan with Locklear (2009) and Cramb and McCarthy (2016). For an analysis of the political economy of oil palm production in Indonesia, see Pye and Bhattacharya (2013), Mizuno et al. (2016) and Okamoto and Hayashida (2018).

Looking at the emergence of a production site for an industrial commodity in the midst of a riverine landscape raises a number of urgent inquiries into the kinds of change new terrestrial connectivity brings to traditional riverine social formation, and how the terrestrial road network alters the movement of people, labour and capital. The sociocultural research team thus focused on transformations from a traditional natural economy (swidden cultivation, hunting and gathering of forest produce) to off-farm wage labour (in timber camps and urban areas) and to agricultural income generation (oil palm smallholdings). We conducted a series of household interviews on topics such as functionally and spatially extended kin networks, circular labour migration and flows of remittances (Soda et al., Chap. 15).

Road networks necessary for oil palm production have expanded into interior Dayak communities, where it is now possible for weekend returners from the city to join household oil palm smallholding operations. Rural villages have been depopulated and are now dependent on the urban economy, undergoing a structural transformation. However, the diffusion of oil palm smallholdings in accordance with plantation development in the interior has sparked a return migration from urban to rural areas for weekend oil palm farming. This return has revitalised longhouse communities (Soda and Kato, Chap. 17). The strengthened relations between urban areas and longhouses have brought about a new kind of rural–urban continuum where functionally as well as spatially extended local households play a key role (Soda et al., Chap. 15; Soda et al. 2015).

1.6 Commodification and Local Processes

The plantation system brings about changes to biodiversity and social organisation and also affects the way the local community, both ecological and social, is connected to the wider political economy. In the course of our research, we came to question whether the analysis of local processes is sufficient to explain 'community' and even whether the local ecological and social community is a realistic construct. These issues still remain controversial to us as social and natural scientists, but a consensus has gradually emerged that local community dynamics cannot be understood without attention beyond the local community per se.

One of the focal points of our study was thus to examine the changing nature of commodity chains, with a starting point in the interior river basin and an end point in the international market as well as with cross-continent consumers. To better understand the dynamics surrounding regional, national and transoceanic commodity chains, our attention has expanded to include the micro–macro nexus and its change over time, which has, during the course of fieldwork, translated to the following research foci: the interaction between the local ecological process and the commodification process; interfaces between local food webs and the commodification process; the emergence and disappearance of commodity chains; and the changing threshold between nature and non-nature through international certification systems instituted by corporations and civil society (Naito and Ishikawa, Chap. 26).

In the course of our fieldwork, several kinds of natural resources-cum-commodities became contact points for the collaboration between researchers with different disciplinary specialisms. We paid special attention to such commodities as the Dipterocarpaceae family, oil palm, birds' nests, rattan and bezoar stones to document the newly emerging and fast disappearing commodity chains. They function as academic ecotones, where disciplinary boundaries get blurred and interdisciplinary inquiries are fostered.

1.6.1 Rattan

Both forest ecologists and economic historians worked together on rattan as an important indicator species for biodiversity as well as a commercial agent that historically connected local communities with regional and international markets. In the midst of anthropogenic forests, the collaborative team examined the ecological, economic and cultural functions of *pulau*, literally the 'green island' communally managed by local people, and its location in global supply chains.

Rattan, for instance, has long been an important forest resource for communities in rural Sarawak and is still widely traded today. The ability to collect and weave rattan to sell for cash is closely related to the conservation of natural forests in the vicinity of local communities. A plant ecologist, a human geographer and a global historian conducted collaborative research in villages under pressure from logging and plantation development to elucidate the communal forest conservation system and its relation with the diversity of plant species (Takeuchi et al., Chap. 21; Takeuchi and Kobayashi 2016; Takeuchi et al. 2017). Researchers also investigated how forest plant resources have been extracted and traded within local and regional markets, both historically and in the present (Takeuchi et al., Chap. 22). By clarifying the significance of the communal forest in terms of the surrounding environment, rural economy and trade patterns, the research provides practical suggestions for forest management policy.

1.6.2 Swiftlets

Edible nests (*sarang burung*) of swiftlets (*Aerodramus fuciphagus*) are one of the most valued forest products in the area. The nests constitute an important meeting ground for cultural anthropologists, historians and bird ecologists to observe how commodity chains and food webs are being reconfigured. The diffusion of swiftlet farming—a new method of semi-domestication of the birds—also affects both habitat changes and birds' nest trading customs. In the lower reaches of the Kemena, we constructed a swiftlet farmhouse to collect basic information on the feeding ecology of the birds in the transformed landscape. The supply chains of birds' nests have been both economic and cultural linkages connecting the riverine basin to Chinese culinary and medicinal communities. To follow the chains and examine the interfaces where various cultural and economic linkages are generated, we organised multidisciplinary teams composed of ethnic Chinese specialists, anthropologists, ecologists and historians. For instance, tracing long chains of *guanxi* (personalised relationships) crossing over ethnic and national boundaries, the birds' nest study team revealed the strength of Chinese networks connecting the interior of Sarawak with regional and international markets. They traced the commodity chains that link Bintulu to the region and beyond. These lead to the busy streets of Sheung Wan in Hong Kong, Kobe in Japan, and even Chinatown in New York City (Chew et al., Chap. 18).

The study of swiftlet farming examined how the feeding ecology of domesticated swiftlets has been transforming itself in the midst of a landscape dominated by oil palm plantation (Fujita and Leh, Chap. 19). With reference to the newly emerging commodity chain of edible birds' nests, the feasibility of farmhouse management in rural Sarawak was also examined (Suzuki et al., Chap. 20).

1.6.3 Porcupines

The subsistence (natural) economy of the upriver areas has long been connected with regional and global markets. Although many non-timber forest products are now minor commodities, they are still important forest resources when considering relations between village natural environments, the plantation-based economy and international markets. Our research examined how high-value forest products such as porcupine bezoar stones and edible birds' nests connect basin societies in central Sarawak with the wider world. With the advent of oil palm plantation, bezoar stone-producing porcupines have become a kind of windfall for local hunters in the basin society. According to informants, because of their habit of eating very hard oil palm seeds, porcupines started producing bezoar stones in their stomachs, which fetch extremely high prices in the market. Porcupines and the bezoar stones they produce are a case where the change in food webs leads to the re-emergence of Chinese commodity chains (Okuno and Ichikawa, Chap. 23). Specialists of cultural anthropology and overseas Chinese studies adopted multisited ethnographic methods to trace the commodity chain from hunting sites to consuming cities such as Kuala Lumpur, Penang and Singapore.

1.6.4 *Timber, Oil Palm,* Acacia mangium *and Fossil Fuels*

Taking as a case in point the reduced impact of logging activities and oil palm plantations endorsed by the international system of certification and governance, we examine a dynamic process of negotiation within an increasingly complex nature/non-nature threshold for the betterment of social and environmental conditions. Through the construction of a road network by which the interior is connected to processing mills and further down to international markets, the local community is now a producer of industrial commodities and emitters of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). With the data provided by a plantation company and a local Dayak community, we compare the peasantry and industrial sector in the wider milieu of climate change (Ubukata and Sadamichi, Chap. 24).

Unlike traditional forest products, modern global commodities such as oil and natural gas play important roles in the state economy. Chap. 27 describes the changing patterns of export trade, discusses its implications for the fate of a high biomass society, with detailed analysis of trade statistics in and beyond Sarawak, and identifies the long-term trends and changes from the perspective of global economic history (Kobayashi and Sugihara, Chap. 27).

1.7 Beyond Exceptionalism

Because of the consequences of large-scale land-use change taking place in a heterogeneous, transitional riverine landscape, the research assumes that only multi-sited transdisciplinary fieldwork can capture and understand the nature of the frontier. The distinction between the social and natural domains continues to make communication between researchers in these two categories an uneasy task. Our research agenda required us to overcome two kinds of exceptionalism: human exceptionalism in the natural sciences as well as nature exceptionalism in the social sciences. In the course of planning this research, we attempted to create new scales and units of analysis that enable an integrated understanding of the human–nature relationship in the hope that we include sociality in the natural sciences and a multispecies perspective in the social sciences.

We found the best way was simply doing things together. We visited the research sites together, stayed overnight in Dayak longhouses, ate rice from the same bowl, and saw what others do and interrogated the intention of the research. We gradually started to pay attention to the entanglements, or relational encounters, located at the interfaces between previously separated realms of the natural and social sciences. The multilingual assets of the transdisciplinary team also helped us conduct better research in terms of data collection. Scholars from Kyoto University and graduates who had been trained in the strong tradition of interdisciplinary field sciences there formed the core of the research team.[15] The majority of the team have also had years of fieldwork experience in Southeast Asia. Most, including the natural scientists, have a good command of vernacular languages and dialects (Iban, Kayan, Kenyah, Bukitan, Melanau, Penan, Sihan, Mandarin, Hokkien, Teochew, Sarawak Malay and Indonesian, in addition to standard Malay) and bring with them solid knowledge of local culture and society.

In the course of the fieldwork, we encountered multifocal windows for investigation for both natural and social scientists. Rattan, wild animals, birds' nests, culturally preserved forests and rivers became these windows and compelled us to facilitate our research with a multidisciplinary as well as a multiscalar perspective.

Our research was also meant to be transdisciplinary in the sense that we sought cooperation and assistance from various non-academic stakeholders before, during and after the fieldwork. The cooperation among multistakeholders enabled us to conduct research in newly created interface among the government, the business community and academics.[16]

1.8 Structure of the Book

The structure of this volume reflects our research design which was geared to examining new interfaces and connections emerging on the plantation frontier. The first section 'Landscape, Culture and History' provides basic information on the geomorphology, land use and human society of the basin catchments of the Kemena and Tatau rivers, including the history of forests and history of communities (Chaps. 2, 3, 4, 5, 6 and 7). The second section 'Inflection Points of Nature' is concerned with the interfaces among fauna, flora and the human community in the Kemena–Tatau basin. This includes an analysis of species composition, biomass and tree biodiversity in a transitional landscape and the influence of large-scale land-use change on the environment (Chaps. 8, 9, 10, 11, 12, and 13). The third section titled 'Plantations as Social Complexes and Infrastructure' focuses on the changing relationship between the plantation economy, the traditional natural economy based on

[15] For interdisciplinary scholarship at Kyoto University, see Heather Anne Swanson et al. (2015).

[16] Our field study was made possible by the permission, endorsement and logistical support of multiple stakeholders in Sarawak. The State Planning Unit Sarawak granted a five-year research permit, while numerous government agencies provided support for fieldwork. In particular, academic collaboration with the Sarawak Forestry Department, Sarawak Forestry Corporation (SFC) and Universiti Malaysia Sarawak (UNIMAS) was indispensable. We also received endorsement from private companies engaged in plantation and logging activities. They allowed us to conduct research inside their operation sites, providing personnel, transportation, accommodation (in the case of interior research sites) and information on their business operations. Zedtee Sdn Bhd, Sarawak Planted Forest Sdn Bhd and Keresa Plantations Sdn Bhd allowed us to conduct on-site research by both social and natural scientists (Hon et al., Chap. 9; Samejima et al., Chap. 10; Tokuchi et al., Chap. 11; Ubukata and Sadamichi, Chap. 24). We held two seminars in Kuching, Sarawak, to share research outcomes with local academics, government officials and business communities (*Borneo Post* 2012).

hunting and gathering and swidden agriculture, and oil palm smallholdings. It focuses on the changes in social formations of local communities (Chaps. 14, 15, 16, and 17). The final section 'Commodification and Local Processes' examines the social and ecological dynamics connecting the Kemena–Tatau basin catchment to the outside world, where new commodity chains are emerging. The case studies concentrate on products such as birds' nests, rattan, bezoar stones and timber and oil palm, and conclude with an overview of the changing patterns of Sarawak exports over a period of nearly a century and a half (Chaps. 18, 19, 20, 21, 22, 23, 24, 25, 26, and 27).

References

Bevis, William W. 1995. *Borneo log: The struggle for Sarawak's forests*. Seattle: University of Washington Press.

Borneo Post. 2012. Research helps to improve well-being of local people—Professor. http://www.theborneopost.com/2012/06/30/research-helps-to-improve-well-being-of-local-people-professor/. Accessed 29 Mar 2018.

Bulan, Ramy, with Amy Locklear. 2009. *Legal perspective on native customary land rights in Sarawak*. Kuala Lumpur: Suruhanjaya Hak Asasi Manusia.

Cramb, R.A., and J. Dian. 1979. *A social and economic survey of the Bintulu extension region—Report no. 8*. Kuching: Planning Division, Department of Agriculture, Sarawak.

Cramb, Rob, and John F. McCarthy. 2016. Characterising oil palm production in Indonesia and Malaysia. In *The oil palm complex: Smallholders, agribusiness and the state in Indonesia and Malaysia*, ed. Rob Cramb and John F. McCarthy, 27–77. Singapore: NUS Press.

Edwards, David P., Ainhoa Magrach, Paul Woodcock, Yinqiu Ji, Norman T.-L. Lim, Felicity A. Edwards, Trond H. Larsen, Wayne W. Hsu, Suzan Benedick, Chey Vun Khen, Arthur Y.C. Chung, Glen Reynolds, Brendan Fisher, William F. Laurence, David S. Wilcove, Keith C. Hamer, and Douglas W. Yu. 2014. Selective-logging and oil palm: Multitaxon impacts, biodiversity indicators, and trade-offs for conservation planning. *Ecological Applications* 24 (8): 2029–2049.

Fitzherbert, Emily B., Matthew J. Struebig, Alexandra Morel, Finn Danielsen, Carsten A. Brühl, Paul F. Donald, and Ben Phalan. 2008. How will oil palm expansion affect biodiversity? *Trends in Ecology and Evolution* 23 (10): 528–545.

Fong, Hon Kah. 1996. *A history of the development of Rajang basin in Sarawak*. Sibu: Dewan Suarah.

Haraway, Donna, Noboru Ishikawa, Scott F. Gilbert, Kenneth Olwig, Anna L. Tsing, and Nils Bubant. 2016. Anthropologists are talking—About the Anthropocene. *Ethnos* 81 (3): 535–564.

Harvey, David. 2003. *The new imperialism*. Oxford: Oxford University Press.

Ishikawa, Noboru. 2010. *Between frontiers: Nation and identity in a Southeast Asian borderland*. Singapore: NUS Press.

———, ed. 2011. *Flows and movements in Southeast Asia: New approaches to transnationalism*. Kyoto: Kyoto University Press.

Ishikawa, Noboru, Ryoji Soda, and Hiromitsu Samejima. 2013. The complex system of tropical biomass society: Nature's time and human time. In *Chikyuken seimeiken no senzairyoku: nettaichiikishakai no seizonkiban* [Potential of the geosphere and biosphere: Sustainable foundations for the tropical region], ed. Masayuki Yanagisawa, Yasuyuki Kono, Osamu Kozan, and Mamoru Kanzaki, 283–315. Kyoto: Kyoto University Press

King, Victor T. 1996. Environmental change in Malaysian Borneo: Fire, drought and rain. In *Environmental change in South-East Asia: People, politics and sustainable development*, ed. Michael J.G. Parnwell and Raymond L. Bryant, 165–189. London: Routledge.

Langub, Jayl, and Noboru Ishikawa. 2017. Community, river and basin: Watersheds in northern Sarawak as a social linkage. In *Borneo studies in history, society and culture*, ed. Victor T. King, Zawawi Ibrahim, and Noor Hasharina Hassan, 365–384. Singapore: Springer.

Mintz, Sidney W. 1959. The plantation as a socio-cultural type. In *Plantation systems of the New World*, ed. Research Institute for the Study of Man and Pan American Union, 42–50. Washington, DC: Pan American Union.

Mizuno, Kosuke, Motoko S. Fujita, and Shuichi Kawai, eds. 2016. *Catastrophe and regeneration in Indonesia's peatlands: Ecology, economy and society*. Singapore: NUS Press.

Morrison, Philip S. 1993. Transitions in rural Sarawak: Off-farm employment in the Kemena basin. *Pacific Viewpoint* 34 (1): 45–68.

Okamoto, Masaaki, and Hideki Hayashida. 2018. Aburayashi nōen kakudai no seiji keizaigaku: akutā, gensetsu, seido no shiten kara [The political economy of oil palm expansion: Actors, narratives and institutions]. *Tounanaja Kenkyu* [Journal of Southeast Asian Studies] 55 (2): 169–399.

Owen, Donald A. 1909. *Sarawak Gazette*, 1 April.

Parnwell, Michael J.G., and David M. Taylor. 1996. Environmental degradation, non-timber forest products and Iban communities in Sarawak: Impact, response and future prospects. In *Environmental change in South-East Asia: People, politics and sustainable development*, ed. Michael J.G. Parnwell and Raymond L. Bryant, 269–300. London: Routledge.

Pye, Oliver, and Jayati Bhattacharya, eds. 2013. *The palm oil controversy in Southeast Asia: A transnational perspective*. Singapore: Institute of Southeast Asian Studies.

Raes, Niels, Saw Leng Guan, Peter C. van Welzen, and Tetsukazu Yahara. 2013. Legume diversity as indicator for botanical diversity on Sundaland, South East Asia. *South African Journal of Botany* 89: 265–272.

Sahlins, Marshall. 1968. Notes on the original affluent society. In *Man the hunter*, ed. Richard B. Lee and Irven Devore, 85–89. New York: Aldine.

Scott, James C. 1998. *Seeing like a state: How certain schemes to improve the human condition have failed*. New Haven: Yale University Press.

Soda, Ryoji. 2007. *People on the move: Rural–urban interactions in Sarawak*. Kyoto/Melbourne: Kyoto University Press/Trans Pacific Press.

———. 2017. Culture and acceptance of disasters: Supernatural factors as an explanation of riverbank erosion. *Ngingit* 9: 18–24.

Soda, Ryoji, Yumi Kato, and Jason Hon. 2015. The diversity of small-scale oil palm cultivation in Sarawak, Malaysia. *The Geographical Journal* 182 (4): 353–363.

Steward, Julian H., and [and others]. 1956. *The people of Puerto Rico: A study in social anthropology*. Urbana: University of Illinois Press.

Swanson, Heather Anne, Nils Bubandt, and Anna Tsing. 2015. Less than one but more than many: Anthropocene as science fiction and scholarship-in-the-making. *Environment and Society: Advances in Research* 6 (1): 149–166.

Takeuchi, Yayoi, and Masaki Kobayashi. 2016. Combining field and molecular approaches to understand the regeneration processes of tropical tree species. In *Proceedings of the symposium 'Frontier in tropical forest research: Progress in joint projects between the Forest Department Sarawak and the Japan Research Consortium for Tropical Forests in Sarawak'*, 38–45. Kuching: Forest Department Sarawak and Kyoto, Japan Research Consortium for Tropical Forests in Sarawak.

Takeuchi, Yayoi, Ryoji Soda, Bibian Diway, Tinjan ak Kuda, Michiko Nakagawa, Hidetoshi Nagamasu, and Tohru Nakashizuka. 2017. Biodiversity conservation values of fragmented communally reserved forests, managed by indigenous people, in a human modified landscape in Borneo. *PLoS One* 12 (11): e0187273.

Taylor, D.M., D. Hortin, M.J.G. Parnwell, and T.K. Marsden. 1994. The degradation of rainforests in Sarawak, East Malaysia, and its implications for future management policies. *Geoforum* 25 (3): 351–369.

Tsing, Anna Lowenhaupt. 2005. *Friction: An ethnography of global connection*. Princeton: Princeton University Press.

———. 2012. On nonscalability: The living world is not amenable to precision-nested scales. *Common Knowledge* 18 (3): 505–524.

———. 2015. *The mushroom at the end of the world: On the possibility of life in capitalist ruins*. Princeton: Princeton University Press.

Wolf, Eric R. 2001. Specific aspects of plantation systems in the new world. In *Pathways of power: Building an anthropology of the modern world*, ed. Eric R. Wolf with Sydel Silverman, 215–229. Berkeley: University of California Press.

Part I
Landscape, Culture and History

Chapter 2
Geomorphological Landscapes of Borneo and Riverine Society of the Kemena Catchment, Sarawak

Kuniyasu Mokudai, Ryoji Soda, and Takuma Watakabe

Abstract Borneo, the world's third largest island, was formed by the collision of several tectonic plates and is located on the southernmost edge of the Eurasian Plate. As a result, its broader geological structure often runs parallel to the plate boundaries. The landforms of the mountains and the channel patterns of the rivers are heavily influenced by this geological structure. Most of northwestern Borneo consists of well-weathered mudstone bedrock. Hardly any gravel exists in the beds of many large rivers. The uplift rate of the mountains is fast but the terrain is heavily influenced by weathering. As erosion by the rivers is weak, the terrain around the rivers does not change drastically over time. Moreover, the ecosystem based on the terrain alongside the river channels is highly homogeneous and the spatial diversity of the terrain and geological features is low. The landscape in this region was not considered a restricting factor for people when they were selecting areas to reside given that the geomorphological environment is fairly homogeneous from a spatio-temporal point of view. This fact may support the high mobility of Borneo's indigenous people.

Keywords Geomorphology · Sarawak · Geoecological systems · Rivers · Erosion · Riverine society

K. Mokudai (✉)
Department of Regional Design, Tohoku Gakuin University, Miyagi, Japan
e-mail: mokudai@mail.tohoku-gakuin.ac.jp

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

T. Watakabe
Kyoto University, Kyoto, Japan

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_2

2.1 Introduction

In humid tropical regions, environmental factors, such as geology, geomorphology, soil, vegetation, climate and hydrology, are more closely related to each other than in other regions, and unique geoecological systems are created. Rivers occupy the centre of these geoecological systems. Although there are mild climatic changes in Sarawak, such as rainy and dry seasons, precipitation is generally high throughout the year, resulting in the formation of large rivers. Rivers like these influence the landscape of the region and also have a strong impact on the resulting manifestations of civilisation, such as human settlements and the course of roads.

The geomorphological research conducted in tropical regions thus far has mainly investigated the material transport processes and speed of weathering of bedrock in environments of high temperature and high humidity (Faniran and Jeje 1983; Thomas 1994; Reading et al. 1995). Rivers in particular are major conduits for mass transfer and play an important role in earth science processes. Geomorphological research into these rivers often focuses on the study of the sedimentary environments of plains (Hori et al. 2006). However, in areas where rivers flow and erode the substrates of mountainous or hilly areas, it is clear that the formation of the river channel is heavily controlled by the substrate structure and for this reason there are a few geomorphological studies conducted in these environments.

When considering the geoecological systems of these areas, including human elements, it is essential not only to understand the earth science background of the river but also to recognise its movement on a spatiotemporal scale and how this has affected the lifestyle of the area's inhabitants. This chapter explains the earth science background, which is essential for understanding the rivers of Sarawak, and outlines the impact that the characteristics of the region's rivers have on the lifestyle of its inhabitants.

2.2 Regional Tectonic and Geological Setting of Borneo

Borneo covers an area of approximately 740,000 km^2 and is located at the southernmost part of the Eurasian Plate, with Sumatra to the west, Java to the south and Sulawesi to the east (Fig. 2.1). The Indo-Australian Plate is located to the south and the Philippine Plate is located to the east of the Eurasian Plate. The boundary between the Eurasian Plate and the Indo-Australian Plate is the Java Trench, located south of Sumatra and Java. Heading toward this, the Indo-Australian Plate is moving north at approximately 6 cm a year, sinking in the trench area (Currie and Hyndman 2006). The Philippine Trench, located offshore to the east of the Philippines, is the southwestern edge of the Philippine Plate.

From the southern part of Borneo to Sulawesi, rock fragments from the Gondwana supercontinent are present (Wakita 2000, 2002). Although the scale of the fragments is smaller than that in the Indian subcontinent, small-scale fragments broke

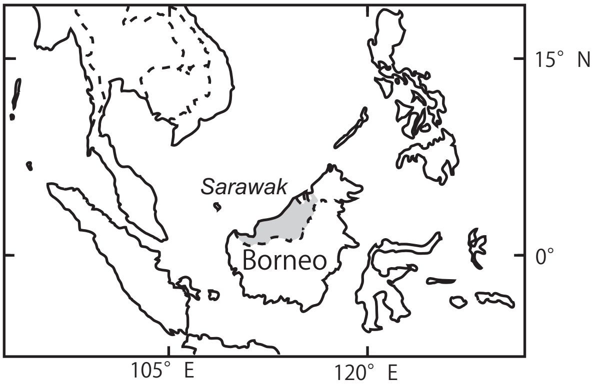


Fig. 2.1 Borneo

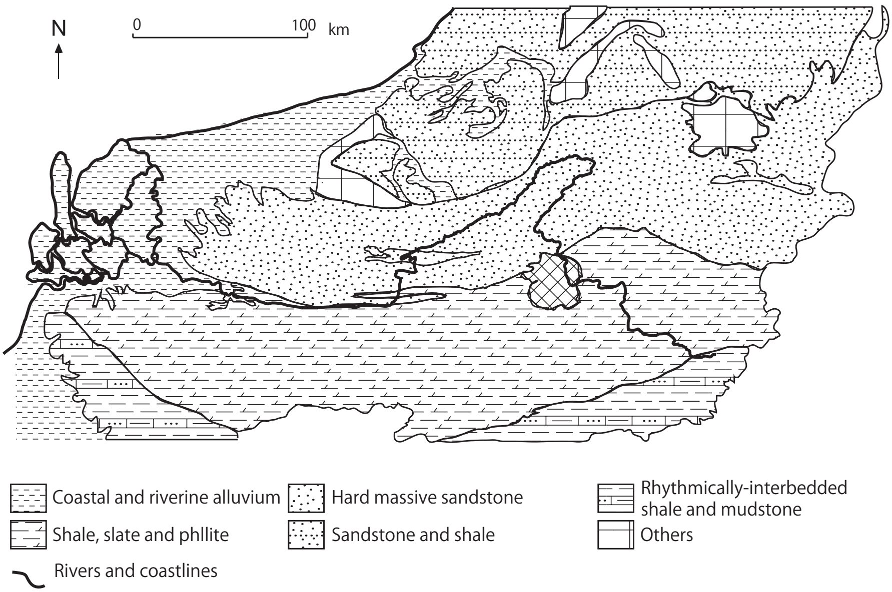


Fig. 2.2 Geological features of central Sarawak
Source: Geological Survey of Malaysia (1992)

away from the Gondwana supercontinent in the same way and collided with the Eurasian Plate. The various layers that accumulated at the bottom of the ocean (lava from erupted submarine volcanoes, limestone formed from calcium carbonate-rich material, chert formed from the remains of plankton, and sandstone/mudstone made of sand and mud from submarine flow) sank into the marine trench with the movement of the plate, producing a rock known as an accretionary complex. These fragments of continents and the accretionary complex are the two main types of geological features dominating both Borneo and the surrounding islands (Fig. 2.2).

Another geological feature in this region are volcanic rocks. Borneo is part of the circum-Pacific volcanic belt known as the Ring of Fire. During the subduction of tectonic plates, rocks sink down and melt to form magma. Because magma has a lower density than the surrounding rocks, it is relatively light and rises toward the Earth's surface. When the magma reaches the surface it becomes a volcano. Such a process is generally seen in subduction zones, and the area from Indonesia to the Philippines is dotted with active volcanoes. Even in Sarawak, traces of previously active volcanoes can be found in the form of volcanic rocks.

The stratigraphy of Borneo was established by the collision and subduction of the aforementioned minute fragments of continents and it also experiences regional tectonic stress. As a result, the broader geological structure often becomes parallel with the boundaries of tectonic plates, heavily influencing landforms such as mountains and river channels.

2.3 Natural Setting of Borneo

2.3.1 Geology and Geomorphology

As noted, the sandstone and mudstone of the accretionary complex is found in the area northwest of the Iran Mountains along the main mountain ridges of Borneo. An alternation of layers of sandstone and mudstone known as the Rejang stratum or the Rajang Group is a geological feature of this region (Fig. 2.3). It is considered a turbidite, a submarine mudflow deposit, from the Paleogene period (Palaeocene to

Fig. 2.3 Alternating layers of sandstones and mudstones in a river bank. (Photograph: Kuniyasu Mokudai 2014)

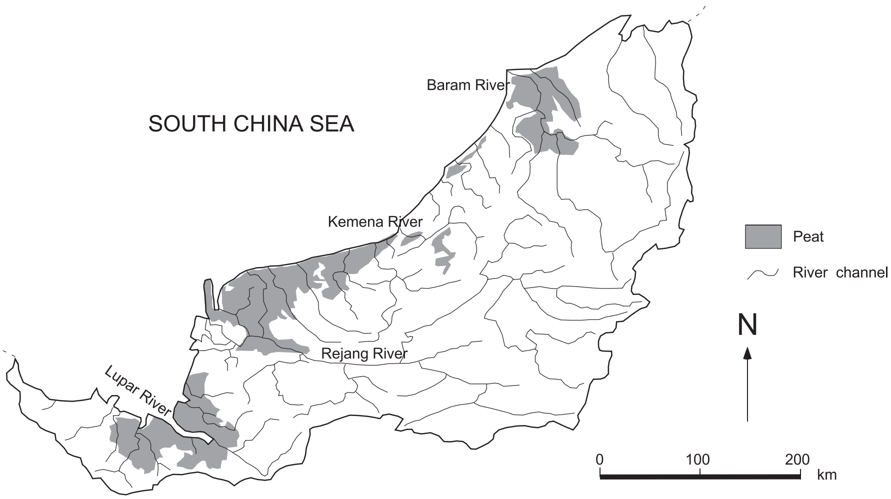


Fig. 2.4 Peat bed topography of Sarawak
Note: Distribution area of peat bed is after Staub et al. (2000)

middle Eocene) (Hutchison 1996, 2005; Honza et al. 2000).[1] Apart from the Quaternary alluvial plane, in which sedimentation is currently ongoing, these strata are the youngest in Borneo.[2] Compared with other strata found in mountainous areas, these layers are softer, more easily weathered and more susceptible to erosion. The coastline from Tanjung Batu, near Bintulu, to the island of Belawai at the mouth of the Rejang River is largely retreating inland, particularly in the vicinity of the mouth of the Lupar River, due to the susceptibility of the Rejang stratum to erosion.

In the central part of Borneo, the main ridge of the Iran Mountains extends from the northeast toward the southwest and forms part of the Malaysian border with Indonesia. Splitting from the Iran Mountains, the Kapuas range and Klingkang range extend from west to east. The area that is surrounded by the Iran Mountains, the Kapuas Mountains, and the northwest shore of Borneo is Sarawak, and the Rejang, Baram and Kemena rivers flow through it (Fig. 2.4). Mount Kinabalu in Sabah is the highest summit in Borneo at 4095 m, and is located at the northeastern part of the Iran Mountains. However, the elevation in most mountainous areas is approximately 2000 m and there are a few mountains with an elevation of 1000 m or more.

The rivers that run through Sarawak flow into the South China Sea. Most of the sea that surrounds western Borneo rests on a continental shelf known as the Sunda Shelf, with water depths of approximately 200 m. The depth of water on this conti-

---

[1] Turbidite is a type of marine sediment, referring to the sediments of turbidity current. It is characterised by alternating layers of sandstone and mudstone. The Palaeogene period took place 23–66 million years ago.

[2] The Quaternary period began 2.58 million years ago.

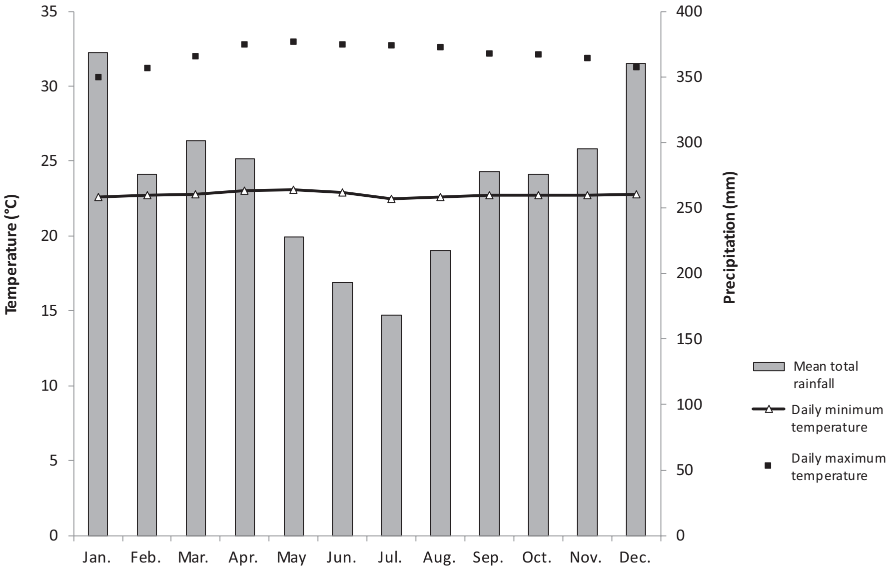


Fig. 2.5 Climate of Sarawak

nental shelf is somewhat consistent with a sea level that decreased during glacial periods. During glacial periods, a huge area of land surrounding today's Borneo emerged out of the sea and is considered to have become connected with the Indochina Peninsula. Throughout the Holocene period, sediments have accumulated in the lowlands around the mouth of the Rejang, leading to an accumulation of peat beds that are 1 m thick or more (Staub et al. 2000; Gastaldo 2010).[3]

2.3.2 *Climate*

Along with the other regions around the equator, Sarawak is covered by an equatorial air mass throughout the year, and thus levels of both precipitation and air temperature are high. Close to the coast in Sibu, annual precipitation is 3500 mm. Rainfall persists throughout the year and rainfall is particularly high in December and January, with a monthly precipitation of over 300 mm. From June to August, there is relatively little precipitation. As a result, there is a large seasonal variation in the flow rate of the rivers. The average temperature is above 30 °C (Fig. 2.5).

[3] The Holocene period began 11,700 years ago and includes the present.

2.4 Geographical Setting of Sarawak's Mountain Areas

The degree of uplift over a wide area of Sarawak has not been estimated and the stratigraphic record of river and marine terraces is insufficient to provide an accurate analysis of uplift. However, from the geological evidence of the volume of sediments accumulated around Borneo, it is estimated that the crust was eroded at least 6 km in thickness for approximately 20 million years of the Neogene period (Hall and Nichols 2002).[4] For Mount Kinabalu, the uplift rate estimated from the age of granite is calculated to be 7 mmy^{-1} (Cottam et al. 2013). In the mountainous areas of the Japanese islands, which are in a subduction zone, the average uplift rate in the central parts of the mountains is estimated to be 5–7 mmy^{-1} (Ohmori 1987), while the erosion rate is estimated at approximately 5 mmy^{-1}. Because the tectonic settings of Borneo and Japan are similar, it is reasonable to assume that the volume of uplift in both places is of a similar value. Furthermore, Alan Dykes (2002) proposes that the ridges in the mountainous area of Brunei have a similar summit height to those in Sarawak and experience the same moderate uplift.

This mountainous area is assumed to have started uplifting as it entered the Quaternary period and an uplift of 400 m is calculated to have occurred in approximately 2 million years. Using this information, the uplift rate is approximately 0.2 mmy^{-1}. Compared with the estimation of uplift rate in the granite mountain areas mentioned above, this estimation is one order of magnitude smaller. This is considered to be a result of the active weathering and denudation of the bedrock in the region. If the uplift rate is calculated based on data of the current topography, the values obtained would be an underestimation of the true values.

This region is one of high temperatures and high humidity with active weathering and denudation of bedrock. In particular, the terrain in the upper and middle areas of the basin is considered to be heavily influenced by weathering of the bedrock (Thomas 1994). Because of the high temperatures and high humidity, the weathering of this bedrock is fast and the creation of silt and clay from this weathering is also rapid (Fookes 1990). However, when the slopes in this location are actually observed, the bedrock is seen to undergo weathering when the B soil layer (subsoil) is thick and the O (organic matter) and A soil (topsoil) layers are very thin (Fig. 2.6). The reason for this is the high amount of precipitation throughout the year, leading to active erosion and mass movement on the slope, which in turn do not allow soil mass to remain on the slope. Since there is a high volume of precipitation and a high river flow rate, there is active erosion by the rivers. On slopes along the river banks, there are occurrences of slope failure in many places (Watakabe et al. 2012) and there are also many occurrences of landslides in the mountainous areas (Dykes 2002).

Borneo, which has a similar uplift rate to that of the Japanese islands but has more surface area, has an average elevation of 2000 m in mountainous regions. As Robert Hall and Gary Nichols (2002) note, this is because of the high rate of

[4] The Neogene period took place 23–2.58 million years ago.

Fig. 2.6 Structure of soil stratum in Tubau. (Photograph: Kuniyasu Mokudai 2013)

denudation. In Sarawak in particular, bedrocks are mostly soft mudstone and sandstone known as the Rejang stratum. These bedrocks are weathered quickly due to the high temperatures and high humidity. As a result, the denudation of slopes in the mountain areas is considered to occur at a faster rate than that of the uplift.

2.5 Geographical Setting of Rivers in Sarawak

2.5.1 The Role of Rivers in the Denudation Process of Humid Tropical Areas

The main river channels that run through Sarawak's mountainous and hilly areas are constrained by the strike direction of strata. In the downstream part of the rivers, the channels flowing parallel to the strike of strata reflect the geological structure, creating a series of linear river channels spanning a distance of several kilometres. In contrast, when the channels flow perpendicular to the strike of strata, channels

Fig. 2.7 Dredger for collection of sand from a river bed. (Photograph: Kuniyasu Mokudai 2013)

meander for an order of several hundred metres. In the upstream part of the rivers, channels meander between several tens and several hundreds of metres, even when the channel flows parallel to the strike of the strata.

In humid tropical areas, without the destabilisation of slopes by river erosion, the weathering of the bedrock making up the slopes is rapid and denudation occurs regardless of the erosion caused by the river. In such circumstances, slopes in mountainous areas are restricted by geological structures, creating a ridge and valley arrangement with rivers running through these valleys.

As already noted, sand, silt, clay and soil mixed with organic matter flow into the rivers at a comparatively fast rate. For example, because the sand at the bottom of the Rejang River has been dredged frequently over several decades, we know that sand accumulates on the river bed (Fig. 2.7). On the other hand, silt and clay, which move downstream in the form of suspended or dissolved loads, accumulate as sediments in the lowlands alongside rivers at times of flooding, eventually accumulating in the shallow sea from the downstream plains (Fig. 2.8).[5]

As discussed above, the well-weathered mudstone undergoes intense weathering due to the humid tropical environment. This is eliminated by running water and mass movement, thus creating the landform of this region comprising gentle ridges and valleys.

[5] Suspended loads are small sediment particles flowing in rivers such as sands and silt. Dissolved loads are dissolved rock residue that is transported downstream in the form of ions.

Fig. 2.8 Flood plain deposits of the Rejang River. (Photograph: Kuniyasu Mokudai 2010)

2.5.2 Characteristics of River Terrain

The terrain of the Bintulu area is mostly mudstone and sandstone. Mudstone is easily weathered, collapses and flows into the rivers. Weathering progresses rapidly with the downward flow process and the mudstone then flows as mud, without remaining as gravel. Some gravel originating from the sandstone layers of this area does exist in the region, although not in large quantities. Furthermore, volcanic rocks that are scattered in many areas remain as gravel, unlike the mudstone and sandstone. As such, although uplift is intense and collapse in mountainous areas frequent, most of the geological formations do not easily turn into gravel, so only a small amount of gravel can be found in the rivers. Because there is so little gravel, there are hardly any gravel bars or sand bars along the river channels (Fig. 2.9).

The accumulation of gravel and sand in the river channels leads to an imbalance in the flow speed, creating a large meander. A large quantity of matter is transported by dissolved and suspended loads with little or no gravel remaining. Thus meanders and bars hardly develop, even though there is an enormous amount of erosion. When gravel flows through rivers it erodes the bedrock to carve the river's course. However, given the relative absence of gravel, the erosive power of the rivers, particularly lateral erosive power, is weak.[6] Consequently, wide areas are not formed along river channels. The channels are formed under the restriction of the geological features and there are lowlands along the river channels without much depth. In

[6] Lateral erosive power is erosion that widens the river.

Fig. 2.9 Absence of gravel bars or sand bars along the river channels. (Photograph: Kuniyasu Mokudai 2013)

these lowland areas, flood plain deposits are the dominant sedimentary structures found on the weathering substrate.

2.5.3 Hydraulics of Rivers in Sarawak and Their Use

In the middle and lower reaches of the Rejang and Kemena rivers, the flow speed (surface velocity) is approximately 1.0–2.0 m/second. The elevation of the Kemena River is approximately 10 m at Tubau, 10 km from the river's mouth, and the average gradient is approximately 1:10,000 from this point to the mouth of the river. However, even with such a gentle gradient the flow rate is high. This is because the flow volume is high and the bedrock erodes easily. As a result, the roughness of the river bed is not pronounced, leading to little friction preventing water flow.

There is a large difference in the water level of this river, depending on whether it is the rainy season or the dry season (Fig. 2.10). During the rainy season, when the flow volume increases and the water level rises, the flow rate of the river increases, which also intensifies the carrying power. In contrast, when the water level is lower in the dry season, the flow rate and carrying power both decrease. As sediment bars can appear on the banks, trees and other debris are easily caught on river banks and river beds, slowing the river flow.

Riverside deforestation has also taken place using this change in flow rate (Soda et al. Chap. 15; Kato and Soda Chap. 16). Just before the water level rises in the rainy season (from October to December), riverside trees are chopped down and when flooding occurs floating logs are turned into rafts. These log rafts are pulled

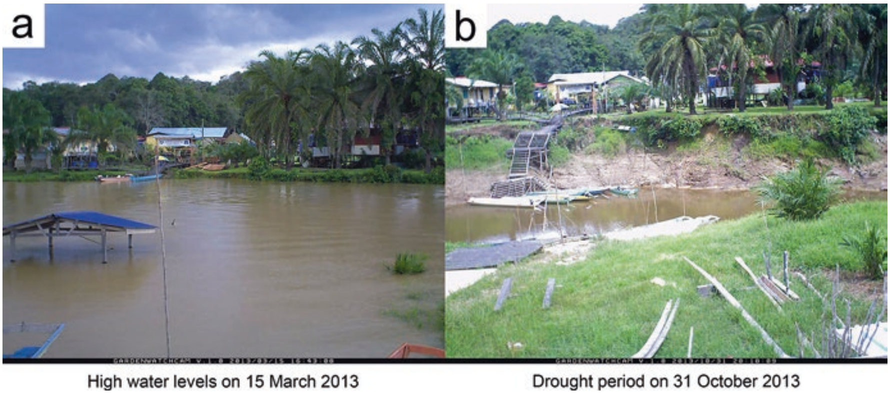


Fig. 2.10 Differences in the Kemena River at (**a**) high water levels and (**b**) drought. (Photographs: Kuniyasu Mokudai and Ryoji Soda 2013)

downstream using a boat and sold to middlemen and timber traders. In this manner, local people have built communities along these rivers and earned a livelihood. Those who routinely use small boats due to the lack of roads pay close attention to water level changes during their everyday navigation and are well attuned to the changes in the river water levels.

2.6 Geomorphological Setting of the Kemena River and the Formation of Riverine Society

2.6.1 Kemena River Terrain

The Jelalong, Tubau, Pandan and Sebauh rivers merge into the Kemena River as it flows to Bintulu. The length of the main channel is approximately 200 km. The mouth of the Kemena River is several hundred kilometres away from the mouths of the rivers in the adjoining basin. Because the mouth of the river is not an area of subsidence, multiple rivers do not converge here. As the basin area is not that large, a large-scale delta does not form around the river mouth. This is in a contrast with the Rejang River, the longest river in Malaysia, where there is a delta zone with elevations at sea level stretching for over 100 km from the river mouth toward Sibu, with a wide distribution of peat bogs.

Here we observe the characteristics of the Kemena River, starting from the downstream area (Fig. 2.11).[7] The lowlands along the river around its mouth are narrow. The town of Bintulu and the surrounding settlements stretch from the low-

[7] The distances expressed here refer to the distance from the river mouth, unless otherwise specified.

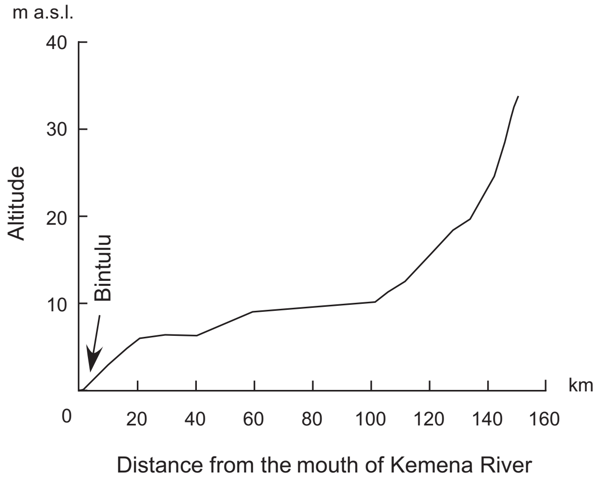


Fig. 2.11 Longitudinal profile of the Kemena river bed

lying coastal area to plateaus with elevations of several tens of metres, made up from the surrounding bedrock. Up to approximately 20 km upstream from the river's mouth, the river flows through a relatively flat area, diagonal to the strike of the strata. In this section, the elevation of the river increases, reaching 5 m at approximately 20 km upstream.

Further upstream to 65 km, most of the flow is parallel to the strike of the strata, while one part is perpendicular. The gradient of this section is gentler than that around the river mouth. This section flows perpendicular to the strike of the geology from the 65 km point to Tubau. Here it continues to meander for several hundred metres. Tubau is approximately 100 km from the river mouth. The river bed gradient of the downstream side from the convergence point with the Tubau River is very gentle at 1:10,000, but upstream from the convergence point, the gradient becomes approximately 1:1000. In general, the river's channel follows along the strike of the strata, though meanders develop over several hundred metres.

In the channel further upstream from Tubau, there are cliffs of weathered mudstone in the undercut slopes (outside) of the meanders. On the slope slip face (inside of the meanders) on the opposite shore, an accumulation of mud and plant residue can be seen. At meander points where the direction of the channel changes significantly, there are tall protrusions and hills that reach higher than their surroundings (Fig. 2.12). These are assumed to be bedrock that is relatively harder than the surrounding rocks. When a river channel that had weak lateral erosive power and a small quantity of gravel meets a location like this the river channel bends and continues to flow because it cannot erode them. The location of these protrusions (hills) has not changed over a long time and, despite its large meanders, the channels of the Jelalong River are not considered to have changed very much.

The people who live in the basin have a lot of knowledge about this type of geomorphological setting, and when specifying a certain location they often use the

Fig. 2.12 Protruding hill along a river bend. (Photograph: Kuniyasu Mokudai 2015)

expression ‘after meandering X amount of times from such-and-such a place’. They also give names to the small tributaries that are easily crossed on foot. The way of linking the name to the conditions of the terrain (place-naming method) is an important element in ease of communication between the people of the basin.

2.6.2 Characteristics of the River Terrain and Formation of Riverine Society

The course of the Kemena River runs through alternate layers of sandstone and mudstone. Although the channel of this river mainly flows parallel to the strike of the strata, it meanders occasionally to avoid the outcrops of hard geological features. As such, it is the geological and climatic conditions that determine the form that the river channel takes. These conditions are homogeneous in the basin as a whole. Geoecological systems centred on the river may have variations arising from differences in geomorphological conditions such as river bed gradients. However, differences regulated by finer conditions than this are currently not found. Even upstream, the elevation of the mountainous zones is only approximately 2000 m, and the geomorphic settings do not vary significantly. In the basin, variations in the environment are not drastic, making for a relatively homogeneous geoecological system.

The lack of significant changes in the geomorphology of the river channels and terrain means that the environment for people living alongside rivers in the basin has not changed in a long time. Considering that the local infrastructure in the Kemena basin is largely based on the geomorphological settings, it can be said that an environment was maintained with little change in both space and time.

Environmental variations are not noticeable in other locations along the Kemena and there is little change in morphological settings. This means that for the people living in this region of Sarawak there are similar geomorphological settings wherever they go. It is possible to live anywhere without any major changes to their fundamental style of living. In contrast, there is a variety of geological features in Japan with a drastic change in gradient from mountainous areas to the sea. In locations that have significant variations in geomorphology and ecosystems, there are significant differences in terms of flood control, land use and lifestyle even within the same basin. In such environments, the skills necessary for everyday life tend to become specialised for each location. Since it takes time and effort to acquire these skills, groups living in each area tend to stay where they are due to the burden of moving.

In Sarawak, the natural environment is the basis of the livelihood of local communities and the uniformity of this landscape in both space and time does not present a physical barrier for people to move. Furthermore, given that the elevation of mountainous areas in the region is not that high, it is likely that crossing the basin on foot was relatively easy. The mobility of Borneo's indigenous people has often been discussed, and though there are ecological factors such as the support of biomass in tropical rainforests, geomorphological and geological factors also led to an environment that made travelling straightforward.

2.7 Conclusion

In most of Sarawak, including the Kemena River and its surrounding areas, the mudstone that makes up the bedrock is well weathered and there is hardly any gravel in the rivers. The uplift rate in mountainous areas is rapid and the terrain is heavily impacted by weathering. As the lateral erosion of the rivers is weak, the terrain around the rivers does not change drastically over time though there are extremely weak changes that happen continuously. The geoecological system based on the geomorphology along the rivers is mostly homogeneous. This type of geomorphological setting, which is relatively homogeneous in time and space, is not considered to be a limiting factor for the people living in the region when choosing an area for settlement.

References

Cottam, Michael A., Robert Hall, C. Sperber, Barry P. Kohn, Marie Anne Forster, and Geoffrey E. Batt. 2013. Neogene rock uplift and erosion in northern Borneo: Evidence from the Kinabalu granite, Mount Kinabalu. *Journal of the Geological Society* 170 (5): 805–816.

Currie, Claire A., and Roy D. Hyndman. 2006. The thermal structure of subduction zone back arcs. *Journal of Geophysical Research Solid Earth* 111 (B8).

Dykes, Alan P. 2002. The role of bedrock failures driven by uplift in long-term landform development in Brunei, Northwest Borneo. *Transactions of the Japanese Geomorphological Union* 23 (2): 201–222.

Faniran, Adetoye, and L.K. Jeje. 1983. *Humid tropical geomorphology: A study of the geomorphological processes and landforms in warm humid climates*. London: Longman.

Fookes, P.G., ed. 1990. Tropical residual soils geological society engineering group working party report. *Quarterly Journal of Engineering Geology* 23: 4–101.

Gastaldo, Robert A. 2010. Peat or no peat: Why do the Rajang and Mahakam deltas differ? *International Journal of Coal Geology* 83 (2/3): 162–172.

Geological Survey of Malaysia. 1992. *Geological map of Sarawak*. Kuala Lumpur: Geological Survey of Malaysia.

Hall, Robert, and Gary Nichols. 2002. Cenozoic sedimentation and tectonics in Borneo: Climatic influences on orogenesis. *Geological Society, London, Special Publications* 191 (1): 5–22.

Honza, Eiichi, J. John, and Richard Mani Banda. 2000. An imbrication model for the Rajang Accretionary Complex in Sarawak, Borneo. *Journal of Asian Earth Sciences* 18 (6): 751–759.

Hori, Kazuaki, Yoshiki Saito, and Susumu Tanabe. 2006. Chuseki-so' in the coastal plains of large Asian rivers. *Memoirs of the Geological Society of Japan* 59: 157–168.

Hutchison, Charles S. 1996. The 'Rajang accretionary prism' and 'Lupar Line' problem of Borneo. *Geological Society, London, Special Publications* 106: 247–261.

———. 2005. *Geology of North-West Borneo: Sarawak, Brunei and Sabah*. Amsterdam: Elsevier.

Ohmori, Hiroo. 1987. Mean quaternary uplift rates in the central Japanese mountains estimated by means of geomorphological analysis. *Bulletin of the Department of Geography, University of Tokyo* 19: 29–36.

Reading, Alison J., Russell D. Thompson, and Andrew C. Millington. 1995. *Humid tropical environments*. Oxford: Blackwell.

Staub, James R., H.L. Among, and Robert A. Gastaldo. 2000. Seasonal sediment transport and deposition in the Rajang River delta, Sarawak, East Malaysia. *Sedimentary Geology* 133 (3/4): 249–264.

Thomas, Michael F. 1994. *Geomorphology in the tropics: A study of weathering and denudation in low latitudes*. Chichester: Wiley.

Wakita, Koji. 2000. Cretaceous accretionary–collision complexes in central Indonesia. *Journal of Asian Earth Sciences* 18 (6): 739–749.

———. 2002. Majime na Indonesia no chisitsu—Indonesia hakuaki fukatai kikou soushuhen [Collision and accretion tectonics in Indonesia: A geological trip of Cretaceous accretionary complex in Indonesia]. *Chisitsu Nyusu* [Chishitsu News], *Geological Survey of Japan* 579: 24–47.

Watakabe, Takuma, Ryoji Soda, Kuniyasu Mokudai, Hiroshi Ikeda, and Kazuhiro Yuhora. 2012. Bank erosion along the Rajang River and its social impacts. *Equatorial Biomass Society* 6: 1–5.

Chapter 3
Land-Use Types Along the Kemena River–Tubau–Lower Jelalong Region, Sarawak

Jason Hon and Hiromitsu Samejima

Abstract Rapid development in Bintulu has resulted in large-scale changes in land use, especially the conversion of forests into oil palm plantations and industrial tree plantations. Using high-resolution satellite imagery, we analysed land-cover types in the Kemena–Tubau–Lower Jelalong region of Sebauh subdistrict and classified them into nine major land uses. Forest covered most (55.33%) of the 62,133.8 ha project area, followed by swidden agricultural practice (*temuda*) (21.85%), oil palm plantations (15.92%) and industrial tree plantations (1.35%). The large extent of degraded forest implies that logging has been a main economic activity in this region. Areas planted with oil palm have increased, especially along the roads. These results suggest there will be an increase in the areas covered by oil palm plantations in the future and may surpass the extent of land currently covered by *temuda*.

Keywords Sarawak · Land use · Bintulu · Oil palm plantations · Logging · Satellite imagery

3.1 Introduction

The Bintulu Division in the Malaysian state of Sarawak has undergone rapid development in the last decade. The regional development plan for Sarawak, adopted in 2009, gave rise to the establishment of the Sarawak Corridor of Renewable Energy (SCORE), one of the five economic corridors in Malaysia. Ten priority industries have been identified by SCORE, of which two—timber-based and palm oil-based industries—have the highest direct impacts on large land-use changes.

J. Hon (✉)
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_3

The introduction of heavy industries to the region has increased the demand for energy. Consequently, SCORE has proposed the development of hydroelectric dams to cater to this increased demand.

Historically, rubber (*Hevea brasiliensis*) production in Sarawak was the first agricultural activity to have a significant impact on land-use change. Introduced in 1881, rubber was then only planted by smallholders on a larger scale from 1905 and has remained the case until today (Aiken and Leigh 1992). As the price of rubber became less attractive, the timber industry began to take over, with large swaths of virgin forests being exploited. With the introduction of machinery, logging intensified and expanded from the coastal swamps into the interior hills (Wong 1992; Aiken and Leigh 1992). The twenty-first century saw a new form of land development in Sarawak, with land being converted at a very fast pace for the planting of a global oil-producing crop, oil palm (*Elaeis guineensis*). A latecomer among Malaysian states in the development of oil palm plantations, Sarawak has outpaced all other states in terms of expansion rate since 2002, achieving an average annual increment of 10.5% in planted area (Hon and Shibata 2013). The expansion of oil palm plantations has resulted in more land being deforested in Sarawak at an average rate of 0.64% per year (Tsuyuki et al. 2011). The early 2000s also saw the establishment of industrial tree plantations. Among these is the Sarawak planted forest zone, a government initiative covering approximately 480,000 ha that comprises three major types of land uses: 210,000 ha of state land for forest plantation; 110,000 ha of swidden agriculture areas, locally termed *temuda*; and 160,000 ha of fragmented areas for conservation purposes (Sarawak 2009).

The administrative division of Bintulu covers 1.2 million ha in three subdivisions: Bintulu (199,000 ha), Sebauh (523,000 ha) and Tatau (495,000 ha). The Kemena–Tubau–Lower Jelalong region is situated in the Sebauh subdistrict and lies within the secondary corridor of development connected by the existing Bakun road (WAHBA Engineering Consultants and GHD Consultants 2006).

This chapter describes different types of land use, which were analysed on the basis of satellite imagery data and site visits. Such a map can provide insight into the economic activities of this region.

3.2 Methodology

3.2.1 Study Site

The study area follows the Kemena River, using the Bakun road as guidance, stretching from the approximate location of Rumah Joseph almost as far as Rumah Awai, and thereafter along the upper reaches of Kemena River in the Jelalong area up to Rumah Ketil (Sarawak 2009). This area falls under the administrative subdivision of Sebauh in the Bintulu Division. It is accessible by car via the Bintulu–Miri trunk road, heading northward from Bintulu town and turning right at the Bakun road intersection, which is known locally as Simpang Bakun.

3.2.2 Satellite Imagery

High-resolution multispectral and panchromatic satellite images were obtained from DigitalGlobe (http://www.digitalglobe.com). The images were obtained in two batches under delivery orders 052896239040_01 (containing Products 01 and 02) and 052927222010_01 (Product 01) (Appendices 3.1 and 3.2 respectively). In this chapter, these images are referred to by geographical area based on prominent features. Hence, the western portion is referred to as the Tubau image (named after Tubau bazaar) and the eastern portion is referred to as the Jelalong image (named after Jelalong River) (Fig. 3.1). The Tubau image was captured on 5–13 August 2012 and the Jelalong image was captured on 5 August 2012. Multispectral and panchromatic raster data sets, with cell sizes of 2 m and 0.5 m respectively, were obtained.

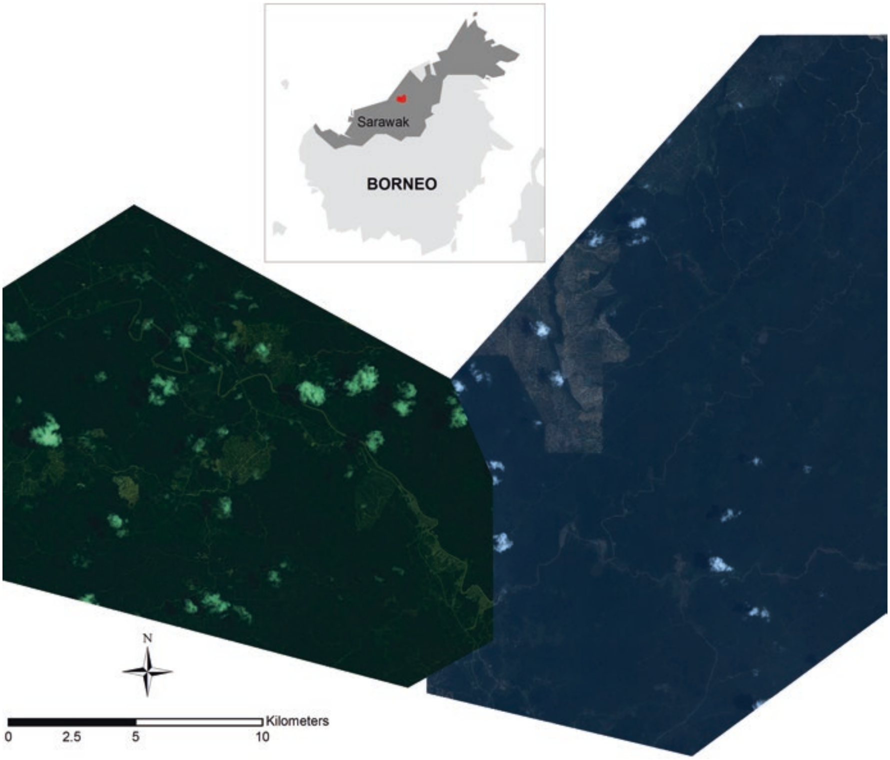


Fig. 3.1 *Upper panel*: map of Sarawak indicating the location of project area; *lower panel*: red-green-blue composite of the Tubau image (west) and the Jelalong image (east). (Image copyright 2013 DigitalGlobe, Inc., Longmont CO USA 80503)

3.2.3 Analysis of Land Use

Analysis of land use was carried out using the software ArcGIS 10.1 ArcGIS (version 10.1; Esri 2012). Data frame properties follow that of raster data sets from DigitalGlobe, which were projected using the WGS 84 / UTM zone 49 N (Transverse Mercator) coordinate system. The multispectral raster data set was combined with the panchromatic raster data set to create a pansharpened red-green-blue raster with the resolution of the panchromatic raster. The raster data was first analysed using the normalised difference vegetation index (NDVI) to segregate vegetated and non-vegetated areas. Expert interpretation, based on visual analysis and ability to discern vegetation types, was used to delineate the boundaries and categorise the different classes of vegetated areas. A detailed classification is given in the following section.

3.2.4 Classification of Land Use

Altogether, nine major categories of land use were identified, which were further classified into subcategories. The rules and criteria for each category are listed. Because of the limitations of the methodology used (visual analysis and interpretation), only a more generalised set of rules is applied, notably for vegetated areas. The land-use classification consists of the following.

1. *Forested areas*
   - Forests: forest areas with tall standing trees and/or closed canopies.
   - Degraded forests: forest areas with uneven canopies, canopy gaps that cover more than 30% of the forest area and/or the presence of old tracks/shrubs.
   - Forest clearings: areas with cleared forests, felled trees, exposed earth and/or canopy gaps with exposed earth, sometimes with the presence of grass and shrubs.
   - Forest clearings for oil palm: cleared forests adjacent to oil palm plantations that are likely to be converted to oil palm plantations.
2. *Oil palm plantations*
   - Mature oil palm plantations: areas with fruiting trees and/or a closed canopy.
   - Young oil palm plantations: areas with non-fruiting oil palm trees, small crowns and/or gaps in the canopy with exposed earth and were planted within the past 3 years.
   - First year *temuda* with oil palm: *temuda* fields that were planted with oil palm within the past year.
   - Plantation terraces: plantation terraces not yet planted with oil palms.
   - Nurseries: nursery areas for oil palm seedlings.
   - *Temuda* (swidden agriculture fields)
   - Old *temuda*: swidden agriculture sites left idle for more than 5 years.
   - Intermediate *temuda*: swidden agriculture sites left idle for between 2 and 5 years, dominated by grass with shrubs present.

- Recent *temuda*: swidden agriculture sites cleared less than 2 years ago, dominated by shrubs or recently planted.
- Bare ground *temuda*: recently cleared forest (done on a small-scale basis) for swidden agriculture activity or for planting of crops by local villagers.

3. *Cash crops*

- Rubber: rubber plantations/farms.
- Orchards: areas comprising tall fruit trees such as durian, mango, jackfruit and other palms that are not oil palm.
- Other cash crops: areas with tapioca or pepper or cultivated farms with other unidentified crops.

4. *Industrial acacia/tree plantations*

- Mature acacia/tree plantations: industrial tree plantations planted mostly with acacia species (other tree species such as *Eucalyptus* spp. may be planted or present).
- Recent acacia/tree plantations or recent clearings: sites either adjacent to existing acacia plantations that are cleared for plantation expansions or have just been recently planted.

5. *Water bodies*

- Major rivers: Kemena River, Tubau River.
- Small rivers: tributaries of major rivers, upstream of major rivers.
- Irrigation: man-made channels for irrigation purposes, usually to drain peat water for oil palm cultivation.
- Ponds and lakes: man-made or natural ponds or lakes, including aquaculture ponds.

6. *Roads*

- Major expressways: Simpang Bakun to Tubau expressway.
- Secondary roads: arterial roads branching from major expressways or connecting major settlements.
- Logging roads: unpaved roads used predominantly for logging activities.
- Plantation roads: unpaved roads inside oil palm plantations.

7. *Man-made structures*

- Buildings: settlements, shops, villages, clinics, schools and any form of buildings.
- Log ponds: collection points for logs.
- Power lines: high voltage power lines.

8. *Keresa plantations: A separate category specifically for Keresa Plantations Sdn Bhd*

- Oil palm plantations managed by the company were also delineated and the planting year for each plot indicated in a separate layer in ArcGIS (see Fig. 3.22 in Appendix 3.3).

- Offices and staff barracks.
- Palm oil mills.
- Oxidation ponds.

9. *Grass and shrubs*

    - Areas with grass or shrubs, either planted or naturally grown after road construction that are found either underneath power lines, or in surrounding settlements and other areas.

Examples of classifications based on satellite images are shown in Appendix 3.3 while the completed map of land uses for the study region is shown in Appendix 3.4.

3.3 Results

The total area covered in this mapping exercise was 62,133.8 ha. Using both raster data sets, 96.84% of the area was successfully classified. The remaining 1.9% was covered by clouds and therefore could not be mapped correctly (see Table 3.1; Fig. 3.2).

Forested areas represented most of the study area, constituting 55.33% of the project area. Of this, good standing forests accounted for 2.59%, whereas the remaining 52.74% was classified as degraded forests or forest clearings.

The second highest coverage was by *temuda*, which represented 21.85% of the project area. Of this, old *temuda* accounted for 17.53% of the project area and was the largest of the *temuda* categories. This was followed by intermediate and recent *temuda*. In total, intermediate and recent *temuda* constituted 3.67% because of the high probability of overlap between these two land-use categories. Recently cleared forest adjacent to *temuda* was likely a *temuda* itself and was therefore classified as bare ground *temuda*, which represented 0.65% of the project area. Within the *temuda* category, recently created *temuda* (less than 2 years old) represented 3.89%, indicating that local people used very little land for swidden agriculture biannually. In terms of area, this accounted for 528.10 ha or 0.85% of the project area. In addition, another 0.11% of the project area consisted of *temuda* that was converted and planted with oil palm, but this figure could be an underestimate as a large portion of young oil palm planted areas could also have been converted from *temuda*.

Oil palm plantations accounted for 15.92% of the project area, the third largest major land-use type. Within this category, mature oil palms covered 9.12% or 5666 ha of the project area, followed by young oil palms which covered 6.36% or 3954 ha of the project area. About 0.32% of the project area was classified as plantation terraces, most likely prepared for future plantations with oil palm. Some overlap was also observed with *temuda* areas that were planted with oil palm, and it cannot be accurately determined where the exact boundaries lie between *temuda* recently converted for oil palm and recently expanded oil palm plantations. The boundaries between some of the larger oil palm plantations operated by companies

Table 3.1 Land-use types in the Kemena–Tubau–Lower Jelalong region study area

Land-use category	Land-use subcategory	Area (ha)	Percentage of project area
Industrial acacia/tree plantations	Mature acacia/tree plantations	590.22	0.95
Industrial acacia/tree plantations	Recent acacia/tree plantations or recent clearings for plantation expansion	245.66	0.40
Temuda	Bare ground *temuda*	404.80	0.65
Temuda	Intermediate *temuda*	1750.72	2.82
Temuda	Old *temuda*	10,893.70	17.53
Temuda	Recent *temuda*	528.10	0.85
Oil palm plantations	First year *temuda* with oil palm	69.13	0.11
Oil palm plantations	Mature oil palm plantations	5665.98	9.12
Oil palm plantations	Young oil palm plantations	3953.61	6.36
Oil palm plantations	Plantation terraces	201.41	0.32
Forests	Forests	1608.45	2.59
Forests	Degraded/recently logged over/recently disturbed forests	32,685.78	52.61
Forests	Forest clearings	84.53	0.14
Log ponds	Log ponds	266.32	0.43
No data	Cloud cover/no data	1219.12	1.96
Others	Others	1966.27	3.16
	Total	62,133.80	100.00

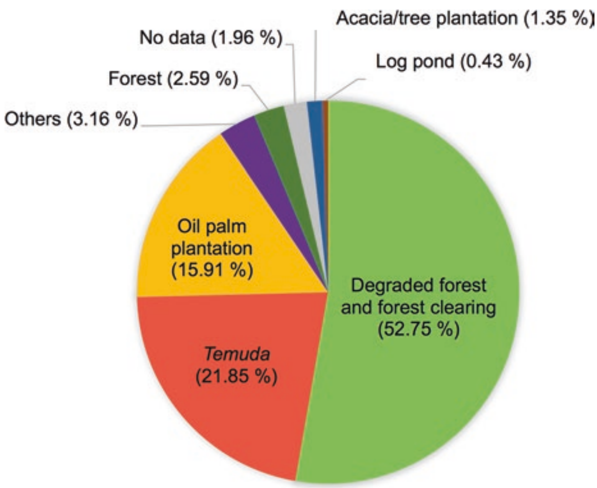


Fig. 3.2 Percentage of the Kemena–Tubau–Lower Jelalong region study area covered by major land-use types

and smallholders' plantations were not evident, which could have also resulted in some overlaps of land-use classification.

Although the project area falls inside the Sarawak planted forest zone area, a large proportion of the area has not yet been converted into acacia or tree plantations. Land classified as planted or worked on for acacia or tree plantations covered only 1.35% of the project area. On-the-ground surveys have identified that most of the area classified as acacia/tree plantations has been predominantly planted with acacia species.

3.4 Discussion

Logging was a main economic activity in this region, as evidenced by the large extent of degraded forests that covered more than half the project area. Tubau bazaar, which lies in the southwestern part of the project area, has been known as a rapidly developing town that prospered during the height of logging operations, especially in the late 1980s until as recently as the late 1990s. However, due to the depletion of timber stocks in the surrounding forests, the town slowly declined and the number of shops in business has reduced to fewer than five, with only one sundry shop still in relatively good business. Tubau has been synonymous with logging and the number of log ponds here is evidence of this. These log ponds are still in operation although the number of log landings has reduced substantially.

Most of the communities in this area are situated along river banks, but many have recently moved nearer the roads, especially along the Bakun road. This is largely due to the expansion of oil palm plantation in the region. Since the completion of the Bakun hydroelectric dam and the access road linking it to the Bintulu–Miri trunk road in 2011, the area along the Bakun road has seen substantial changes. Agricultural plantations in Bintulu consist largely of oil palm, which increased to over 200,000 ha by 2015, twice the area planted with oil palm in 2006 (WAHBA Engineering Consultants and GHD Consultants 2006). As oil palm plantations expand, they can drive additional increases in the conversion of native lands or *temuda* as local communities take advantage of improved road systems and previously established palm oil mills to convert their swidden agriculture areas into small-scale oil palm plantations (Soda et al., Chap. 15). The area currently planted with oil palm will likely increase in the near future and may even surpass the current extent of *temuda*. This is very probable given that the annual conversion rates of *temuda* to smallholder oil palm plantation ranged from 2.2% to 103%, or on average 46.9% per year, from 2004 to 2012 (Soda et al. 2015).

Although the Bakun road has provided opportunities for business development, especially in the palm oil sector, it has also brought about socioeconomic change, such as an influx of foreign workers (Ritchie 2001). The demand for wild meat is also likely to rise as increased employment opportunities draw more people to this region, while the establishment of farms and improved accessibility could enable hunting to increase. Thus, a concerted effort by all agencies involved is needed to monitor the current situation.

Acknowledgements This work is supported by the Grant-in-Aid for Scientific Research (S) 22221010 from the Japan Society for the Promotion of Science.

Appendices

Appendix 3.1: Remote Sensing Data Details for Tubau Image (Fig. 3.3)

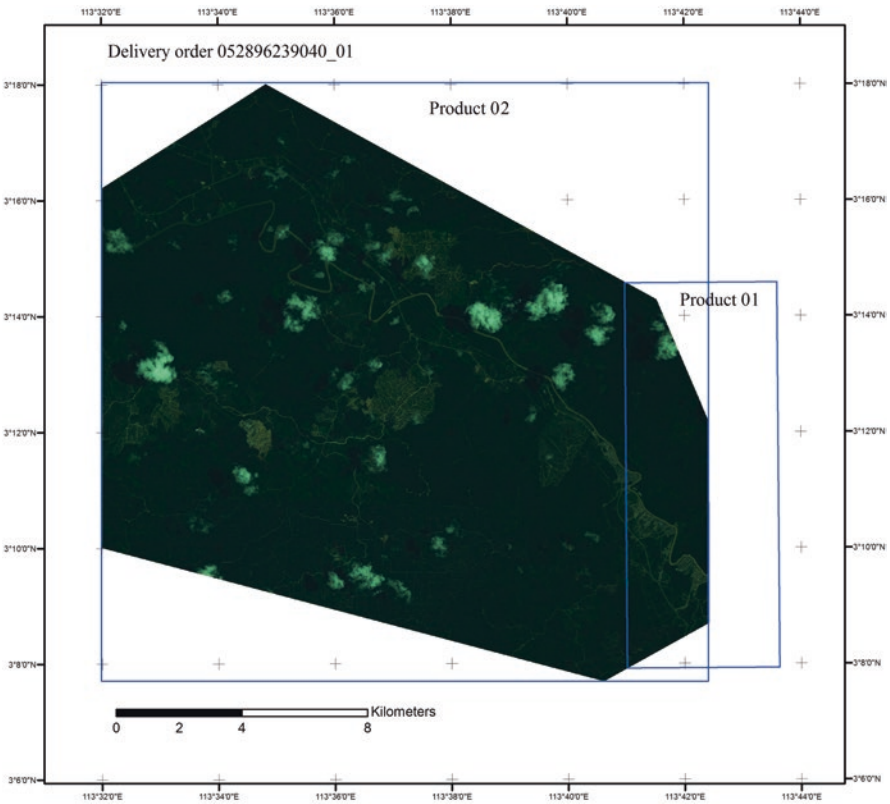


Fig. 3.3 Polygons showing area of interest for data procured from DigitalGlobe, labelled as Tubau image in the text
Note: The dates these satellite images were captured were 5–13 August 2012. (Image copyright 2013 DigitalGlobe, Inc., Longmont CO USA 80503)

Appendix 3.2: Remote Sensing Data Details for Jelalong Image (Fig. 3.4)

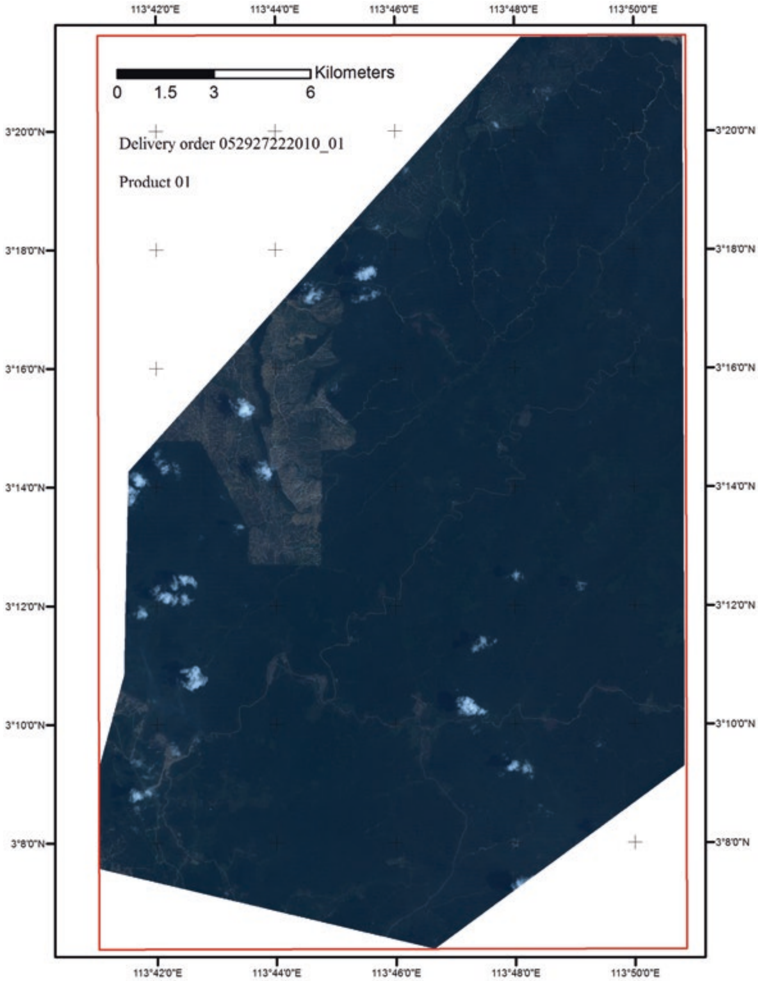


Fig. 3.4 Polygons showing area of interest for data procured from DigitalGlobe, labelled as Jelalong image in the text
Note: The date these satellite images were captured was 5 August 2012. (Image copyright 2013 DigitalGlobe, Inc., Longmont CO USA 80503)

Appendix 3.3: Examples of Raster Data Sets Created in ArcGIS (Figs. 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21, 3.22, 3.23 and 3.24)

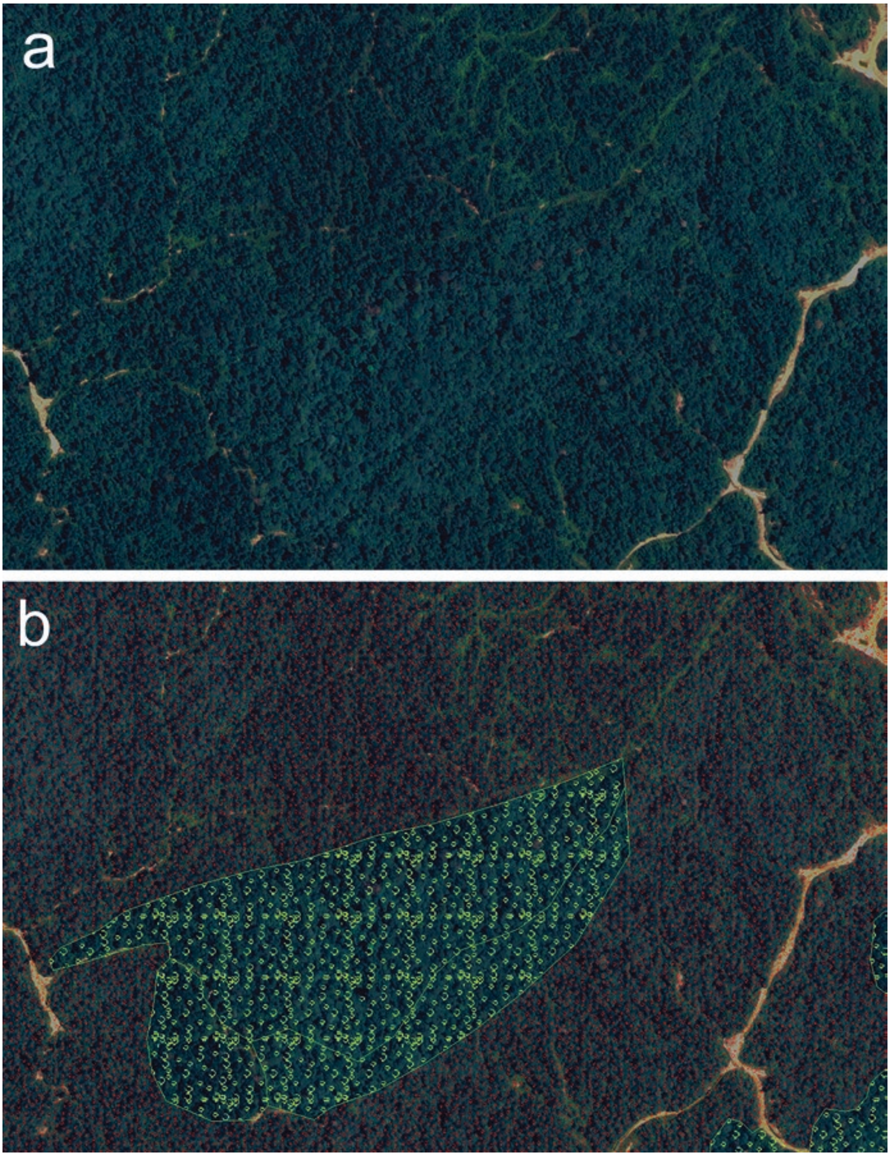


Fig. 3.5 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of forests and degraded forests

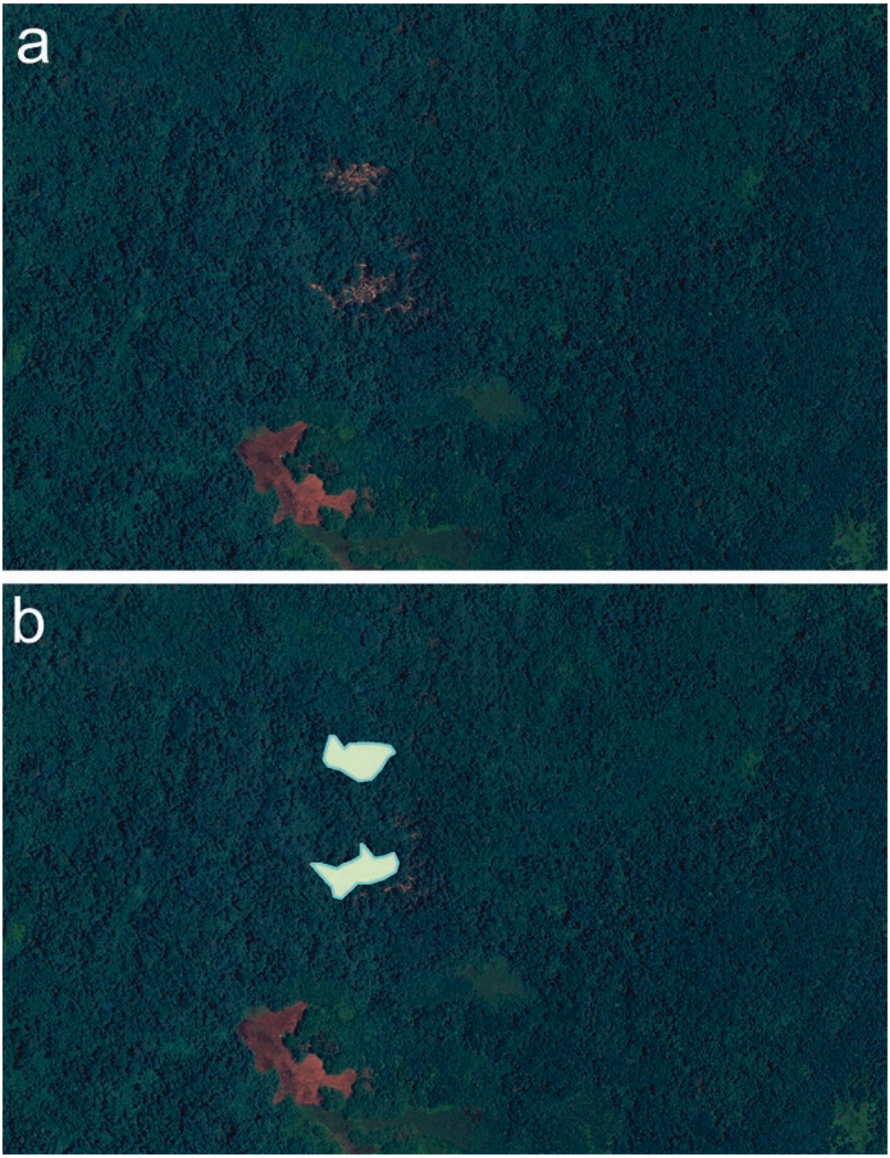


Fig. 3.6 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of forest clearing

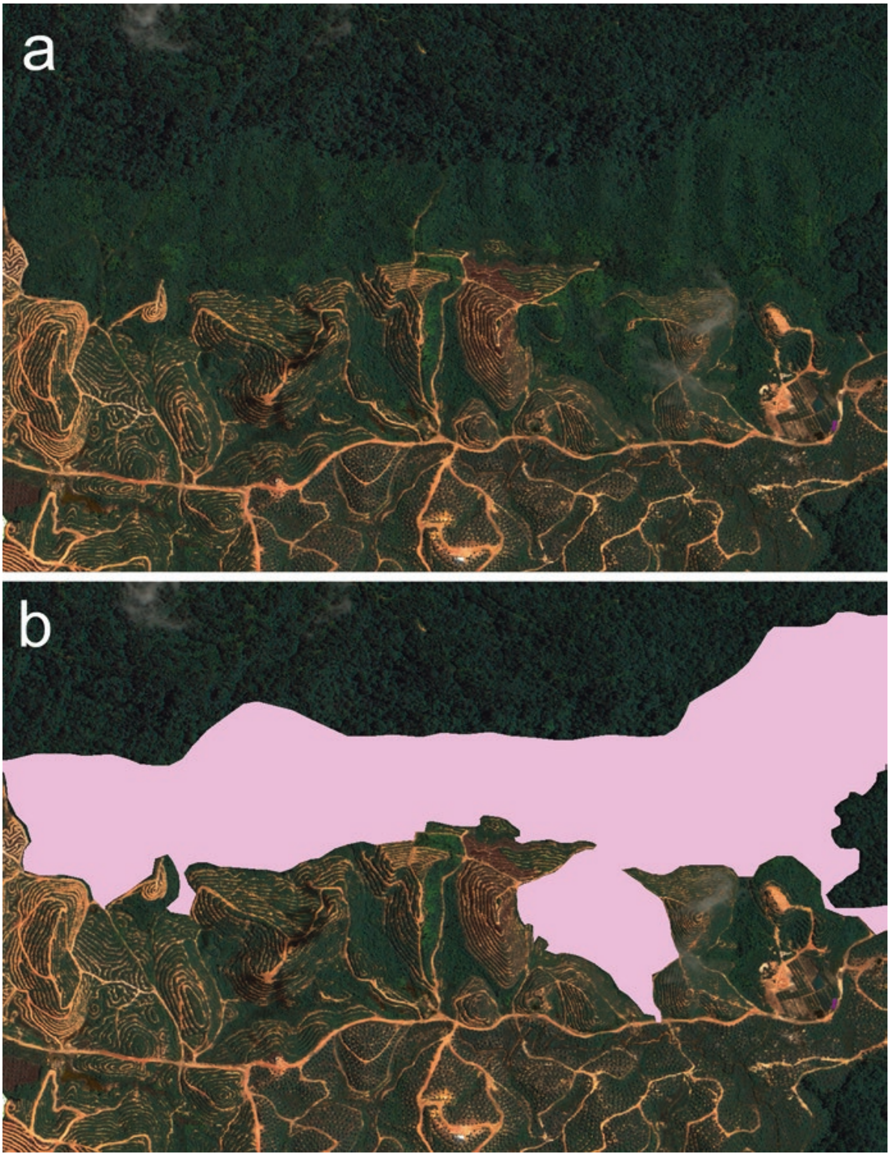


Fig. 3.7 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of forest clearing for oil palm

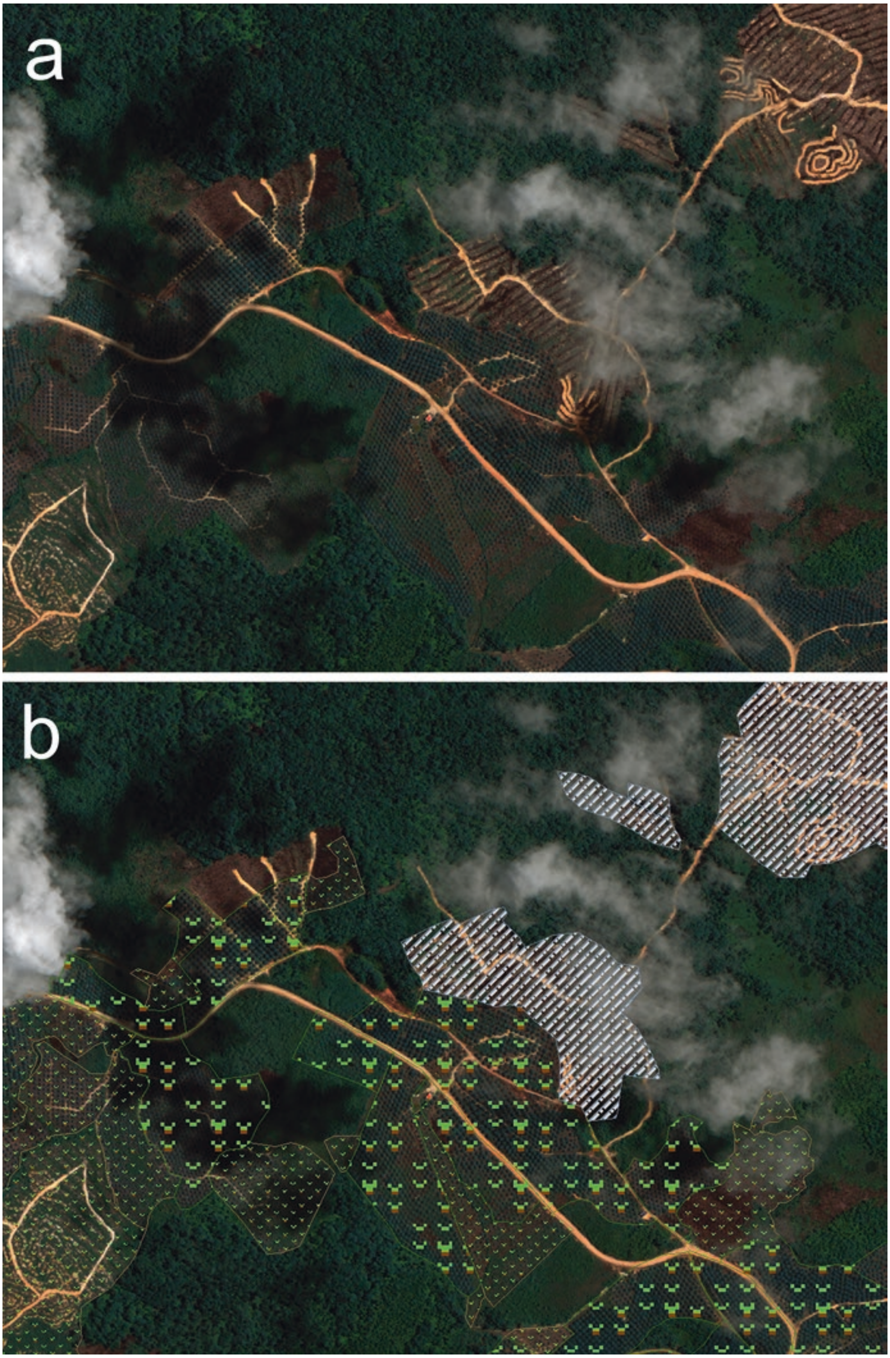


Fig. 3.8 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of mature oil palm, young oil palm, recently planted oil palm and plantation terraces

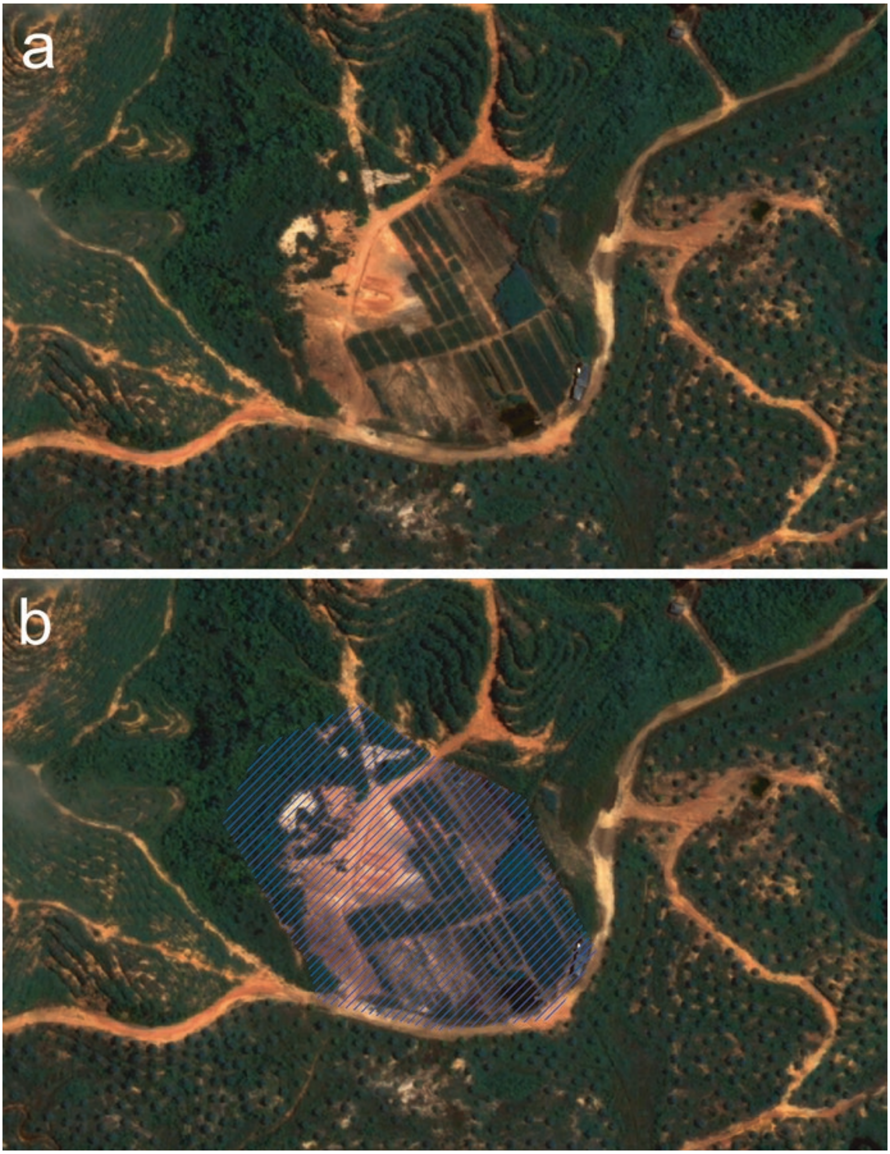


Fig. 3.9 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of oil palm nursery

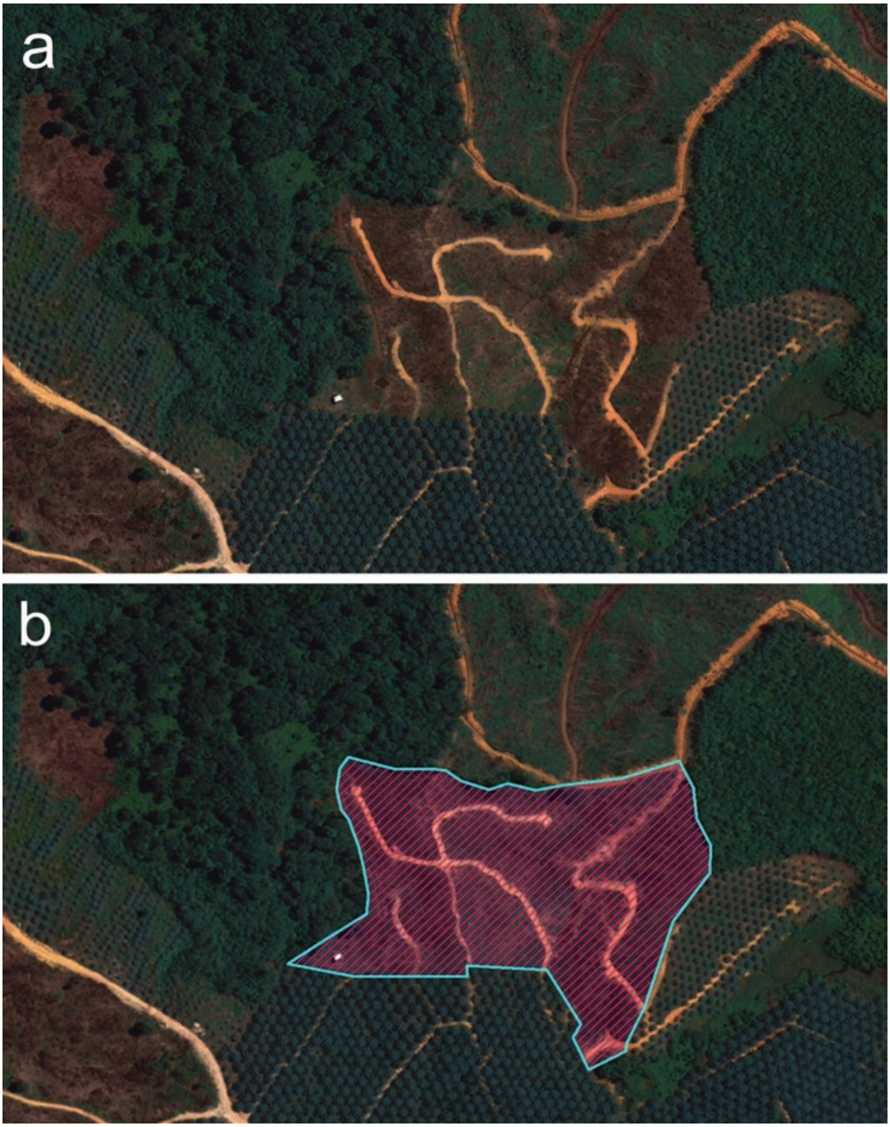


Fig. 3.10 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of cleared *temuda* recently planted with oil palm

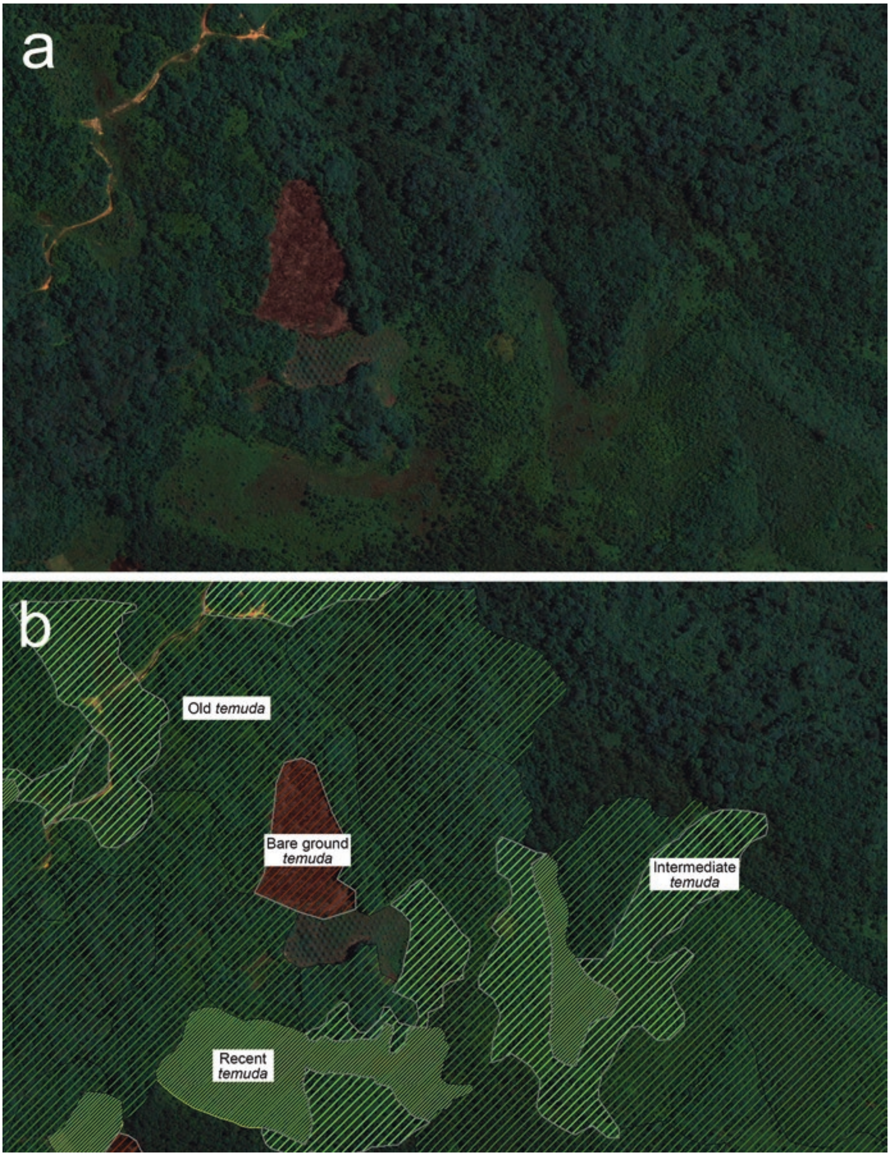


Fig. 3.11 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of old *temuda*, intermediate *temuda*, recent *temuda* and bare ground *temuda*

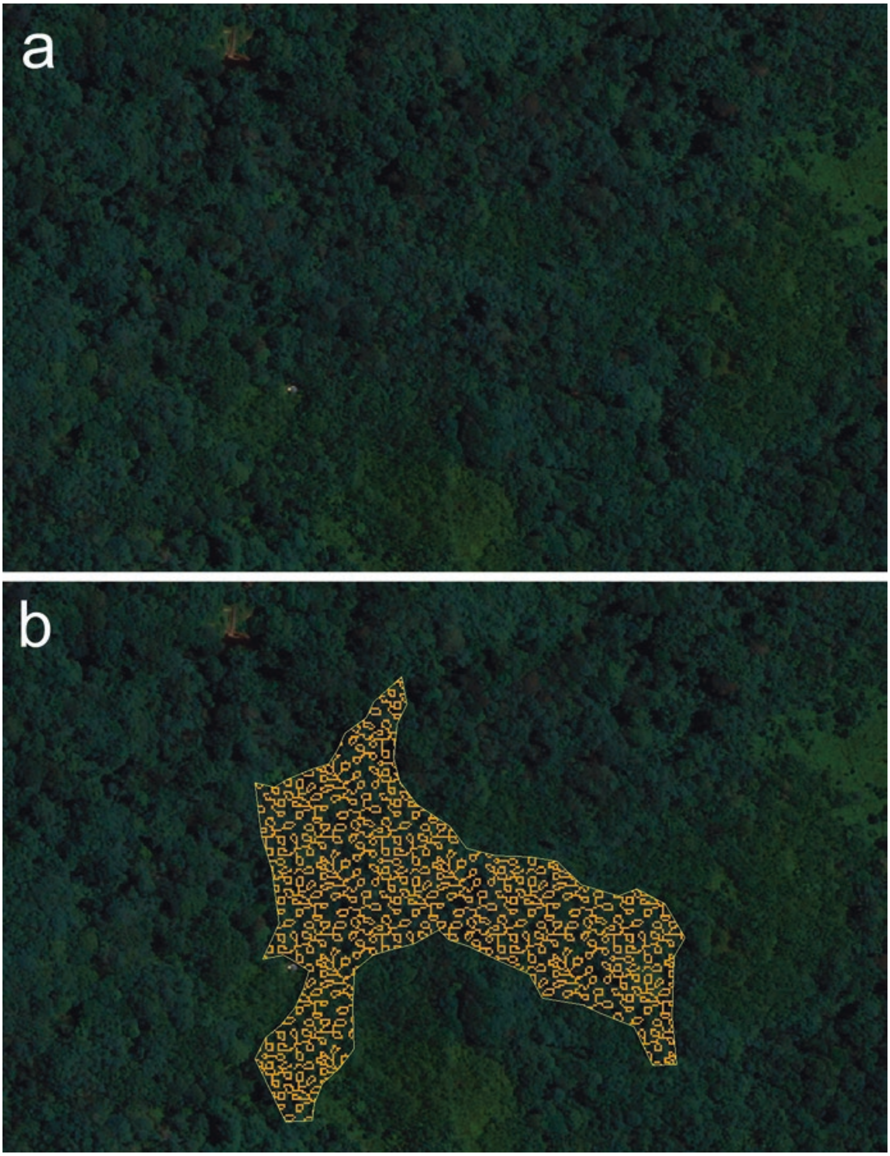


Fig. 3.12 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of rubber plantations

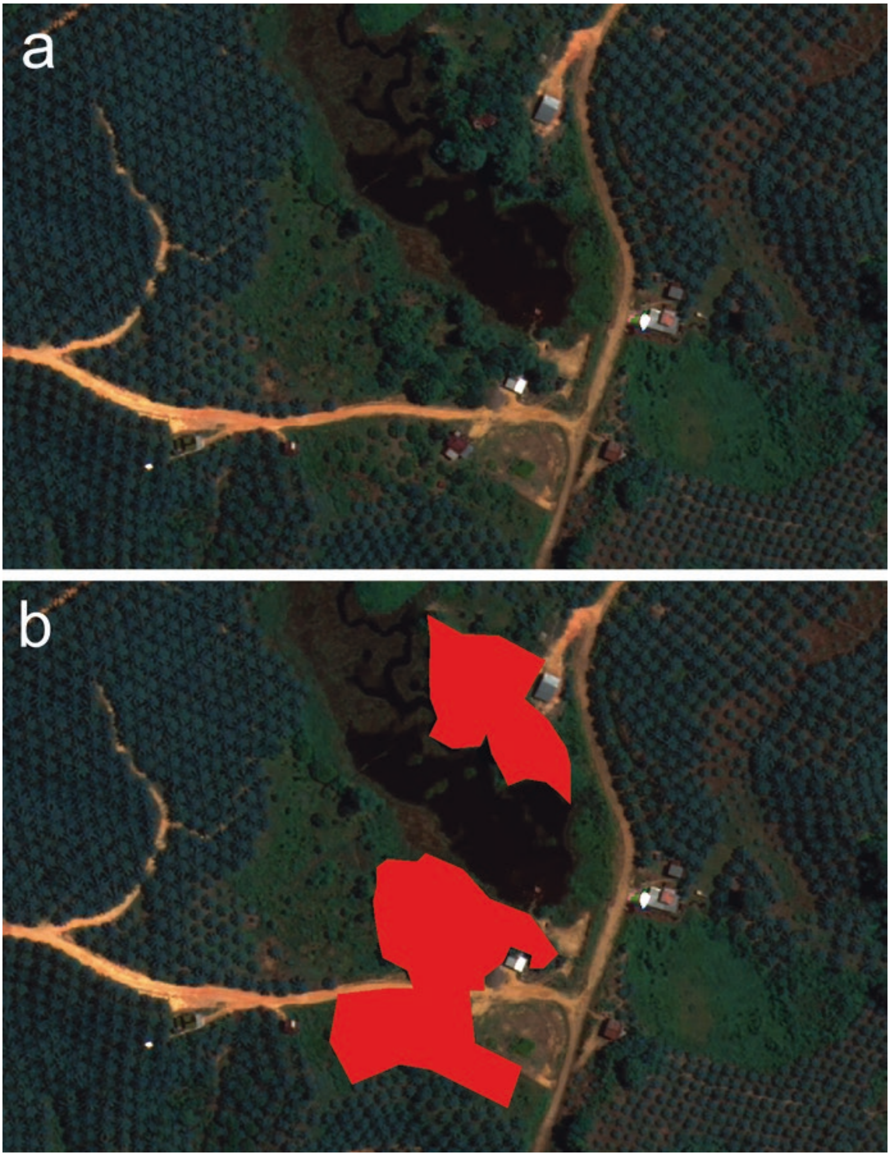


Fig. 3.13 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of orchards

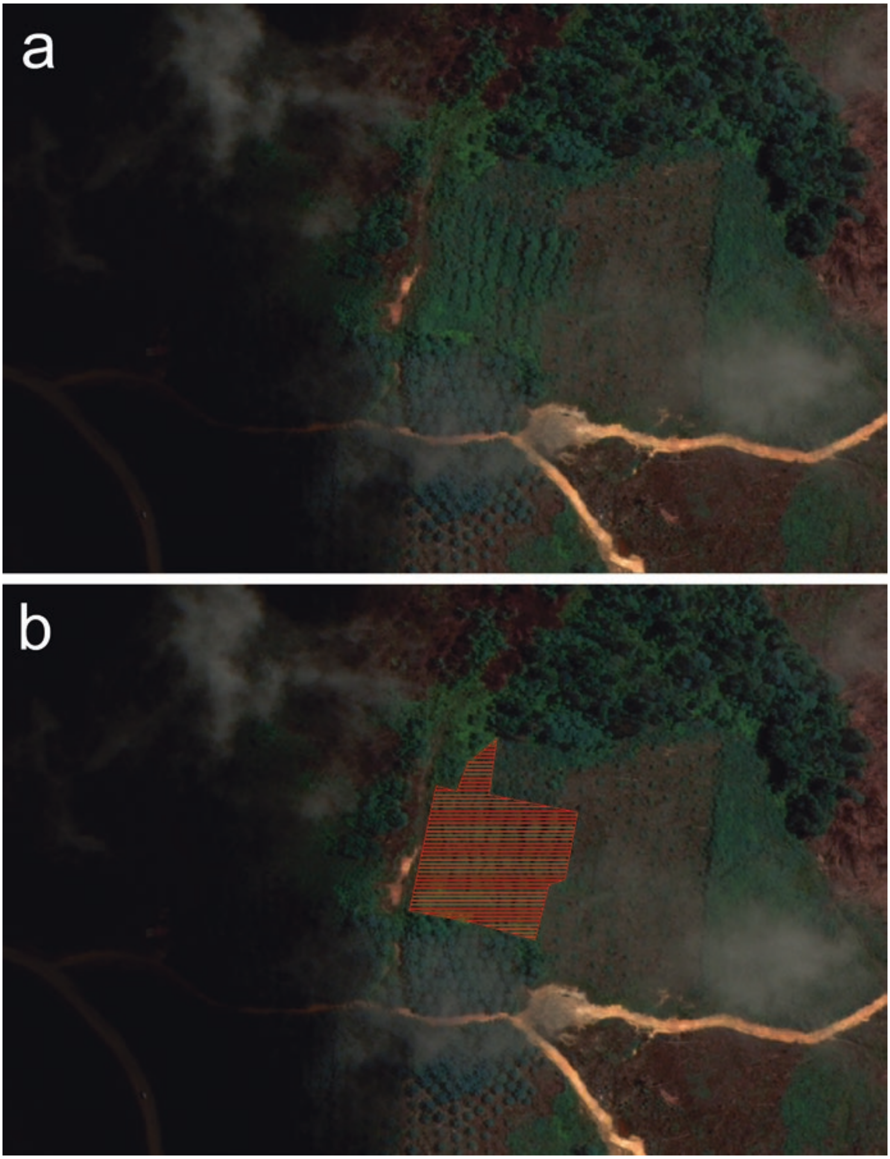


Fig. 3.14 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of other cash crops

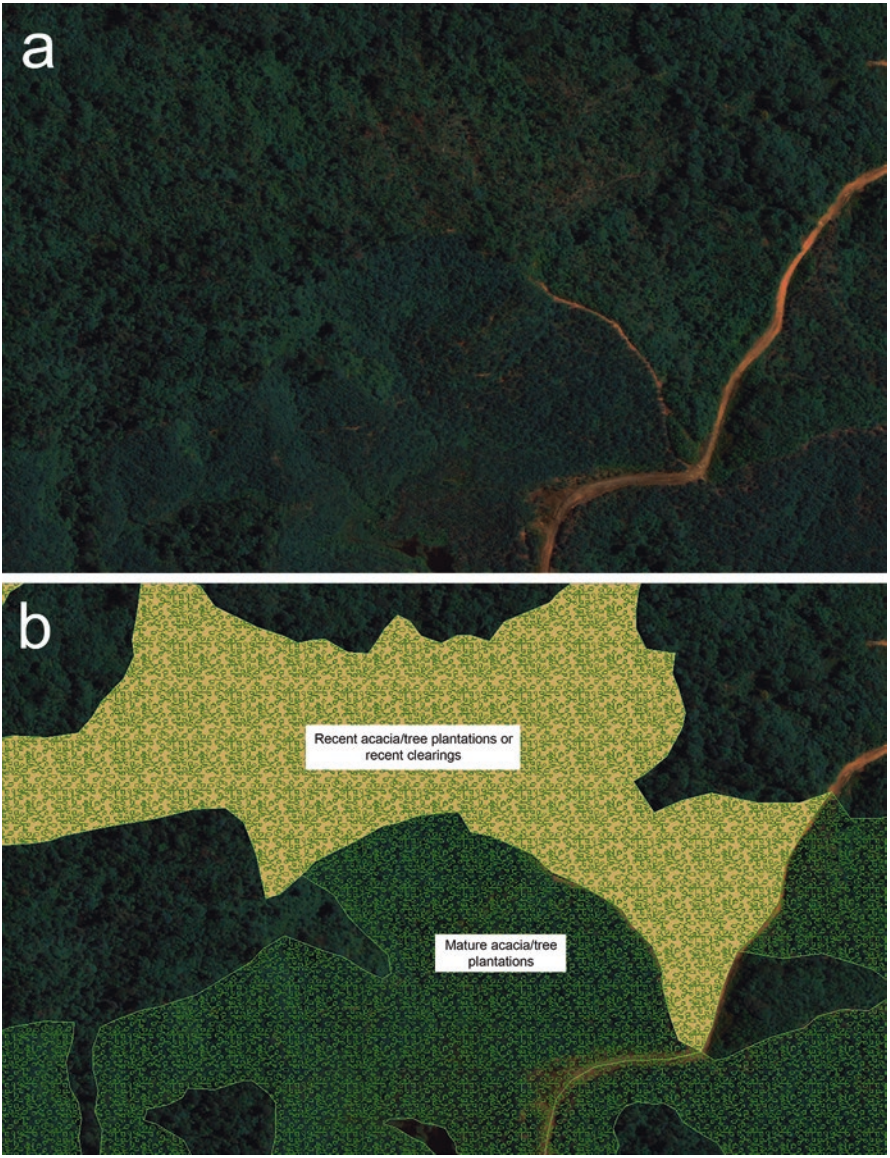


Fig. 3.15 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of mature acacia/tree plantations and recently planted acacia/tree plantations or recently cleared sites for plantation expansion

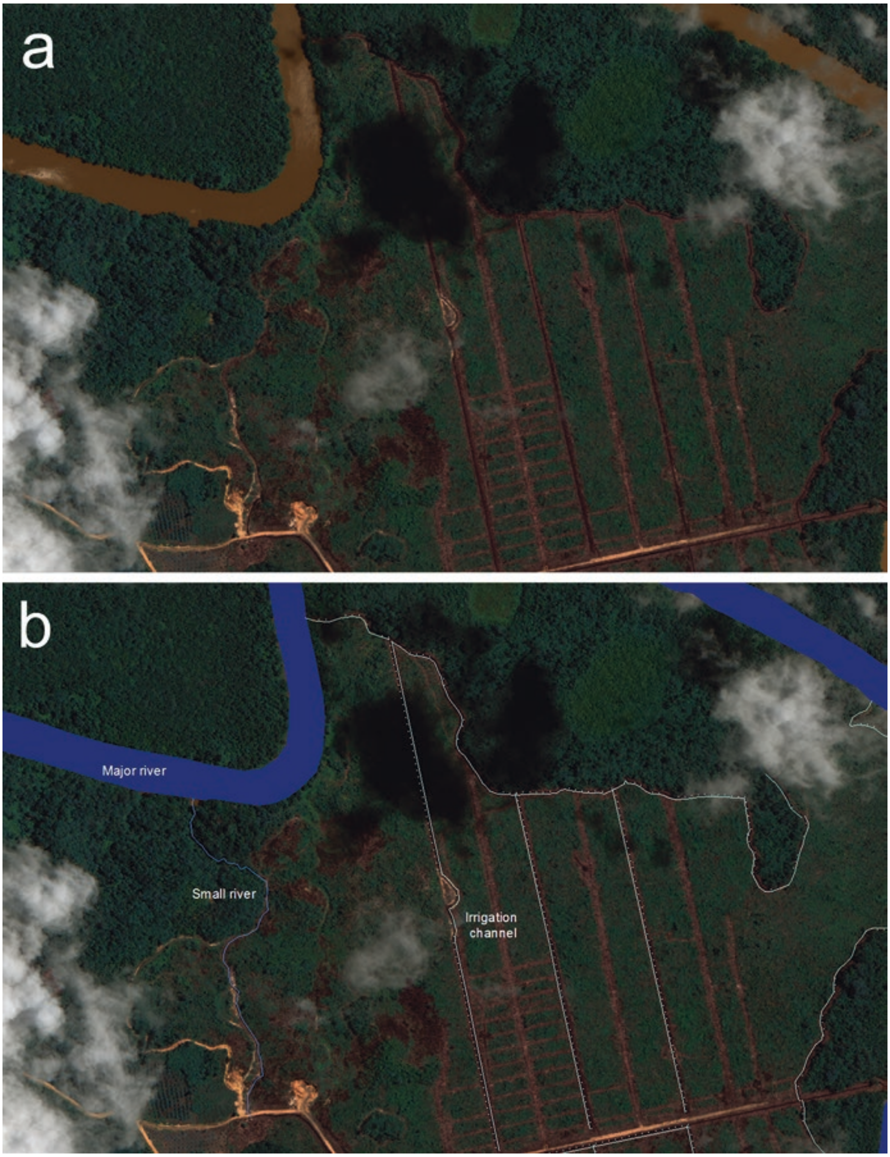


Fig. 3.16 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of major rivers, small rivers and irrigation channels

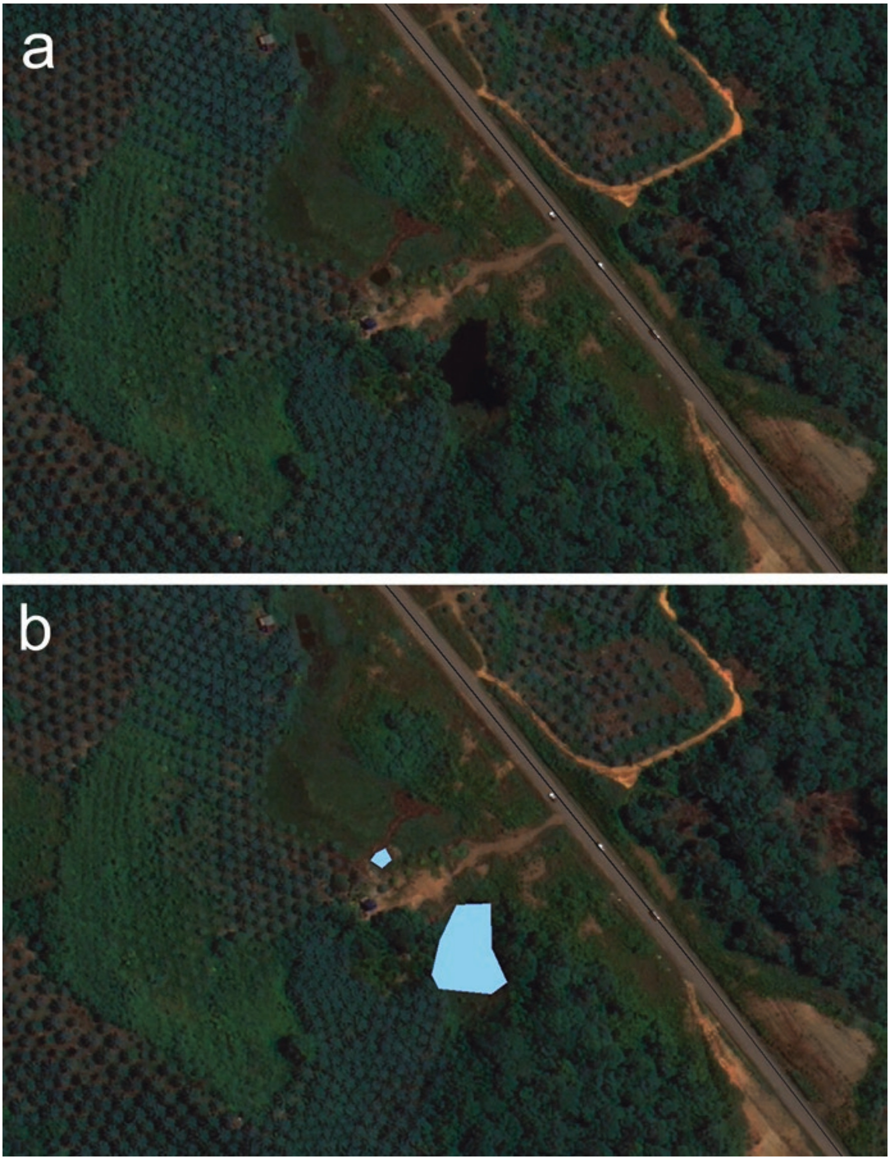


Fig. 3.17 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of ponds and lakes

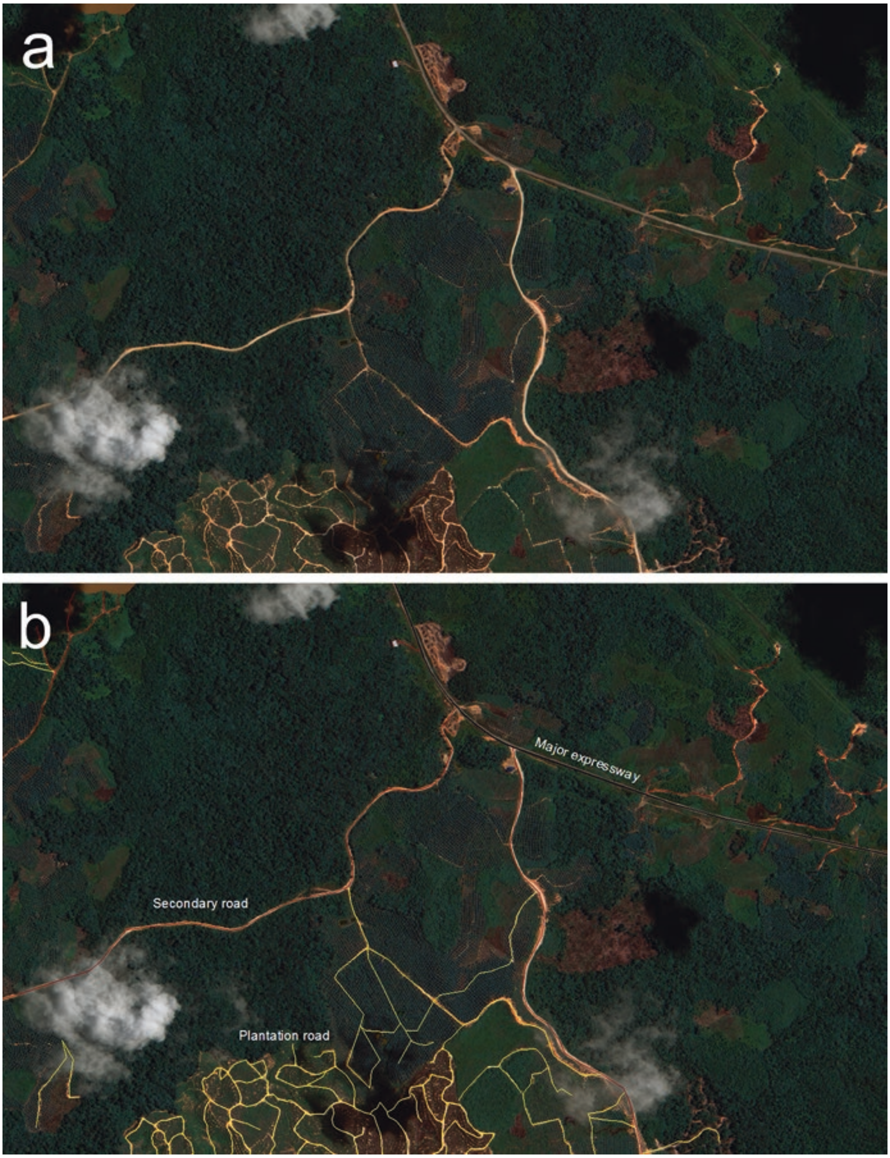


Fig. 3.18 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of major expressways, secondary roads and plantation roads

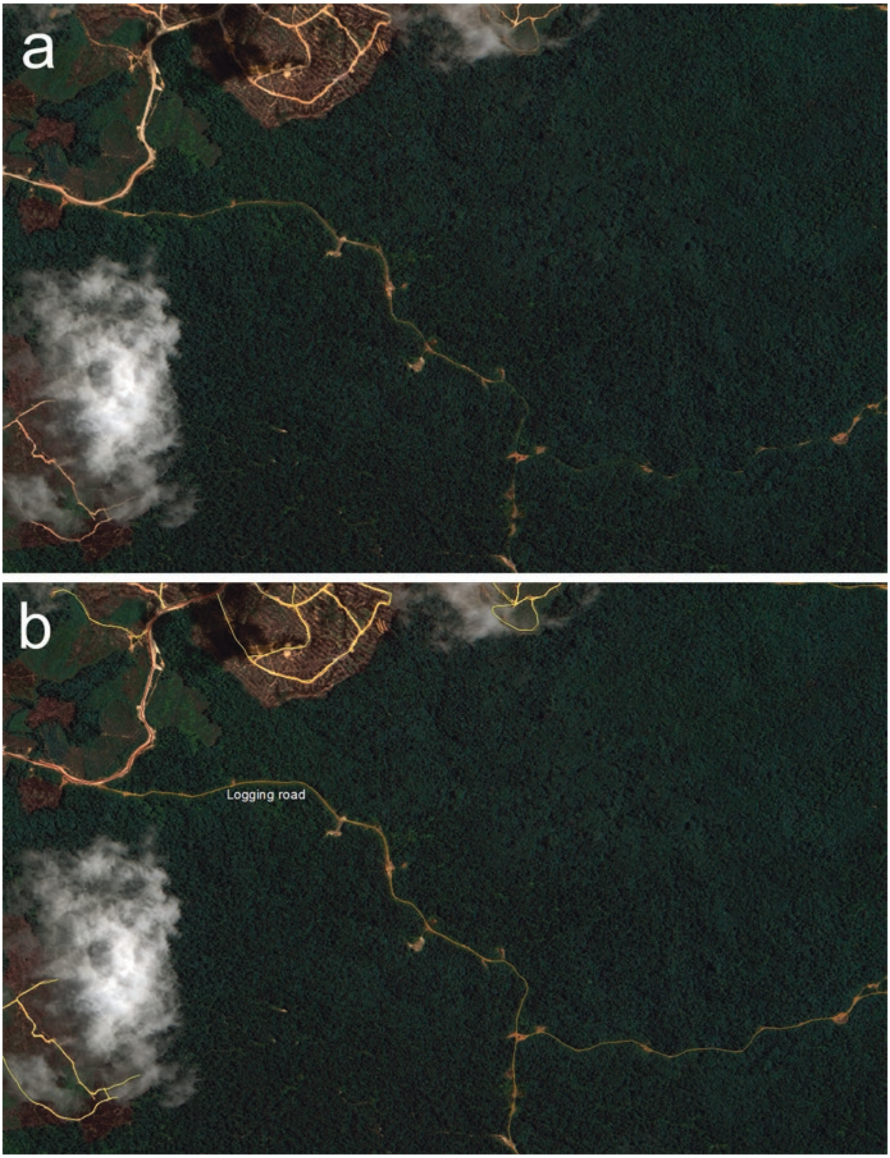


Fig. 3.19 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategory of logging roads

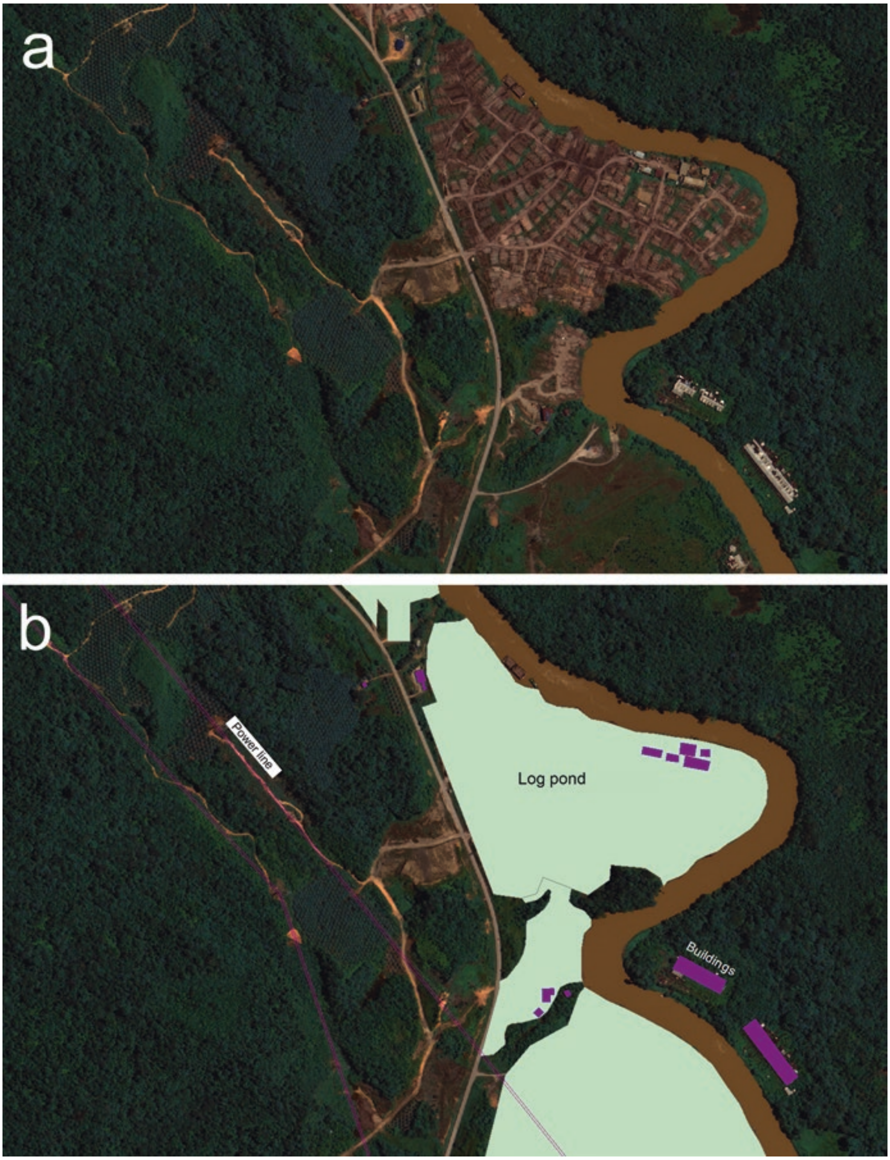


Fig. 3.20 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of buildings, log ponds and power lines

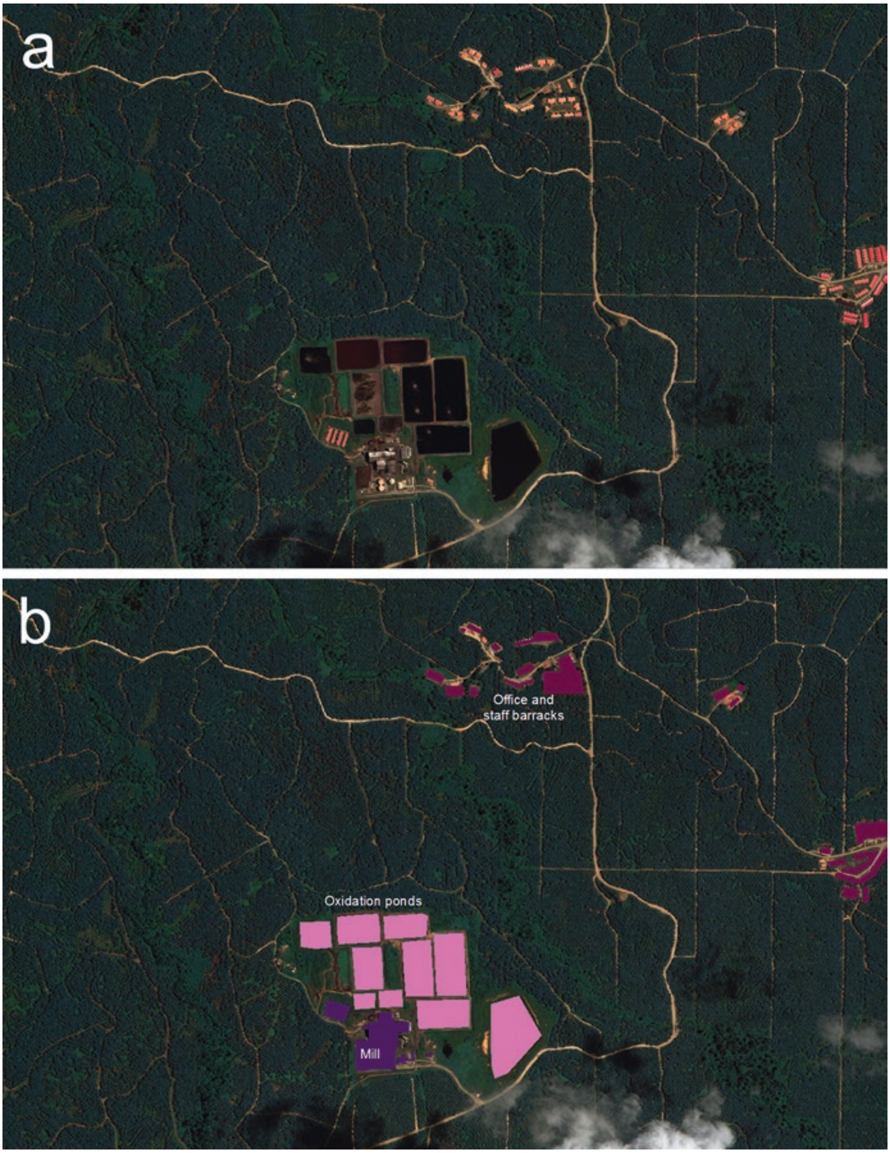


Fig. 3.21 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use subcategories of Keresa Plantations Sdn Bhd offices and barracks, their oil palm mills and their oxidation ponds

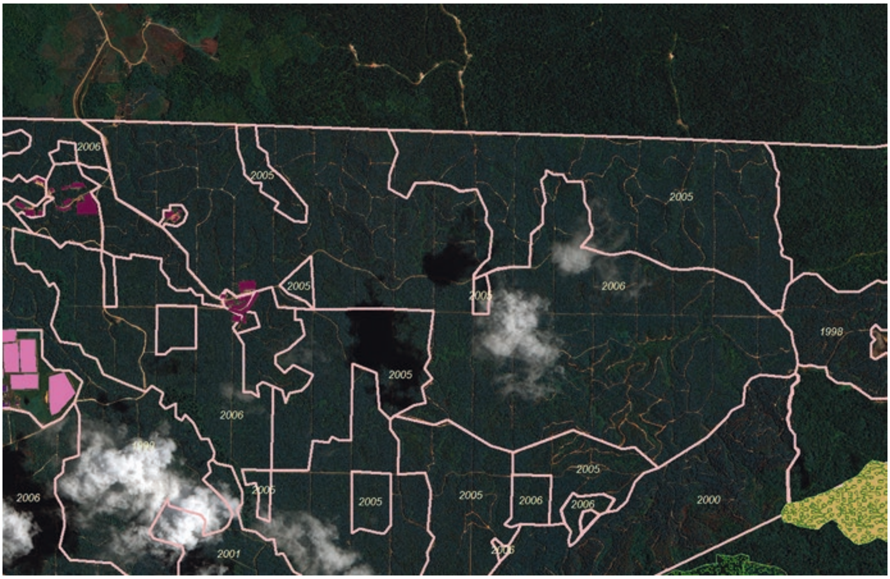


Fig. 3.22 Example of the layer outlining areas of oil palm plantations managed by Keresa Plantations Sdn Bhd, where the planting plan was delineated by embedding the year for each plot where data was available

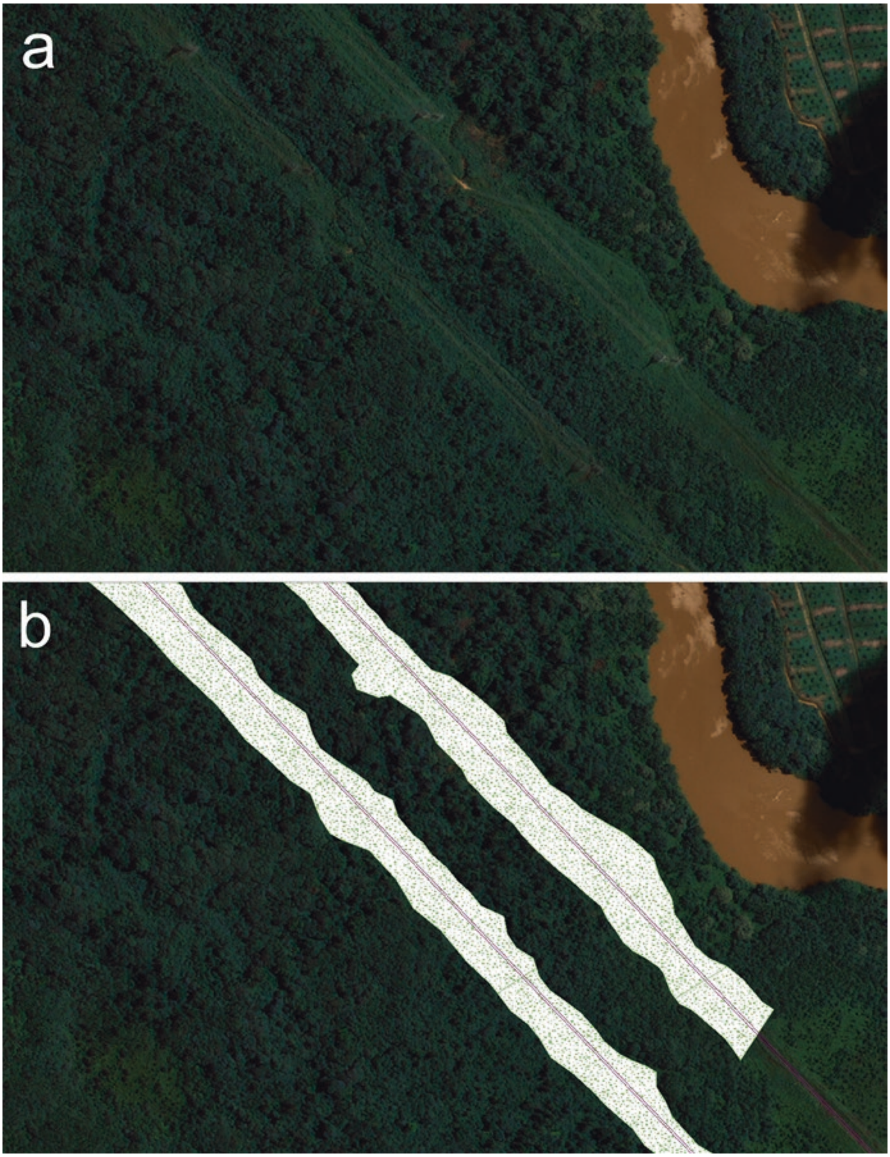


Fig. 3.23 (**a**) Satellite image used and (**b**) example of the resulting raster data set created in ArcGIS for the land-use category of grass and shrubs

Appendix 3.4: Land-Use Map of the Kemena River–Tubau–Lower Jelalong Region

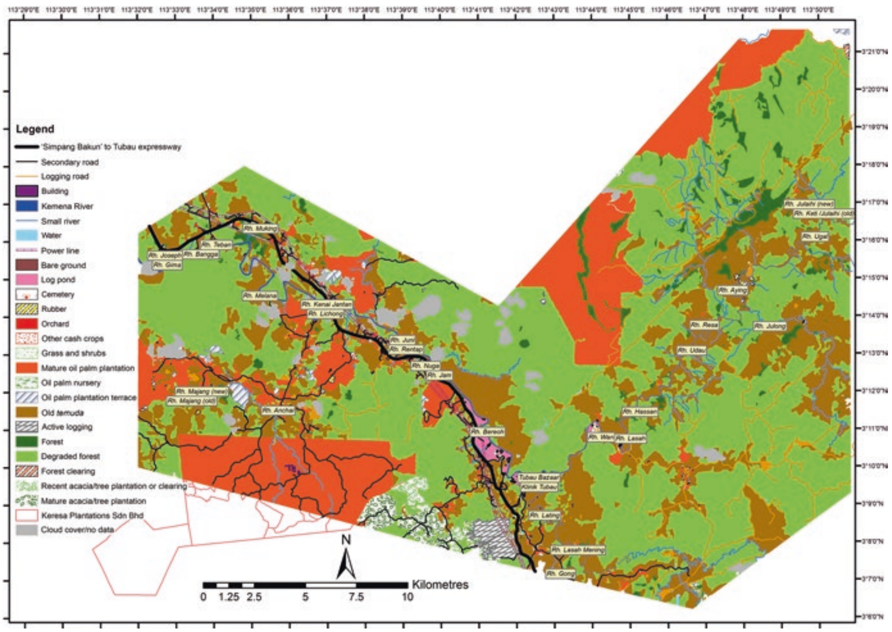


Fig. 3.24 Different land uses in the Kemena River–Tubau–Lower Jelalong region, Bintulu

References

Aiken, Samuel Robert, and Colin H. Leigh. 1992. *Vanishing rain forests: The ecological transition in Malaysia*. New York: Oxford University Press.

Esri. 2012. *ArcGIS desktop: Release 10.1*. Redlands: Environmental Systems Research Institute.

Hon, Jason, and Shozo Shibata. 2013. A review on land use in the Malaysian state of Sarawak, Borneo and recommendations for wildlife conservation inside production forest environment. *Borneo Journal of Resource Science and Technology* 3 (2): 22–35.

Ritchie, James Alexander. 2001. Bakun highway—A price for development. *Sarawak Tribune*, 10 January.

Ryoji, Soda, Yumi Kato, and Jason Hon. 2015. The diversity of small-scale oil palm cultivation in Sarawak, Malaysia. *The Geographical Journal*. doi: 10.1111/ geoj.12152.

Sarawak, State Government of. 2009. *Master plan for community development programme for the communities in Sarawak Planted Forest (Pulp and Paper) Project, Bintulu, Sarawak*, Main report vol. 3. Kuching: State Government of Sarawak.

Tsuyuki, Satoshi, Mea How Goh, Stephen Teo, Kamlisa Uni Kamlun, and Mui-How Phua. 2011. Monitoring deforestation in Sarawak, Malaysia using multitemporal Landsat data. *Kanto Forest Research* 62: 87–90.

WAHBA Engineering Consultants, and GHD Consultants. 2006. *The Bintulu urban and regional study*, vol. 1, part 1: *Regional context.* Bintulu: Bintulu Development Authority

Wong, James. 1992. *Hill logging in Sarawak*. Kuching: James Wong.

Chapter 4
Trend Analysis of Rainfall Characteristics in the Kemena and Tatau River Basins, Sarawak

Osamu Kozan

Abstract Based on mean rainfall data, Sarawak can be considered as having no very dry season. Rainfall analysis at 14 stations reveals that droughts rarely lasted more than a month in most parts of the Kemena and Tatau river basins in the period from 2006 to 2010. Monthly rainfall <100 mm lasted for more than 3 months at two stations. In order to understand the impact of drought on local environments, spatial and temporal rainfall variability needs to be considered. Analysis of the heavy rainy period in these river basins indicates that the mechanism of rainfall is partly affected by the distance from the coastline.

Keywords Sarawak · Kemena and Tatau river basins · Rainfall patterns · Hydrology · Drought · Intertropical convergence zone

4.1 Rainfall Patterns in Malaysia and Indonesia

Most parts of Malaysia and Indonesia have a tropical climate, including the state of Sarawak which is located in the northwest part of Borneo. Sarawak is bordered by the Malaysian state of Sabah to the northeast, Brunei in the north and Kalimantan (the Indonesian portion of Borneo) to the south. Figure 4.1 shows the rainfall distribution estimated from the Tropical Rainfall Measuring Mission (TRMM) precipitation radar over Singapore, Malaysia and Indonesia. Most areas of Sarawak experience more than 2500 mm of rainfall per year with more than 200 mm of rain in most months. Given the rainfall patterns, it can be considered that there is no very dry season and the short dry season that does exist appears to have little effect on the local environment.

The amount of rainfall and annual rainfall cycles in Malaysia, Indonesia and the surrounding region are affected by factors like latitude, altitude, and topography and landforms (which include oceans, rivers and mountainous areas) as well as hydro-

O. Kozan (✉)
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: kozan@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_4

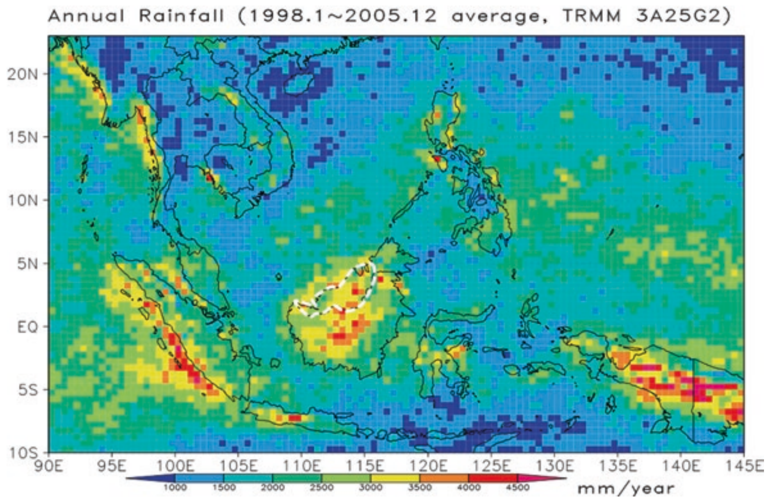


Fig. 4.1 Rainfall distribution estimated from the TRMM precipitation radar over Singapore, Malaysia and Indonesia

Source: Reprinted from Yamanaka (2016: 244). Copyright 2016, The Author(s) licensed under CC BY 4.0

Note: Dotted white line indicates the approximate area of Sarawak

meteorological conditions such as wind patterns and atmospheric temperature. Edvin Aldrian and R. Dwi Susanto (2003) previously investigated the characteristics of rainfall variability in Malaysia and Indonesia using monthly rainfall data from 1961 to 1993 from meteorological stations across Indonesia, which were analysed with a double correlation method. Based on the general patterns observed from the study, there are three types of climatic region, each with a different annual rainfall cycle: (A) the monsoonal region; (B) the equatorial region; and (C) the local region (Fig. 4.2). The mean annual rainfall cycles of each region and their interannual standard deviations are illustrated in Fig. 4.3. From this map and figure, it can be observed that each region has its own distinct precipitation pattern.

Region A has one peak and one trough in its annual rainfall cycle and experiences strong influences of two monsoons, namely the wet northwest monsoon from November to March and the dry southeast monsoon from May to September. Region B has two peaks, in October and November and in March to May. Those two peaks in rainfall are associated with the southward and northward movement of the intertropical convergence zone (ITCZ). N.E. Davidson (1984) and his colleagues (Davidson et al. 1984) described in detail the ITCZ movement in this region in the boreal winter. The ITCZ is also known as the equatorial convergence zone and consists of winds originating from the two hemispheres of the Earth that converge and force air to rise into the atmosphere. The ITCZ shifts together with the north–south movement of the position of the sun's zenith, reaching a latitude of around 10° north on average in the boreal summer and moving south of the equator during the boreal winter. The position of the ITCZ affects the yearly rainfall patterns in countries situ-

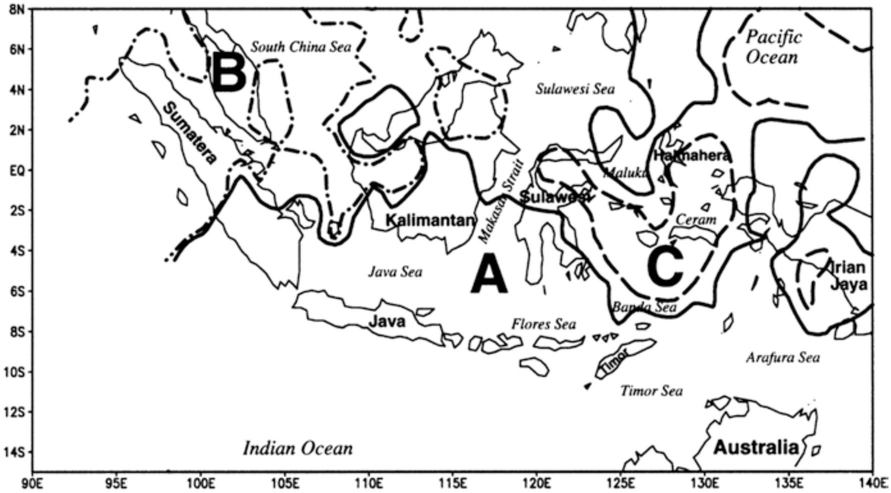


Fig. 4.2 Three climate regions according to the mean annual patterns
Source: Aldrian and Susanto (2003, 1438). Copyright 2003 John Wiley and Sons, Inc. Reprinted by permission of John Wiley and Sons, Inc
Note: Malaysia and Indonesia are divided into region A with a solid line, region B with a short dashed line and region C with a long dashed line

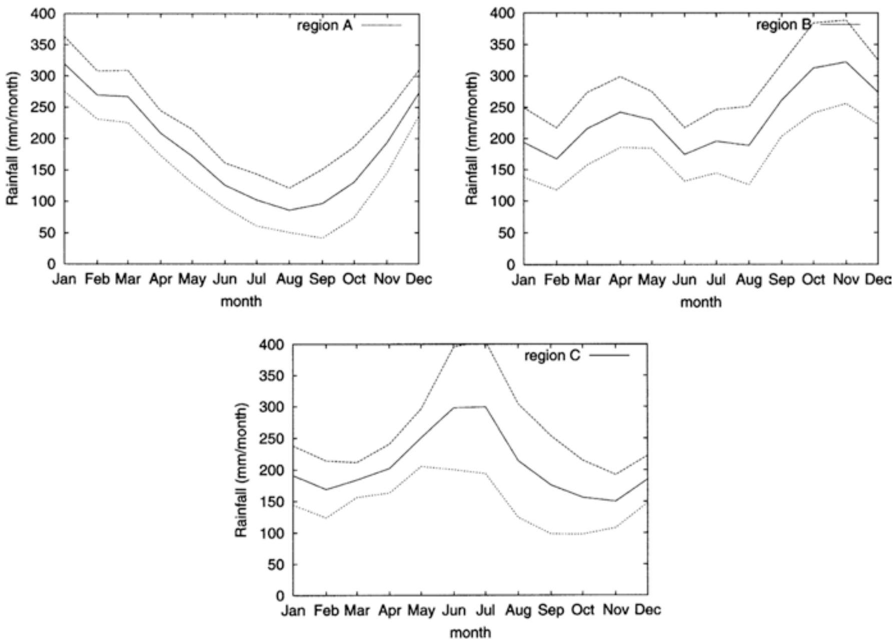


Fig. 4.3 Annual rainfall cycles of the three climate regions using a double correlation method
Source: Aldrian and Susanto (2003: 1439). Copyright 2003 John Wiley and Sons, Inc. Reprinted by permission of John Wiley and Sons, Inc
Note: Dashed lines indicate one standard deviation (σ) above and below average

ated close to or on the equator and is likely to cause rain, winds, continuous cloudy weather and thunderstorms in these areas. The ITCZ is located on the equator twice a year, around the periods of March to May and September to November, accounting for the increased rainfall experienced during these months. Region C has one peak in June to July and one trough in November to February. For this reason, there are two dry seasons every year in Sarawak, which is located on the equator.

4.2 Rainfall Patterns in Sarawak

Sarawak has been recognised as an area with no clear seasonal variation given that the amplitude of variation is relatively smaller than that in temperate zones and other tropical regions. As already noted, Sarawak has three different climatic regions. This indicates that precipitation patterns across Sarawak are very diverse, which is plausible given that it occupies an area of 124,450 km^2 of northwest Borneo with a variety of landforms and topographic features.

Koichiro Kuraji and Tomoaki Ichie (2006) investigated the seasonal variation in rainfall in Sarawak and Sabah (in northern Borneo) using rainfall data since the mid-1950s obtained by the Department of Irrigation and Drainage at 10 stations (Fig. 4.4). Figure 4.5 shows the annual average rainfall from seven of the stations. Kuching (◆) has clear characteristics of region A. Kota Kinabalu (□) and Labuan (—) have small peaks in either May (Labuan) or June (Kota Kinabalu), a large peak

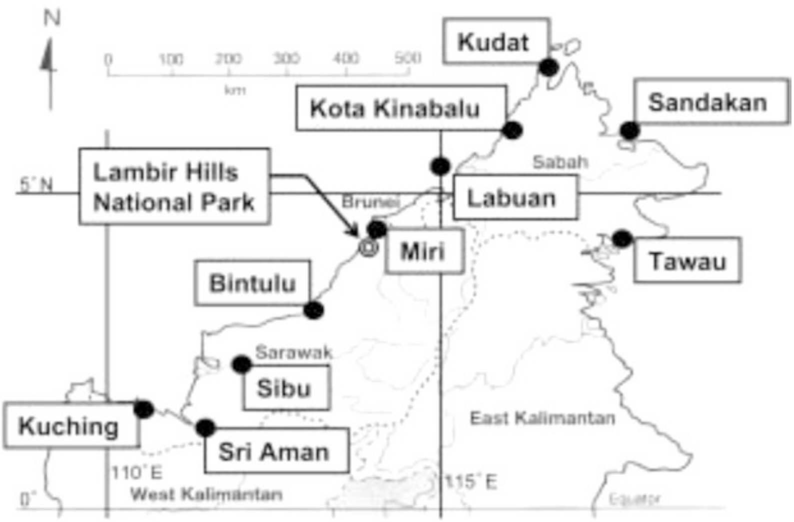


Fig. 4.4 Locations of rainfall data from 10 stations in Sarawak and Sabah
Source: Reprinted with permission from Kuraji and Ichie (2006: 97). Copyright 2006, *Journal of Japan Society of Hydrology and Water Resources*

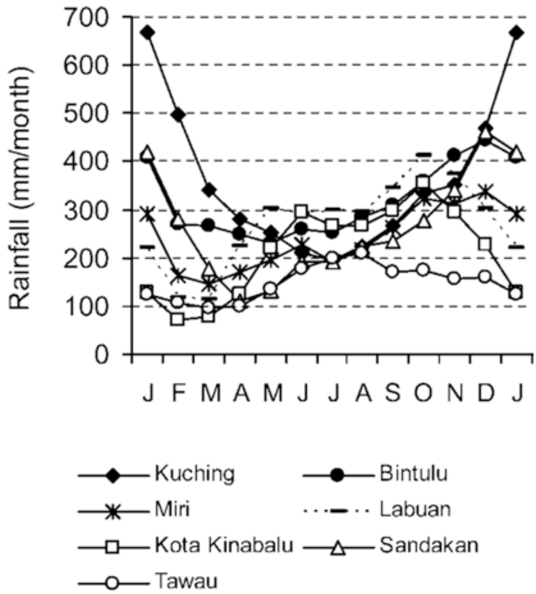


Fig. 4.5 Annual average rainfall at seven stations, Sarawak and Sabah, 1955–2006
Source: Reprinted with permission from Kuraji and Ichie (2006: 100). Copyright 2006, *Journal of Japan Society of Hydrology and Water Resources*

in September to November and one trough in January to April. By contrast, Bintulu (●) and Miri (∗) both have intermediate characteristics that fall between Kuching and Kota Kinabalu/Labuan. Based on analysis of the mean annual rainfall, Sarawak has a high diversity and variation of rainfall patterns depending on the location within the state. The monthly average rainfall during the period covered by the data (51 years up to 2006) is below 100 mm for 2 months in Kota Kinabalu; the lowest monthly rainfall is about 250 mm in Bintulu.

4.3 Long-Term Rainfall and Temperature Trends in Sarawak

The Malaysian Meteorological Department has reported the weather and climate trends for over 65 years. Figure 4.6 shows the annual rainfall from 1951 to 2015. From this figure, it is clear that Sarawak has usually experienced high annual rainfall with some drier years. However, there is no overall discernable rainfall trend over the years and there is a high variability of rainfall which is likely due to the tropical climate. The spatial and temporal variability of rainfall lacks the regularity that is generally found with temperature.

In Fig. 4.7, the Oceanic Niño Index (ONI), which is a measure of warm and cool events in the tropical Pacific Ocean, indicates that 1972, 1982/1983 and 1997/1998 were years with El Niño events and this correlates with the annual rainfall data for the whole of Sarawak when 1972, 1982 and 1997 were drought years. However, 1990 was also a drought year in Sarawak although it was a La Niña year. It is widely

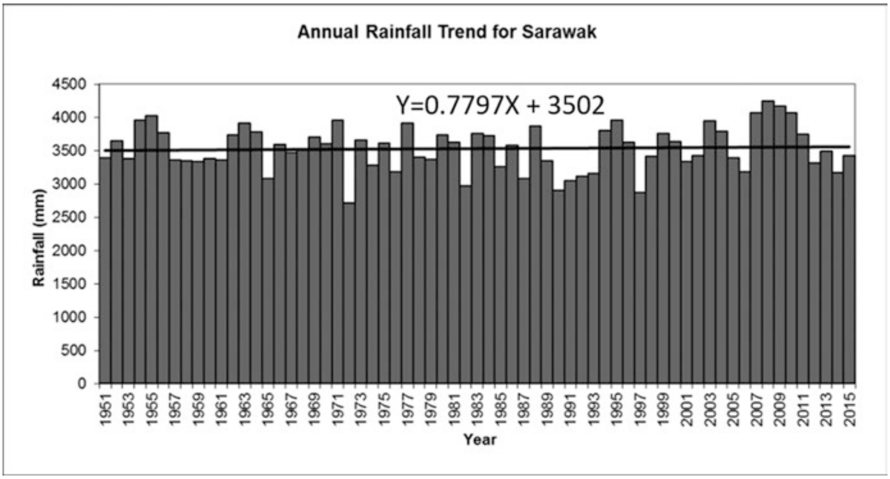


Fig. 4.6 Annual rainfall trend for Sarawak, 1951–2015
Source: Yap (2017: 12). Copyright 2016, The Author(s) licensed under CC BY-NC-SA 3.0

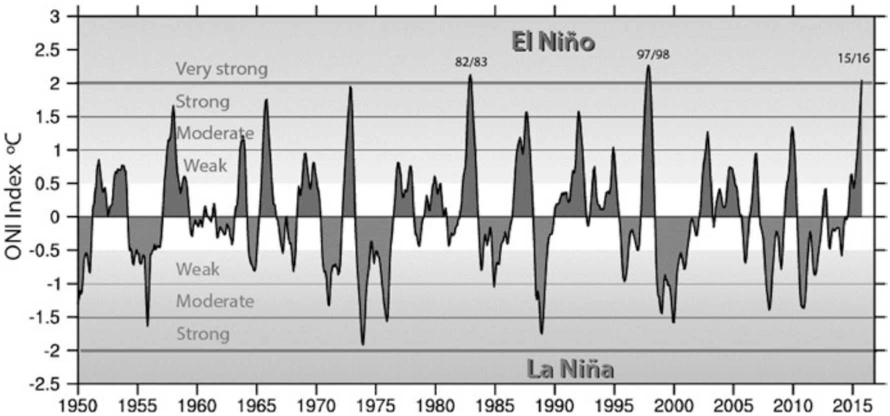


Fig. 4.7 Oceanic Niño Index (ONI), 1950–2015
Source: Reprinted from Trenberth and NCAR (2018). Copyright 2018, University Corporation for Atmospheric Research [UCAR]

recognised that during El Niño years droughts and dry weather tend to occur in Malaysia, Indonesia and other parts of Southeast Asia. These droughts can have severe environmental and societal effects such as large-scale forest fires.

The correlation between rainfall and the El Niño Southern Oscillation (ENSO) in Malaysia was studied by Liew Juneng and Fredolin T. Tangang (2005). They found the ENSO–Malaysian rainfall relationship during the northeast monsoon period is only apparent in Borneo. Liew and Tangang (2006) also investigated the difference in the ENSO–rainfall relationship between peninsular Malaysia and Borneo and found that only Kuching in southwestern Sarawak reported a low simultaneous correlation between northeast monsoon period rainfall and sea surface temperatures. Mie Gomyo and Koichiro Kuraji (2009) classified 18 stations into four groups according to the rainfall–ENSO relationship between southwestern and northeastern Sarawak during the period from 1963 to 2003. Figure 4.8 shows the maximum and minimum temperature for Sarawak for 47 years (1969–2015) and indicates an overall warming trend. An increase in average temperature can cause rainfall fluctuations that may result in a variation of extreme climate events such as flood and droughts (Alhoot et al. 2016).

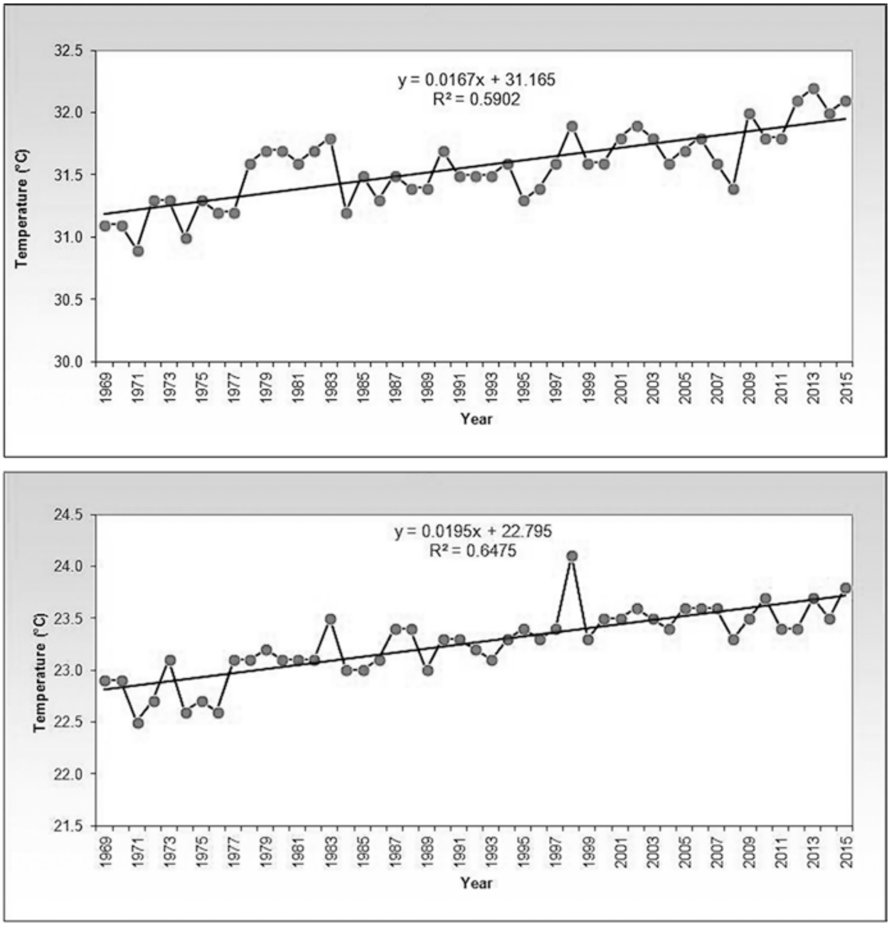


Fig. 4.8 Maximum and minimum temperature trend for Sarawak, 1969–2015
Source: Yap (2017: 5, 7). Copyright 2016, The Author(s) licensed under CC BY-NC-SA 3.0

4.4 Rainfall Trends and Distribution in the Kemena and Tatau River Basins

Based on the analysis of mean annual rainfall in Sarawak and Sabah, Bintulu has no severe dry season. However, rainfall in the whole of the Sarawak region has demonstrated both increasing and decreasing trends over the last decade. To further understand the changes and variations in rainfall at the local level, the hourly rainfall data obtained at 14 stations by the Department of Irrigation and Drainage in the Kemena and Tatau river basins from 2006 to 2010 was analysed (Table 4.1; Fig. 4.9). The Kemena and Tatau rivers are located in Bintulu Division. Sarawak is divided into 21 river basins with the Kemena basin being the fourth largest basin with an area of 6105 km^2 and the Tatau basin being the fifth largest with an area of 5260 km^2 (Fig. 4.10). The Kemena River is 190 km long, flows past the villages and towns of Tubau, Pandan, Sebauh and Bintulu, and is often used for transporting timber downriver.

Table 4.1 Location information of rain gauge stations in the Kemena and Tatau basins

Name	River basin	Latitude	Longitude	Missing data (dates)	Elevation (m)	Distance from sea (km)	Annual rainfall (mm)
Sangan	Tatau	2°46′0″	112°58′20″	–	19	39	3933
Rumah Keseng	Tatau	2°43′55″	113°5′5″	–	10	45	4464
Tatau	Tatau	2°52′35″	112°50′50″	25.12.2010–31.12.2010 (6d)	10	24	4502
Panai Binion	Kemena	2°51′58″	113°25′47″	–	49	60	4378
Bintulu/ Belaga road	Kemena	2°51′19″	113°41′23″	–	174	82	4372
Luang	Kemena	2°59′17″	113°10′50″	–	19	26	3569
Rumah Bansa	Kemena	3°3′25″	113°28′55″	–	24	47	4170
Bintulu, Department of Irrigation and Drainage	Kemena	3°10′20″	113°2′20″	–	7	1	4291
Bintulu new airport	Kemena	3°7′15″	113°01′11″	–	31	5	4554
Sebauh	Kemena	3°6′30″	113°15′45″	–	14	24	3612
Tubau	Kemena	3°9′35″	113°42′20″	–	17	59	4684
Tanjung Kidurong	Kemena	3°15′18″	113°4′38″	1.1.2006–23.3.2006 (82d)	7	0.5	5227
Labang	Kemena	3°15′35″	113°29′15″	–	14	33	3799
Similajau estate	Kemena	3°21′5″	113°26′55″	–	91	24	3589

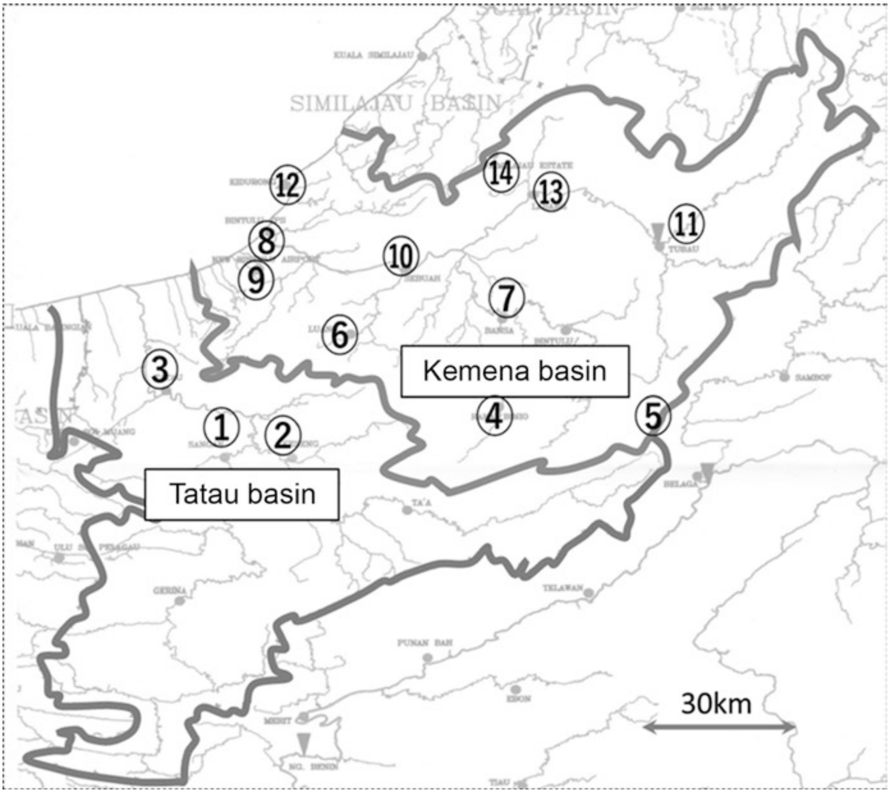


Fig. 4.9 Rain gauge stations in the Kemena and Tatau basins

Figure 4.11 shows the monthly rainfall at the 14 stations and the average rainfall of all stations for 2006 to 2010. Missing data for the stations at Tatau (6 days) and at Kidurong Tanjung (82 days) were complemented by the averaged values of the other 13 stations on the same days. According to the average rainfall, the interannual variability ranges from 3618 mm to 4552 mm for these 5 years. There was no dry season observed in 2007 and 2008; however, a severe drought occurred in June–September 2006 and a heavy rainy season in December 2008–February 2009. Rainfall patterns in 2006 and 2008 (Fig. 4.11) can be categorised as region B (Fig. 4.2), but the other years cannot be accurately categorised. The interannual irregularity in rainfall is thus a characteristic feature of hydrology in the Bintulu region.

Figure 4.12 shows the monthly rainfall during a severe drought period in June–September 2006 and a heavy rain period in December 2008–February 2009 at the 14 stations. Monthly rainfall during the drought period was recorded at <150 mm for at least 1 month at every station. Monthly rainfall in Sangan (no. 1) was recorded at <100 mm for 4 months, and at the Bintulu–Belaga road (no. 5) it was recorded at <100 mm for 3 months. The 30-d moving total of rainfall <100 mm is used as an

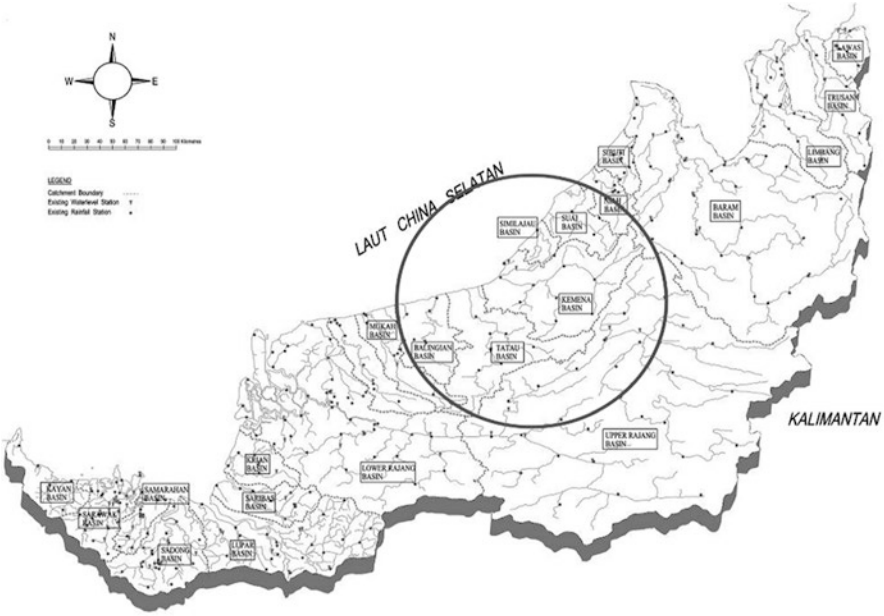


Fig. 4.10 River basins in Sarawak
Source: Reprinted from SIWRM (2008). Copyright 2008, SIWRM
Note: Kemena and Tatau river basins indicated by circle

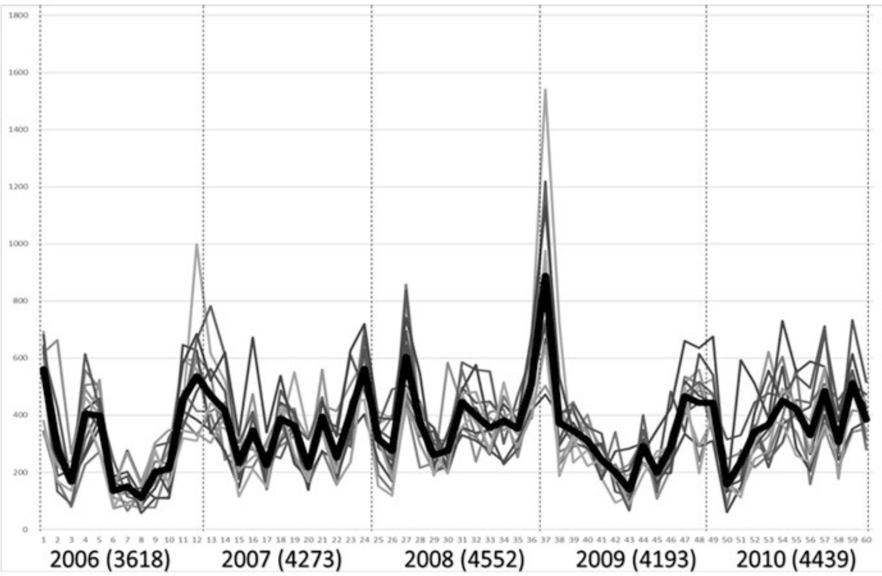


Fig. 4.11 Monthly rainfall at 14 stations, 2006–2010 (mm)
Notes: Average rainfall of all stations indicated by thick line
Figures in parentheses = annual rainfall

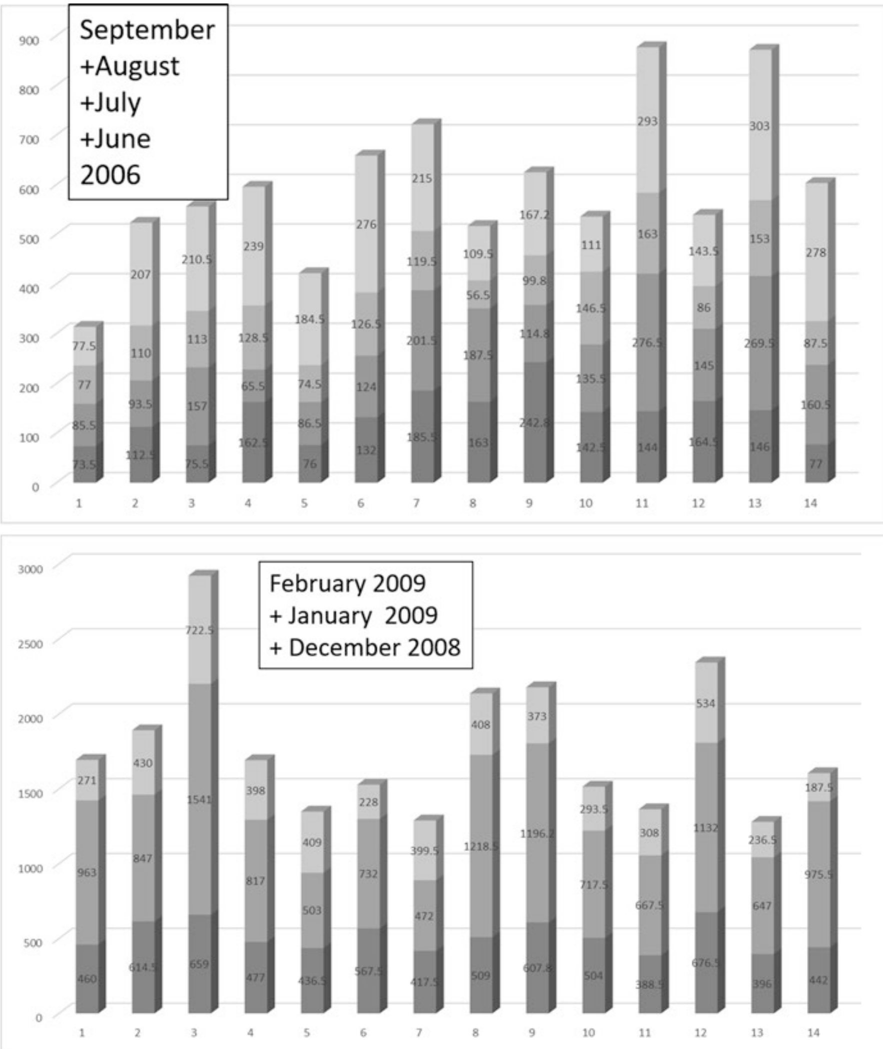


Fig. 4.12 Monthly rainfall during a drought period, June–September 2006, and a heavy rain period, December 2008–February 2009

indicator of limitations on plant growth in Sarawak (Kume et al. 2011). On the other hand, more than 2000 mm of total rainfall for 3 months was recorded at stations nos. 3, 8, 9 and 12 during the rainy period. The characteristics of these four stations are that they are located near the sea. Figure 4.13 shows the relationship between the distance from the sea (km) and rainfall (mm) in January 2009. There appears to be an inverse correlation between the two, though the coefficient of determination (R^2) was 0.4622 which suggests that more variables or factors influence the relationship between the distance from the sea and rainfall. According to historical flood events

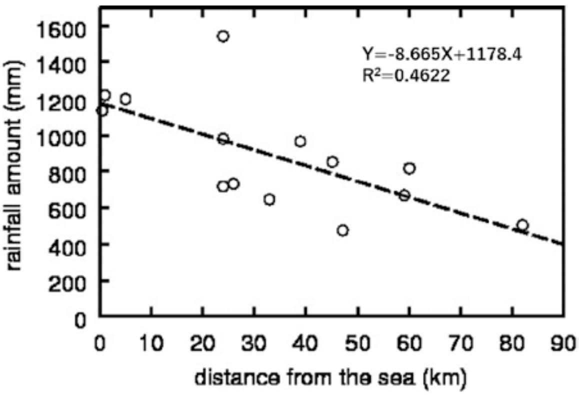


Fig. 4.13 Relationship between the distance from the sea (km) and rainfall (mm), January 2009

recorded from 1946 to 2013 by the Department of Irrigation and Drainage in Sarawak, many floods were reported mainly in the south coastal area of Sarawak in January 2009 (DID 2018).

4.5 Conclusion

Generally, Sarawak experiences a high annual rainfall with a variety of rainfall cycles. Both the maximum and minimum temperature anomalies indicate an overall warming trend in Sarawak that may affect future rainfall cycles and drought periods. Rainfall analysis at 14 stations reveals that drought rarely lasts more than a month in most parts of the Kemena and Tatau river basins. On the other hand, monthly rainfall <100 mm lasts for more than 3 months at two stations. The interannual variation and irregularity of drought and heavy rainfall events is a characteristic feature of the local environment.

References

Aldrian, Edvin, and R. Dwi Susanto. 2003. Identification of three dominant rainfall regions within Indonesia and their relationship to sea surface temperature. *International Journal of Climatology* 23 (12): 1435–1452.

Alhoot, Mohammed A., Wen Ting Tong, Wah Yun Low, and Shamala Devi Sekaran. 2016. Climate change and health: The Malaysia scenario. In *Climate change and human health scenario in South and Southeast Asia*, Advances in Asian human-environmental research series, ed. Rais Akhtar, 243–268. Cham: Springer.

Davidson, N.E. 1984. Short-term fluctuations in the Australian monsoon during winter Monex. *Monthly Weather Review* 112: 1697–1708.

Davidson, N.E., J.L. McBride, and B.J. McAvaney. 1984. Divergent circulations during the onset of the 1978–79 Australian monsoon. *Monthly Weather Review* 112: 1684–1696.

Department of Irrigation and Drainage Sarawak [DID]. 2018. Recorded flood events in Sarawak (P4). http://www.did.sarawak.gov.my/page-0-0-448-Recorded-Flood-Events-in-Sarawak-P4.html. Accessed 29 June 2018.

Gomyo, Mie, and Koichiro Kuraji. 2009. Spatial and temporal variations in rainfall and the ENSO-rainfall relationship over Sarawak, Malaysian Borneo. *SOLA* 5: 41–44.

Kume, Tomonori, Nobuaki Tanaka, Koichiro Kuraji, Hikaru Komatsu, Natsuko Yoshifuji, Taku M. Saitoh, Masakazu Suzuki, and Tomo'omi Kumagai. 2011. Ten-year evapotranspiration estimates in a Bornean tropical rainforest. *Agricultural and Forest Meteorology* 151: 1183–1192.

Kuraji, Koichiro, and Tomoaki Ichie. 2006. Kita Borneo niokeru ippan kishou no kisetsu hendou [Seasonal change of general meteorological factors in North Borneo]. *Suimon mizu shigen gakkaishi* [Journal of Japan Society of Hydrology and Water Resources] 19 (2): 95–107.

Liew, Juneng, and Fredolin T. Tangang. 2005. Evolution of ENSO-related rainfall anomalies in Southeast Asia region and its relationship with atmosphere–ocean variations in Indo-Pacific sector. *Climate Dynamics* 25 (4): 337–350.

———. 2006. The covariability between anomalous northeast monsoon rainfall in Malaysia and sea surface temperature in Indian-Pacific sector: A singular value decomposition analysis approach. *Journal of Physical Science* 17 (2): 33–37.

Sarawak Integrated Water Resources Management [SIWRM]. 2008. Location map of river basins in the state of Sarawak.

Trenberth, Kevin, and National Center for Atmospheric Research Staff [NCAR]. 2018. Climate data: Nino SST Indices (Nino 1+2, 3, 3.4, 4; ONI and TNI). https://climatedataguide.ucar.edu/climate-data/nino-sst-indices-nino-12-3-34-4-oni-and-tni. Accessed 29 June 2018.

Yamanaka, Manabu D. 2016. Physical climatology of Indonesian maritime continent: An outline to comprehend observational studies. *Atmospheric Research* 178/179: 231–259.

Yap, Kok Seng. 2017. Climate change and weather extremes – Challenges for Malaysia, Paper at UNU seminar on climate change and health, 4 May. https://i.unu.edu/media/iigh.unu.edu/news/5210/1_Yap_ClimateChangeExtreme_Wx.pdf. Accessed 29 June 2018.

Chapter 5
Multiethnic Society of Central Sarawak: An Ethnographic Analysis

Yumi Kato, Jayl Langub, Abdul Rashid Abdullah, Hiromitsu Samejima, Ryoji Soda, Motomitsu Uchibori, Katsumi Okuno, and Noboru Ishikawa

Abstract This chapter discusses the historical formation and current features of society in the Kemena and Tatau river basins in Bintulu, central Sarawak, where various ethnic groups live close together in a small area as a result of the historical migration of each group. We refer to previous studies and to interviews we conducted, mainly in 2011. Historically, Vaie Segan and Penan lived in the Kemena basin, Tatau lived in the Tatau basin, and Melanau and Malays came from the inhabited coastal areas. The basins' ethnoscape changed along with migrations of various ethnic groups—Kayan, Punan Bah, Bekatan, Chinese, Iban and Kenyah—from neighbouring basins. These groups migrated through various routes from the south (Bah River), southeast (Bukit Lumut), east (Belaga River), northeast (Tinjar River,

Y. Kato (✉)
Center for Arts and Sciences, Fukui Prefectural University, Eiheiji, Japan

J. Langub
Institute of Borneo Studies, Universiti Malaysia Sarawak, Kota Samarahan, Malaysia

Abdul Rashid Abdullah
Independent Researcher, Selangor, Malaysia

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

M. Uchibori
Hitotsubashi University, Tokyo, Japan
e-mail: mmuc@nifty.com

K. Okuno
Graduate School of Humanities and Social Sciences Society and Collaboration, Rikkyo University, Toshima, Japan

N. Ishikawa
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_5

Suai River and Brunei), west (various places including Mukah, Oya, Saribas and Sri Aman) and southwest (Pelagus and Merit rivers). Factors that triggered migration included disease, natural disasters, topography, hydrology, economic interests, political crises, trade, land shortages, access to natural resources and marital relationships. The current multiethnic society is shaped from these multiple migrations and intermarriage. People's ethnic backgrounds are therefore diverse in any given village, creating a coexistence of religions, languages, family histories and ethnic identities within a single community. There is thus wide variation within each ethnic group depending on the diversity of its members and the interaction with neighbouring communities.

Keywords Sarawak · Kemena River · Tatau River · Ethnoscape · Migration · Multiethnic society

5.1 Introduction

Ethnic diversity is a salient feature of the demography of Borneo. It has been formed through spatial mobility and the attendant social interaction and cultural contacts among various ethnic groups. In Borneo, rivers are the preferred means by which communication and movement of people take place, even though moving between two adjacent river systems is an arduous undertaking (Rousseau 1990; Metcalf 2010; Langub and Ishikawa 2017). This chapter examines the nature of the basin society in central Sarawak, Malaysia, with attention to the movements of people that have shaped the current multiethnic society along the Kemena and Tatau rivers. To examine the ethnoscape of the basin society, a dozen ethnic groups are examined—Chinese, Kayan, Kenyah, Iban, Punan Bah, Bekatan, Penan, Malay, Melanau, Vaie Segan, Tatau and Lugat.

Until recent times, the river system in Borneo bound people to the river basins as movement was limited by the navigability of the rivers and their tributaries. The navigability of rivers was such a crucial factor that there are discernible sociocultural differences between societies beyond the navigable point in the river system and societies inside the navigable area. Pointing out that each river basin forms a social unit, Jérôme Rousseau (1990) refers to such units as a 'basin society'. Economic activities, such as swidden agriculture and trading with other ethnic groups, were made possible by river travel. William Conley (1973) also notes that river networks were the main means of transportation for the Kenyah. Rousseau (1990) argues that river rapids constituted a social boundary by hampering the movement, communication and interaction between people upstream and those downstream, central Borneo being the area above the rapids. In most major Bornean rivers, the rapids are the uppermost point of navigability.[1]

[1] These rivers are still accessible beyond these rapids, but it requires great effort, skill and local navigational knowledge.

Fig. 5.1 Main rivers in Borneo
Source: Authors' field research

Meanwhile, people overcame the obstacles of river travel by moving through overland passes that connect tributaries in adjacent river systems (Lumenta 2008; Kato et al. 2014; Langub and Ishikawa 2017). The movement of people in Borneo until the early twentieth century, particularly in the interior, had been through overland jungle trails. Dave Lumenta (2008) argues, for example, that the Apau Kayan Kenyah migrated via diverse watershed trails in various directions from central Borneo.[2]

Rather than focusing on particular ethnic groups, this chapter describes the historical migration of multiple ethnic groups that shape the current ethnoscape in the Kemena and Tatau basins. The unit of analysis, then, is the vast basin society that formed in the area of the South China Sea coast and the Rejang and Baram rivers (Fig. 5.1). By investigating the river basins of central Sarawak, we offer a bird's-eye view of the conventional studies of migration and social formation in Borneo. The aim is to examine the historical movements across watersheds and within river systems in the formation of an ethnically diverse landscape. First, the historical trajectory of transriver migration and the social formation of each ethnic group are

[2] See also Langub and Ishikawa (2017) on movements of peoples from the Rejang, Balui and Belaga rivers to Baram, Sebauh, Bintulu and Tatau districts and vice versa.

analysed. We refer to results from previous ethnographical studies and information collected through interviews conducted mainly in 2011. Then the details of interactions between migrant ethnic groups and those endemic to each area, as well as the interactions among different ethnic groups, are discussed.[3] Multiple migrations into the basins have resulted in various ethnic enclaves that live together in a small area. Each community thus has intimate interrelations with others and is significantly affected by neighbouring groups. These processes were critical in the formation of riverine societies in the Kemena and Tatau river systems where we conducted fieldwork, and perhaps more generally in Borneo.

5.2 Geography and Social Background of the Kemena and Tatau Basins

The Kemena and Tatau rivers are located in Bintulu Division in central Sarawak. These are medium-sized rivers compared to others in Borneo. The main stream of the Kemena River is 200 km long (Mokudai et al., Chap. 2) and its catchment area is 6100 km^2. From downstream to upstream, the Kemena's main tributaries are the Sebauh, Pandan, Labang and Tubau rivers. Its name changes to the Jelalong River at its confluence with the Tubau River. To the south of the Kemena River lies the Tatau River, with the Belaga River to the east, the Tinjar River to the northeast and the Suai River to the north. The catchment area of the Tatau River is 5260 km^2. The main stream of the Tatau River changes to become the Kakus River at its confluence with the Anap River, of which the Sangan River is its the main tributary. The Tatau basin is flanked by the Rejang River to the southeast and the Kemena River to the northeast.

Bintulu is the third most populous division in Sarawak, with a population of approximately 230,000 in 2010. The Iban, who represent 39.6% of the population, are the major ethnic group, followed by the Chinese (14.5%), Melanau (9.7%), Malay (8.7%) and Bidayuh (1.2%) (Fig. 5.2 and Table 5.1). The Orang Ulu, comprising inland ethnic groups such as the Kayan, Kenyah, Bekatan, Punan Bah and Penan represent just over a mere 5% of the population. Though not significant statistically, there are also Bidayuh, Kelabit, Lun Bawang and other peoples from Sabah and peninsular Malaysia residing in Bintulu. Therefore, most of the ethnic groups in Sarawak are found in this division. The numbers of villages and population categorised by ethnic groups are based on governmental information, but we should note, as further discussed later, that it is difficult to define the boundaries of ethnic categories because of intermarriage and other interethnic relations.

[3] An ethnic group generally considered the earliest known inhabitants of an area in Bornean ethnography.

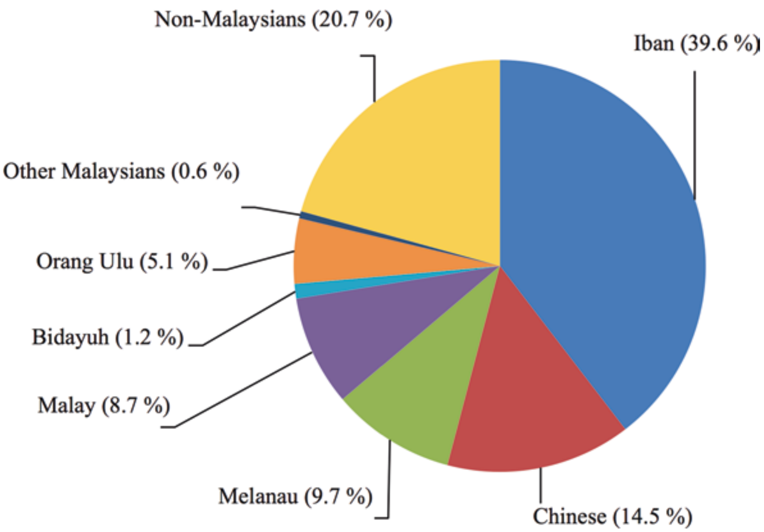


Fig. 5.2 Population composition by ethnic group in Bintulu Division
Source: Department of Statistics Malaysia, Sarawak Branch (2011). Modified from Kato et al. (2014). Copyright 2014 The Author(s)

Table 5.1 Demographic changes in Bintulu Division

	1879	1887	1947
Dayak	947	755	5276
Tatau	105	100	118
Punan	196	213	197
Lugat	75	112	–
Bekatan	50	157	268
Malay	–	8	426
Chinese	–	30	299

Sources: *Sarawak Gazette* (1879), Buck (1887) and Noakes (1947)
Note:
'Dayak' refers to Iban
'Punan' includes both Penan and Punan Bah

5.3 The Migration History of Ethnic Groups into the Kemena and Tatau Basins

5.3.1 Vaie Segan

'Vaie Segan' is often written as 'Vaee', 'Baee' or 'Segaan'. The people are also called 'Bintulu' (Rensch 2012), 'Melayu Bintulu' and 'Melanau Vaie'.[4] In Tatau,

[4] The name 'Bintulu' is assumed to come from the Vaie Segan words, '*metu ulau*' which means 'to smoke the head of the enemy'.

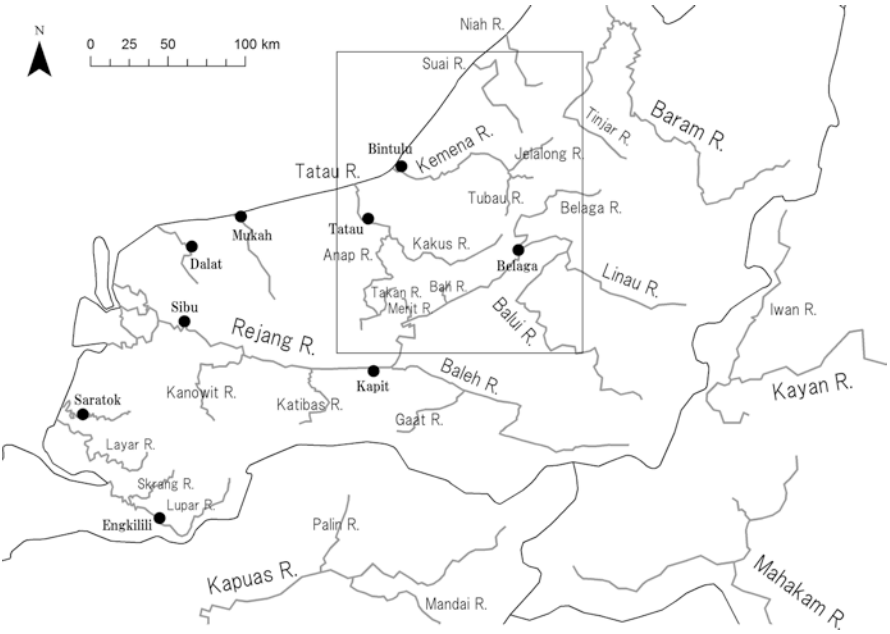


Fig. 5.3 Major rivers in northwest Borneo and central Sarawak
Source: Authors' field research. Modified from Kato et al. (2014). Copyright 2014 The Author(s)

they call themselves 'Melanau Telian' or just 'Telian' (Sandin 1980). The Vaie Segan were settlers in the coastal area of Bintulu and the lower Kemena River before the Penan inhabited this area (Sandin 1980). Before Bintulu was ceded to James Brooke from the Brunei sultanate on 11 August 1861, the Vaie Segan and the Malays from Brunei chiefly occupied the coastal area (*Sarawak Gazette* 1879: 38). Benedict Sandin (1980) reported that the Vaie Segan were grouped together with the Melanau when Bintulu was ceded. At the time, Bintulu comprised little but uncultivated land and was sparsely populated (Table 5.1). Today the Vaie Segan live in Bintulu town and around the lower Kemena, Pandan, Sebauh, Labang and Tubau rivers (see Fig. 5.3), yet their population is not officially reported.[5] The Vaie Segan language is used as the lingua franca in Bintulu.

According to a Vaie Segan oral legend, long ago they lived around Bukit Lumut, which is located 15 km northwest of Belaga bazaar, in the watershed of the Kakus and Pandan rivers (Fig. 5.4). They made their living by hunting and gathering, and sago was their staple food. Gradually they moved down to the Binyo river basin where they practised a nomadic lifestyle. Over time they continued moving down the Kemena River to the Segan River and finally settled in this area. On the other

[5] *Ethnologue: languages of the world* reports the Bintulu (Vaie Segan) population as 4200 (Lewis 2005). However, it assumed their population would be twice that which was reported.

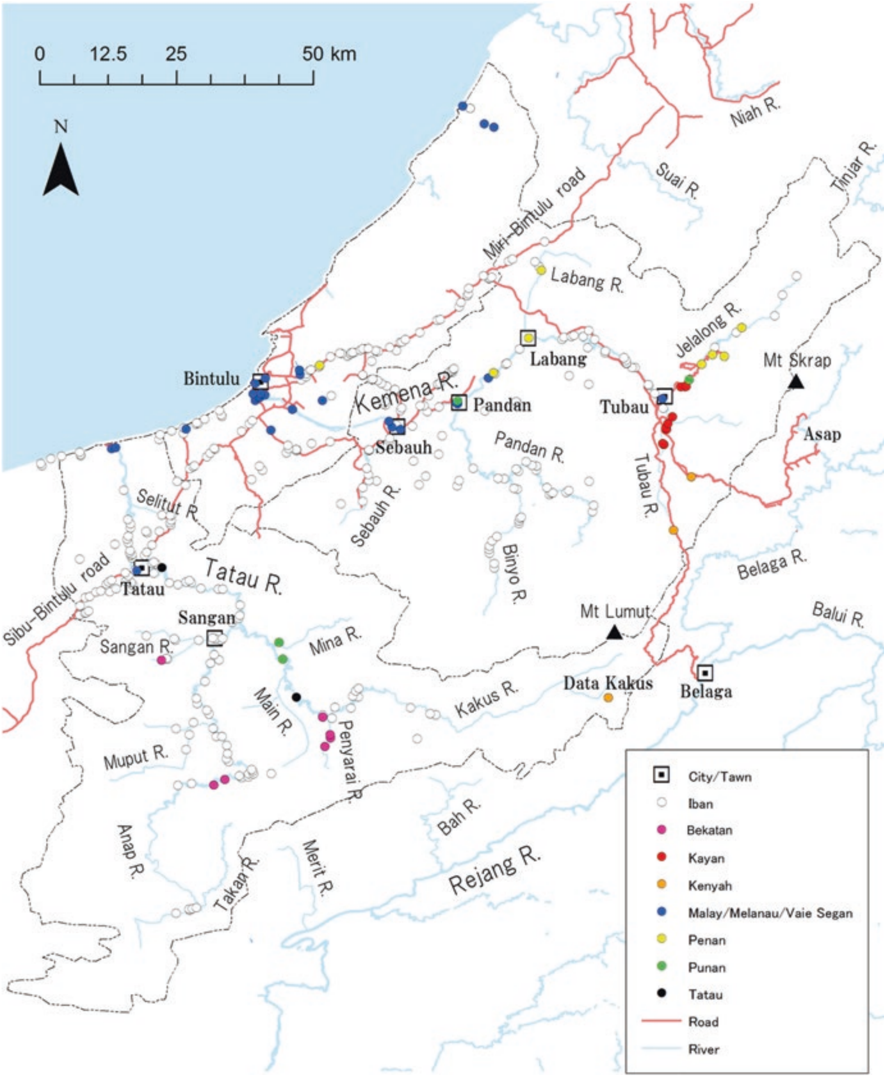


Fig. 5.4 Distribution of villages along the Kemena and Tatau rivers
Source: Authors' field research. Modified from Kato et al. (2014). Copyright 2014 The Author(s)

hand, a Melanau legend indicates that the Vaie Segan are descended from Tugau, who was the son of the great Melanau chief Semaun and lived at the mouth of the Rejang River. Tugau was also a well-known Rejang chief (Sandin 1980). Historically, the Vaie Segan lived in coastal areas, such as the Sibiu, Similajau, Nyalau, Sebatang and Sepadok rivers and engaged in trade with *nakodah* traders from Brunei during the era of the Brunei sultanate to the mid-nineteenth century (Sandin 1980). They were frequently threatened by Illanun pirates and raided, slaughtered and captured while they mainly lived by fishing (*Sarawak Gazette* 1879: 38; Sandin 1980).

Interaction with Malay traders from Brunei during the sultanate era, and later with the Arab missionaries who came to the area in the 1930s to sell agate, encouraged the Vaie Segan to convert to Islam. Islamisation advanced in accordance with the number of intermarriages with Malays from Brunei, and the number of Arabs living among the Vaie Segan gradually increased (Sandin 1980). Sandin reports that intermarriages of the Vaie Segan have been very common since the Brunei sultanate era. These relations include marriages with Melanau, Malay, Penan, Iban as well as other ethnic groups. Many Vaie Segan married Penan along the Miri–Bintulu road, at the Labang and along the Jelalong River. In these cases, the Penan tended to convert to Islam. Therefore, they are sometimes called Melayu.

5.3.2 Tatau

The Tatau are the oldest settlers along the Tatau River and their total number is not clear. Historically, there were six different groups in the Tatau basin,[6] but the current Tatau population is much smaller than earlier (Sandin 1980). Almost all have alliances with other ethnic groups. Today the descendants of the Tatau are scattered in various longhouses. Some of them live in Bekatan longhouses along the Sangan and Penyarai rivers. The longhouses located upstream of Tatau town and along the middle part of the Kakus River are originally Tatau longhouses (Cramb and Dian 1979). However, the current official record reports them as belonging to the Iban or Punan Bah.

Historically, the Tatau were scattered along the Tatau River. They lived along the Takan River, along the upper Anap River and along the Penyarai River at the upper Kakus River, where they had a larger population. They began to move downstream much earlier than such groups as the Punan Bah and Bekatan. Although burial poles of the Tatau, called *kliering* and *salong*, are scattered along the Tatau River and along the middle basins of the Tatau, the upper Anap and the Penyarai, most of them have fallen when heavy floods hit this area. These poles are the traces of previous Tatau habitation along the entire Tatau River.

A legend from the Tatau explains that the reason for depopulation and migration was a natural misfortune. Several generations previously, a Tatau man killed a huge serpent and shared the meat with other villagers along the Penyarai River. Soon after almost all the villagers became cursed (Sandin 1980). Much earlier they had another stroke of misfortune when they lived downstream of the Tatau River. There, legend has it that they caught a caterpillar as big as a wild boar, which they cooked and ate. After this incident, their newborn babies began to die one after another, the

[6]These six Tatau groups are: Tatau Murung Data; Tatau Murung Tugang; Tatau Murung Legan; Tatau Murung Muput; Tatau Murung Kakus; and Tatau Murung Balio (Kedit and Chang 2005).

curse precipitating a sharp decline in their population.[7] Aside from these legends, outbreaks of smallpox in the Main and Selitut rivers also took many Tatau lives. This predicament led them to intermarry and live scattered among various ethnic groups (Kedit and Chang 2005).

5.3.3 Penan

The Penan are one of the earlier settlers in the Kemena basin. They live mainly along middle reaches of the Kemena, Labang and Jelalong rivers, and alongside the Miri–Bintulu road. Two features distinguish the Penan in this area from those in other areas. First, they started settling and rice farming between the 1820s and mid-1860s, relatively earlier than other groups (Needham 1965; Cramb and Dian 1979). Second, they have always lived close to other ethnic groups. Due to their exposure to other Muslims, a number of Penan have adopted Islam as their religion.

The migration history of the Penan started in Usun Apau and they are assumed to have moved and lived along the Seping River (Needham 1965; Brosius 1986, 1990, 1992). They then split, with some migrating to the Tinjar River and some to the Jelalong River. There are four Penan villages along the Jelalong today with a total population of 400 (Bintulu District Office 2011). Some Penan in Jelalong believe that their ancestors once lived in the caves of Bukit Sekalap and gradually moved down the Kebulu River. In contrast, others recognise their ancestors as having migrated from the Suai River. They lived nomadically before along a considerable range of the Kemena River. The Penan in Rumah Julaihi on the Jelalong River today recognise that their ancestors used the great open space between the confluence of the Jelalong and Kemena rivers as settlements.

The Penan along the Labang River are called ‘Orang Labang’ or ‘Labang’. The Punan Bah call them ‘Laveang’ (Nicolaisen 1976). This term later included the Vaie Segan because of intermarriages between the Penan and Vaie Segan.[8] The Penan along the upper Labang River report that they had once lived along the Latap River near the watershed of the Labang and Suai rivers. They also sometimes lived in the cave near the headwaters of the Labang River. They began to move downriver gradually. According to Kayan in Tubau, the ancestors of the Penan at the confluence of the Labang River lived around Tubau when the Kayan migrated from along the Balui River in the 1800s (see also Needham 1965).

The Penan along the Miri–Bintulu road, who now number 500, once lived along the Sepadok River and moved around that area (Bintulu District Office 2011). They settled relatively earlier and many of them gradually turned to Islam, which indicates

[7] According to an oral presentation by Motomitsu Uchibori at a seminar on biomass society and planted forest, Kyoto University, Japan, 2013.

[8] Ida Nicolaisen (1976) explains that when the Punan Bah began to settle in Pandan, they called the Penan people ‘Laveang’. Soon they started to use ‘Segaan’ for the Penan (Laveang) when many of them began to intermingle with Malays and Melanau and became Muslims.

they had intimate contact with Muslims such as the Vaie Segan (Cramb and Dian 1979). Many Penan along the Kemena River and some along the Jelalong River are Muslims. They are called Penan-Muslims. Some people along the upper Labang River said they converted to Islam in the 1940s and 1950s on the advice of the Vaie Segan *imam* at the time. Other people then followed gradually from the 1960s to the 1980s. Currently only a few people hold their old *adat* (customs).

Intermarriages are common in Penan, so the residents have a multiethnic identity. There are close marital ties between the Vaie Segan and Penan in the villages along the Miri–Bintulu road, the middle Kemena River and the Jelalong River (Langub and Ishikawa 2017). These people speak both Penan and Vaie Segan languages. In contrast, intermarriage with the Iban is more common along the upper Jelalong River because the Iban groups migrated to the upper Jelalong River around 1960 (see Langub, Chap. 7). In this case, many people speak both the Penan and Iban languages. In addition, some people follow the Iban custom of *gawai*. Apart from the Iban, some groups of Kejaman and Punan Bah also joined the Penan along the Jelalong River, which is why some Kajang-style burial poles are found there (Needham 1965; Cramb and Dian 1979).

5.3.4 Malays and Melanau

The Melanau and the Malays are the third and fourth largest ethnic groups, constituting 15% and 14% respectively of the total population in Bintulu Division. The total population of Malays and Melanau is 19,000 in Bintulu district and 1600 in Tatau district (Bintulu District Office 2011; Tatau District Office 2011). There are 33 Malay and Melanau villages in Bintulu district and three Melanau and two Malay villages in Tatau district. Most of the villages in Bintulu district are located in Bintulu town and Sebauh. They also live along the middle reaches of the Kemena, Tubau and Nyalau rivers. Villages are located at the confluence of the Tatau River and Tatau town in Tatau district.

Some of them recognise themselves as descendants of Malays from Brunei who came to trade and then settled in this area during the Brunei sultanate era. Malay traders (*nakodah*) from Brunei actively engaged in trade with inland people at that time (Low 1884; Langub and Ishikawa 2017). They used ridge trails to enter the Jelalong river basin and their eventual destination of Belaga. It is assumed that the Muslim population gradually increased with intermarriages between coastal and inland settlers in this region.[9] The ethnic category of Malay has a flexible meaning in Sarawak, as a person who is Melanau, Penan or some other ethnic group will be regarded as Malay once he or she converts to Islam. Therefore, those who are referred to as Malay may actually have a variety of different ethnic backgrounds.

The Melanau are some of the earliest settlers in Sarawak and claim that the name 'Melanau' was given to them by the Malays of Brunei. The name is thought to

---

[9] However, currently there are also many Malays who migrated from other regions in Malaysia.

signify 'coast dweller' as opposed to 'inland dweller'[10] (Morris 1993). The Melanau lived in today's Sarawak before other groups, such as the Iban or Kayan, moving in from today's Kalimantan. The coastal Melanau and the Kajang groups in the interior relate that their ancestors migrated from central Borneo and founded a Kajang kingdom from which the coastal Melanau broke away (Morris 1993). The Melanau were scattered along the Rejang River in the nineteenth century. It is assumed that they arrived in Bintulu and other coastal areas from the middle part of the Rejang River, and from such places as Kapit and Kanowit, as early as the sixteenth century (Morris 1976). The Melanau were fishermen in the coastal areas. They exported sago flour to Malay traders from Brunei and later to Singapore (Morris 1953). Meanwhile, after the conquest of the coastal district by James Brooke, Rajah of Sarawak, in 1861, the Melanau and Malay carriers and traders were replaced by Chinese immigrants, who were protected by the Brooke government (Morris 1993).

From a linguistic viewpoint, Calvin Rensch (2012) reports that 74.8% of Melanau words are similar to the Kajang language, 66.8% to the Bintulu (Vaie Segan) language and 65.5% to the Penan language.[11]

5.3.5 Kayan

Kayan longhouses are found only along the Kemena River in this region, not along the Tatau River. Two Kayan longhouses are located along the lower reaches of the Jelalong River and eight longhouses are located along the middle reaches of the Tubau River. The total population in those eight longhouses is about 1500 (Bintulu District Office 2011). They have strong affinal ties with the Kayan along the Balui River. Meanwhile, intermarriages with other ethnic groups such as the Iban, Chinese and Malays are also very common. The motherland of the Kayan is the upper Kayan River in North Kalimantan, Indonesia (Rousseau 1990). They were assumed to have entered the Balui basin by the 1780s, from whence they moved to the Tubau River around the 1800s. The Kayan fled conflicts with other groups seeking better farmland (Cramb and Dian 1979; Rousseau 1990).

According to the oral tradition of the Kayan in Tubau, they had lived in Uma Juman before they entered Tubau, where they now have five longhouses.[12] The Labang (Penan mixed with Segan, who currently live at the confluence of the Labang and Kemena rivers) had lived along the Tubau River when the Kayan migrated there.

---

[10] They refer to themselves as '*a liko*' which means 'the people of a river, a district or a village' depending on the context.

[11] According to Rensch (2012), Kajang is composed of Lahanan, Kejaman, Sekapan and Tatau. For some time it has been thought that Kajang is related to Melanau in the Melanau-Kajang linguistic grouping. Well acquainted with the Melanau languages, Iain Clayre (1971) was of the opinion that the 'links [of Sekapan] with the Melanaus are hard to dispute'. Jennifer Alexander (1989) states that 'the Kajang, including the Lahanan, also claim to have close links to the Melanau'.

[12] These are the Uma Juman, Uma Awai, Uma Paku, Uma San and Uma Tevo.

There, the Kayan saw the scattered remains of Labang durian gardens. The Kayan held a peacemaking ceremony with the Labang because an interethnic battle had heated up. After the ceremony, the Kayan were not allowed to live lower than the confluence of the Tubau and Kemena rivers, whereas the Labang were confined to the Kemena River no higher upstream than its confluence with the Labang River.

5.3.6 Punan Bah

The Punan Bah are different from the Penan. While the Penan have led a nomadic life, the Punan Bah have practised swidden agriculture for 300–400 years (Nicolaisen 1976). Their homeland is the Mandai River of today's West Kalimantan, Indonesia (Nicolaisen 1976). Punan Bah oral narratives point to the Punan River, a right bank tributary of the Bah River, as the myth of origin of the Punan Bah people (Nicolaisen 1976: 65). A quarrel many generations ago between two brothers, Kavu Oko and Kavu Oka, principal leaders of the Punan Bah, over a very beautiful young woman, Oro Saka, caused the Punan Bah to migrate to different directions. One group moved to West Kalimantan and settled at the Madai River and refer to themselves as Punan Madai (Nicolaisen 1976: 78). Today three groups remain along the Rejang River: Punan Bah at the confluence of the Bah and Rejang; Punan Biau at the confluence of the Biau and Rejang; and Punan Sama at the confluence of the Sama and Rejang. Two longhouses are located along the middle the Kakus River in the Tatau basin. One longhouse is located in Pandan and another is along the Jelalong River in the Kemena basin. The government census shows that the population in these four longhouses is 1400 (Bintulu District Office 2011; Tatau District Office 2011).

The Punan Bah along the Kakus River migrated from the Bah River, a tributary of the Rejang River, around the 1820s (Sandin 1970; Nicolaisen 1976). Their migration coincided with the Kayan migration to the Balui basin from Usun Apau. The political unrest and ethnic conflicts against the Kayan triggered a move on the part of some Punan Bah aristocrats to the Kakus River, upstream of the Bah River (Sandin 1970; Nicolaisen 1976). At that time areas along the Tatau River were inhabited by the Tatau. Soon the Punan Bah began to settle along the Kakus River and their aristocrats married Tatau women living there (Sandin 1970). Therefore, Punan Bah longhouses along the Kakus are recognised as originally Tatau (Sandin 1970). The Punan Bah derived political advantage from these marital relations in the Kakus area (Sandin 1970).

The Punan Bah along the Pandan River also came from the Bah River around the same period (Sandin 1970). The Kemena basin was then dominated by the Penan and the Vaie Segan. Punan Bah aristocrats married Vaie Segan women along the Pandan River (Sandin 1970), encouraging other Punan Bah, whose territory was encroached on by the Iban, to follow them and migrate to Pandan. There are many Punan Bah burial poles between Pandan and Labang. The Punan Bah along the Jelalong River migrated much later. They are also originally from the Bah River. In the first half of the twentieth century, the Punan Bah lived in Belaga bazaar under the protection of the Brooke government against Iban encroachments. Occasionally they visited the Punan Bah along the Pandan River and gradually migrated to areas along the Jelalong River (Nicolaisen 1976; Cramb and Dian 1979). The Punan Bah got permission from the neighbouring Kayan to settle in the Jelalong basin (Cramb and Dian 1979).

People from the Bah, Kakus, Pandan and Jelalong rivers frequently visit each other. The Punan Bah along the Kakus River reported that people from along the Bah River have come to sell food, and there are also strong affinal ties among these two groups (Nicolaisen 1976). Meanwhile, intermarriage is also common between the Punan Bah and other ethnic groups like the Kayan, Iban, Tatau and Penan.

5.3.7 Bekatan

The Bekatan are sometimes called ‘Bukitan’ by the Iban (Freeman 1970), although they call themselves Bekatan. There are eight Bekatan longhouses in the Kemena and Tatau basins. Two of them are located along the middle part of the Anap River, one along the upper Sangan River and five along the Penyarai River. The total population of these eight longhouses, according to the government census, is about 1200 (Bintulu District Office 2011; Tatau District Office 2011).

The Bekatan are assumed to have originally lived along the Mandai River in West Kalimantan. They entered Sarawak via the Palin River upstream of the Kapuas River and settled along the Batang Ai River for many years (Sandin 1967; Khoo 2000). When the Iban came to this area seeking settlements by practising headhunting, some groups of Bekatan fled as far as the Katibas, Kanowit, Gaat and Baleh rivers (Sandin 1968). Some became allies of the Iban and married into Iban communities, whereas others fought against the Iban and became the Iban’s slaves.

The Bekatan of Sarawak are categorised into four groups based on the route they took to enter Sarawak from West Kalimantan.[13] The Bekatan on the Kemena and Tatau rivers arrived via different routes. The Bekatan in Sangan migrated from Saribas, Oya, Mukah and Balingian (Cramb and Dian 1979). Before the Bekatan arrived in the Tatau basin, the Tatau and Punan Bah dominated in this area. When the Iban arrived later, some groups of Bekatan chose to give in, while others who could not live together with Iban moved further upriver of the Sangan or the Penyarai rivers (Sandin 1967, 1968).

The Bekatan along the Anap River are assumed to have migrated from the Rejang basin via the upper Merit River, and they settled along the upper Takan River in the middle of the nineteenth century (Fig. 5.4). There are Bekatan cemeteries along the

[13] They are the Bekatan Malong, Bekatan Sut, Bekatan Kanyau and Bekatan Ngemah. The Bekatan along the Anap River are said to be the Bekatan Malong and Bekatan Sut, while those along the Kakus River are said to be the descendants of the Bekatan Malong. Once living in Kanowit, the Bekatan Ngemah assimilated into the existing Iban community, beginning in 1945 (Sandin 1968).

Dakat River, near the confluence with the Takan River. The Tatau had lived along the Takan River before the Bekatan came, but they had already moved to the Penyarai River by the time the latter arrived. The Bekatan along the Takan River gradually moved down and settled along the middle part of the Anap River when the Brooke government pushed them downriver. Some of them then migrated further to the Penyarai River.

The Penyarai basin had been the home of the Tatau people before the Bekatan arrived. Later the Tatau left the Penyarai basin fearing a natural misfortune or curse and moved downriver of the Tatau. Then the Bekatan came over from the middle Anap River and filled the area with the consent of the Punan Bah. The Bekatan along the Tatau River have strong marital relationships with the Bekatan along the Rejang River, as intermarriage with other ethnic groups is extremely common.

5.3.8 Lugat

The Lugat are the smallest ethnic group in this region. Rather than forming a long-house village, they live together with the Chinese, Tatau, Bekatan or other ethnic groups through intermarriage. Unlike the Tatau, the Lugat have always had a small population in this area. There are several Lugat families in Tatau old town and all of them are of mixed descent with the Chinese. Some Lugat descendants married Tatau and Punan Bah along the Kakus River, while others married Bekatan along the upper Sangan River (Cramb and Dian 1979).

Historical sources indicate that the Lugat were hunter-gatherers along the Gaat River, a branch of the Baleh River (Low 1882; Brooke 1907; Freeman 1970). By the late nineteenth century, they had started to live along the middle part of the Rejang together with the Sihan, Bekatan and other ethnic groups (Low 1882). Apart from this group, Hugh Brooke Low also reported that a group of Lugat lived along the upper Balui River in the 1880s (Low 1882). The leader of this group was named Tama Kawit. Later they moved to the Tatau basin and oscillated between the Tatau and Rejang basins in the early twentieth century (Owen 1905).

The oral history of the Lugat indicates that a long time ago they lived in Keragan Kawit, an area upriver of the Anap River, and were led by Kawit. Later, one of Kawit's children married a Bekatan from the upper Sangan River and another child married a Tatau. The Lugat who are living in Tatau old town today recognise themselves as descendants of the latter child of Kawit. As this historical background shows, their small population and intermarriage mean that Lugat descendants are scattered in various villages in this region, even in other cities. They use the Lugat language, which is similar to Sihan. Only a few families still use their language today, but despite their small population it is still the language predominantly used among the family.

5.3.9 Chinese

The Chinese are the second largest ethnic group, constituting 14% of the total population in Bintulu Division. Government statistics show that there are 32,000 Chinese in Bintulu district and 2000 in Tatau district (Bintulu District Office 2011; Tatau District Office 2011). Most of them live in town, while others live in small bazaars upriver like Sebauh, Pandan, Labang, Tubau, Sangan and Muput, and even in local longhouses. The Chinese are divided into various dialect groups like Hakka, Fuzhou and Teochew, based on where each of them comes from. Officially, Chinese settlements in Bintulu district began in the middle of the nineteenth century when the Brooke sovereign state was formed in 1861 (Linggang 2008). Before that, Malays from Brunei were the dominant traders in this region.

Historically, the Chinese have lived in Tatau town since the era of the Brunei sultanate. They were active traders, dealing with many kinds of forest products and conducted business with the local people in the upriver areas (Chew 1990; Ichikawa 2014; Ishikawa and Ishikawa, Chap. 6). Trade in forest products such as dammar resin, hard latex from jelutong and rattan in those bazaars was managed chiefly by the Teochew. The Fuzhou came to the Kemena basin from Sibu in the 1920s with the support of the Brooke government in order to cultivate rice and rubber in Sebauh. They were keen businesspeople and soon began to trade sawn *belian* ironwood as roofing (*attap belian*) (see Ishikawa and Ishikawa, Chap. 6). In the upriver areas, there were many cases of intermarriage and adoption of children between the Chinese and indigenous people (Ichikawa 2014). It is therefore common to find people who have parents from both the Chinese and other ethnic groups.

5.3.10 Iban

The Iban are the largest ethnic group in Bintulu Division, making up 40% of the total population (Bintulu District Office 2011; Tatau District Office 2011). The Iban are dispersed throughout the Kemena and Tatau basins, except those living along the upper Tubau and upper Kakus rivers. The Iban are comparatively new settlers in the Kemena and Tatau basins. They are assumed to come from the Kapuas River of West Kalimantan (Pringle 1970). They came to the southwest area of Sarawak by the fifteenth century and settled along the Lupar, Skrang, Saribas, Layar and Rejang rivers, and then gradually spread into all areas of Sarawak in the century that followed (Freeman 1970).

In the nineteenth and early twentieth centuries they practised head-hunting vigorously in accordance with their expansion and, according to Ulla Wagner (1972), in reaction to Brooke rule. Numerous Iban migrated from various areas of western Sarawak, including along the Seratok, Sarikei, Skrang, Sibu, Engkilili, Saribas and Layar rivers, to the Kemena and Tatau basins after the basins were ceded to the Brooke state in 1861. The Brooke government admitted them, after which they used a sea ship to migrate in the basins (Linggang 2008). In contrast, some Iban along the upper Anap River came across the ridges on foot from the Pelagus River in the Rejang basin (Fig. 5.4). People along the upper Anap River have a more intimate connection with the Rejang basin than the Tatau do.

The Iban repeatedly split, with intermittent periods of consolidation, and gradually migrated to upriver areas, except for the Jelalong, Tubau and Kakus rivers, as both the Brooke and British colonial governments did not authorise the Iban to migrate into these areas. This changed with the formation of the federation of Malaysia with Malaya, North Borneo and Singapore in 1963. Some Iban decided to migrate further eastwards to the Baram River after they had settled in these regions for a while.

Aside from the cases of group settlement, several families migrated and lived together with earlier settlers. The Iban from Saribas migrated to the upper Jelalong River in the 1960s. They settled along the Supati River, on the upper Merurong River. After they had lived there for 3 years, they split into four groups because of flooding and insufficient water volume. About 20 families moved to the Tinjar River via the upper Merurong River; eight families remained along the Merurong, four families lived with the Penan in Memulau along the Kebulu River, and the remaining three families moved to the Kemena River, on the upper Sauh River. Therefore, many Penan in the Jelalong basin live alongside the Iban (Langub and Ishikawa 2017).

5.3.11 Kenyah

The Kenyah are comparatively new settlers in the Kemena and Tatau basins. Ten Kenyah longhouses are in Bintulu Division, with a population of 2500 (Bintulu District Office 2011; Tatau District Office 2011). Four longhouses are located along the Tubau River and another six longhouses are located along the upper Kakus River. The Kenyah originally came from the Iwan River of North Kalimantan and moved to Sarawak several centuries ago (Armstrong 1991; Lumenta 2008). Along with their *peselai* (trading journey) custom, they have spread through various areas in Borneo (Lumenta 2008).

The first migration of the Kenyah into Tubau is estimated to have been around 1965. They migrated from Long Bangan along the Belaga River. In contrast, the Kenyah in Long Tebila, mostly upriver of Tubau, migrated in 1978. They split from the Uma Nyaving in Long Linau on the upper Balui River. Some Kenyah from Long Dungan and some Kayan from Tubau also joined this village. When they migrated into Tubau they had a ceremony of presenting the customary knife (*malat dop*) to the earlier Kayan and Kenyah settlers in Tubau. The three Kenyah longhouses along the Bakun highway were separated from this group.

The migration of the Kenyah to the Kakus River was much later, in 1985. Originally from Indonesia, they moved into Long Busang along the upper Balui River in the 1960s and to Long Dungan in the lower Belaga bazaar in 1976 (Langub

2003; Kedit and Chang 2005). From there, some migrated to Data Kakus along the upper Kakus River, seeking a better economic and social situation.

5.4 The Ethnohistory of Migration into the Kemena and Tatau Basins

The migration and high mobility of people in Borneo have been discussed in relation to the Iban's *bejalai* (Freeman 1970; Kedit and Chang 2005) and the Kenyah's *peselai* customs (Lumenta 2008). It is obvious that high mobility and migration are not limited to these two ethnic groups, as demonstrated above. Therefore, we do not see this phenomenon as an essential marker. There are many migration forms and factors that cannot be explained by these *bejalai* and *peselai* customs alone. Here we offer a comprehensive discussion of the variety of migration forms, factors and routes among multiple ethnic groups.

5.4.1 Migration Factors and Migration Chains to Neighbouring Basins

The factors that triggered migration differed for each group and they include trade, disease, natural disaster, topography, hydrology, economic interest, political crisis, land shortage, access to natural resources and marital relations. Most cases of Iban migration into the basins occurred under Brooke rule, particularly in the first part of the twentieth century, as they were seeking sufficient land and forest resources (Kedit and Chang 2005). The migration of the Kenyah into the basins in 1965 and 1985 also stemmed from a search for new land (Kedit and Chang 2005). In contrast, most of the Malays from Brunei, the Melanau and the Chinese migrated into the basins to carry out trade in forest products (Low 1884; Chew 1990; Morris 1993).

We should note that migration is not a singular occurrence; it forms chains and affects other groups' migrations into other basins. For instance, the migration of the Kayan and Iban to the Rejang River pushed other groups to the Tatau and Kemena basins. The Kayan migrated to the Tubau River because they were trying to avoid conflicts with the other groups in the Balui basin (Cramb and Dian 1979). A group of Punan Bah also decided to move to the Kakus River to evade political insecurity and conflicts between the Kayan (Nicolaisen 1976). Some of the Iban migrated because they faced disturbances along the Skrang River in the nineteenth century. A group of Bekatan and Punan Bah migrated into the basins after fleeing from head-hunting by the Iban in the nineteenth century (Sandin 1967, 1968; Nicolaisen 1976). Other smaller ethnic groups were also gradually edged toward the Kemena and Tatau basins (Kedit and Chang 2005). For instance, the Tatau reported that they remained deep in the forest when the Iban and Bekatan were actively head-hunting in the basin. Thus, political crises, battles and invasions were all highly significant factors in propelling migration in this region.

Diseases, natural misfortune and marital relationships were also factors. For instance, the Tatau moved because of both natural misfortunes and smallpox outbreaks (Sandin 1980). The Penan in Kebulu also moved downriver after they had been infected by malaria. The Iban along the Ayam River moved after all the members of one family died. As noted, marital relationships are often a factor for individual migrations. Whereas the Iban, Kayan and Kenyah moved as relatively large groups of several households, the Punan Bah increased their population in the Kemena and Tatau basins through marriage with Vaie Segan and Tatau peoples. This individual traffic and intermarriage would eventually increase their populations enough to form villages. For this reason, the villages in the basins have many people from various backgrounds (Kato et al. 2014; Langub and Ishikawa 2017). The multiethnic society in the Kemena and Tatau basins is thus a result of historical migrations of various peoples that were triggered by various reasons.

5.4.2 Migration Routes and Navigating Knowledge

People migrated into the Kemena and Tatau basins through various routes, not merely according to the river confluences (Kato et al. 2014; Langub and Ishikawa 2017). They entered by way of different watersheds, such as in the south (Bah River), southeast (Bukit Lumut), east (Belaga River), northeast (Tinjar River), north (Suai and Niah rivers), west (various places in west Sarawak) and southwest (Pelagus and Merit rivers). Here we discuss the consequences of the watershed traffics between Tatau, Kemena basins and neighboring basins (Fig. 5.3).

Several key migration points connect with neighbouring rivers. In the Tatau basin, these important points were the upper Anap, Takan, Penyarai, upper Kakus and Pandan rivers (Fig. 5.4). For instance, the Iban along the upper Anap River have strong connection with Rejang River basin. They frequently used trails through Bukit Tugong, which were once major routes connecting the Pelagus, Merit rivers in Rejang basin and Anap River in Tatau basin. The Iban indicated that even the Kenyah had used this trail for head-hunting and, as evidence, the Kenyah cemeteries still remain to this day. The Iban of the upper Tatau basin traded various forest products in the Kapit bazaar but not the Tatau bazaar. People in Rumah Mawang explained that they went up the upper Iran River, a tributary of the Pelagus River, where they would spend the night. Then they went up the Dapu River, a tributary of the Iran River, and across the ridge to the Kilong River, a tributary of the Anap River. Even today this group of Iban frequently visit Kapit bazaar. Their children attend elementary school in Merit and secondary school in Kapit, and many people find jobs in Kapit town. Therefore the Tatau basin and Rejang basin are strongly connected through the watershed trails.

The Bekatan on the Anap River frequently used the watershed route between the Merit and Takan rivers, and the Punan Bah along the Balui River used a watershed route to the Kakus River. People in Rumah Ado reported that they used to stay overnight along the upper Kakus River, then traversed the ridge to the Puti River where it shares a watershed with the Sematai River, a tributary of the Bah River (Fig. 5.4). The Punan Bah along the Kakus River also used a watershed route between the upper Mina and upper Pandan rivers.

In the Kemena basin, one of the major routes for accessing the Rejang basin is the upper Tubau River. This route was very important for Malay traders from Brunei during the Brunei sultanate era whereby they traded various forest products with people in the Balui basin (Low 1884; Ishikawa 2010; Ishikawa and Ishikawa, Chap. 6). Not only the Brunei traders but also local people used this route to access both the Tubau and Belaga bazaars. For instance, the Kayan in Rumah Wan reported that they had trade connections with the Chinese in Bintulu as well as in Belaga. When they traded with the Chinese in Belaga they used ridge trails from Tubau to Belaga. It took two nights, as they first went up the Tubau River and crossed the ridge to the Sepakau River, a tributary of the Belaga River. They would stay overnight at the Kenyah village at Long Unan. Then they would go to the Sepakau River, a tributary of Belaga River, traversing the latter to spend another night at the Kenyah village at Long Bangan. Then they arrived at Belaga. The Punan Bah in Jelalong have also used this route before. They usually spent a night at the Sepakau River, a tributary of the Belaga; they would then cross Bukit Ketirap and spend another night at the confluence of the Unan and Tubau rivers, journeying along the latter the following day. The Kayan in Tubau had a trade network with the Penan on the upper Belaga River, which they accessed via the upper Pesu River. Another route between the Jelalong and Belaga rivers is the upper Kebulu River.

In addition, the Penan in Jelalong had close relationships with the Penan on the Suai River. They visited each other via the watershed of the Bersukat and Suai rivers, and although they still have relations there they have not used this trail for many years (Soda et al. 2012; Langub and Ishikawa 2017). Along the upper Jelalong, there is another route for accessing the Tinjar River in Baram. The Penan on the Labang River were close to the Penan on the Suai River as well, as they visited each other via a watershed for the Spod, Kelida and Suai rivers. They have not, however, used this jungle trail for long time.

The geographical reason that enables this watershed traffic is the lack of high ridges. Generally, there are no high ridges in inland Sarawak except the Iran Mountains and the Tama Abu range. The numerous low ridges thus enabled people in the region to cross these ridges relatively easily to access neighbouring rivers. For example, the ridge between the Pelagus and Anap rivers is about 130 m. The ridge between the Merit and Anap rivers is about 150 m and that between the Bah and the Kakus rivers is about 250 m. The major ridge route between the Belaga and Tubau rivers is 180 m, and the ridge between the Sauh and Suai rivers is 190 m.[14]

Besides the major watershed routes described above, we may assume that each small group used vertical river navigations that could not be traced in this study. For example, the Sihan in Belaga have various inland routes for visiting the Penan Talun on the upper Balui River (Kato 2011). These are not watershed routes but involve vertical river navigation. Therefore, migration routes intersected many rivers, even to reach the

[14] According to GPS data obtained by Osamu Kozan.

upper reaches of the same basin. These repeated migrations and remigrations within the same basin shaped the current mosaic of the ethnoscape in the basins. Even though the people may live in a river basin, they have a wealth of knowledge about the topography—the slope of hills, direction of ridges and valleys, location of precipices and the most suitable paths to any destination. Using such knowledge, they may decide to move to another basin across the ridge.

Previously, the main transportation for people in a basin society was the river (Rousseau 1990), but watershed trails were also frequently used (Lumenta 2008). The numerous watershed routes described here show that people walked, explored and searched in the jungle every day (Uchibori 2004). Terrestrial navigation and transport has had a similarly important role as river transport. Many local people reported that use of the watershed trails has declined since road construction has developed. However, their knowledge about navigating ridges and rivers is still enormous and it is a quite different knowledge from that needed for navigating road networks.

5.5 Conclusion: Multiethnic Society and Identity

The Kemena and Tatau basins are intersections of the histories of various ethnic groups that have shaped the current ethnoscape. We have described the historical trajectories of each ethnic group separately to make the diversity of each group's track and form of migration comprehensible. However, the most notable feature of the Kemena and Tatau societies is their multiethnicity. Ethnic boundaries are considered indistinguishable because of repeated splits and consolidations of goups, frequent interethnic marriage and the residence of various ethnicities in the same longhouse, making clear demarcations of ethnicity difficult. A multiethnic society is shaped by multiple factors, including community formation, its categorisation, ethnonyms (autonyms and exonyms) and everyday interactions with different groups. Here, we discuss why a multiethnic society formed in this area and the features of multiethnic society in the basins.

5.5.1 Comparison of Multiethnic Societies in the Kemena and Tatau Basins and Those in Other River Basins in Borneo

Multiethnic societies are found in many other basins in Borneo, such as on the Balui, Baram, Limbang and Trusan rivers in Sarawak, and on the Kayan, Mahakam and Kapuas rivers in Kalimantan (Rousseau 1990; Langub 2003; Metcalf 2010). The distinguishing feature of the river basin society in this study is the small area and resulting closeness of groups. The Sekapan, Kejaman, Lahanan, Punan Bah, Bekatan, Tanjung, Sihan, Seping, Ukit, Kayan, Kenyah, Penan and Punan Vuhang, which form the multiethnic society along the Balui River, have communities that are more scattered than those in the Kemena and Tatau basins (Rousseau 1990; Langub 2003). They are also more compartmentalised in each area. For instance, the Iban longhouse are limited to the lower Balui River and the Penan settlements are scattered along the upper reaches of each tributary (Langub 1975, 1990, 1996). In contrast, the Iban are found on almost every upper tributary in the Kemena and Tatau basins, and Penan settlements are also found in the lower basin of Kemena. This configuration thus makes the multiethnic society more intricate in this area.

There are undoubtedly several reasons for the closeness of the multiethnic communities in the Kemena and Tatau basins, but here we consider following three perspectives. The first has to do with the geographical features of the basins. The Kemena (200 km) and Tatau (300 km) rivers are of medium length compared to the larger Rejang and Baram rivers. Therefore, compartmentalisation of ethnic groups is less possible on the former two, which means that many different ethnic groups live together in a small area. The larger rivers also provide more resources for the people who live there, whereas the shorter rivers lack a variety of natural resources and the resulting trade. However, the Kemena and Tatau basins are long enough to sustain several trading points, or bazaars, at the main confluences. They thus tend to attract various people within the same basin who gather to attend to the necessities of daily life.

A second reason is the historical trajectories of the basins. The Kemena and Tatau rivers are located along the middle coast of Sarawak. The Iban migrated from the Kapuas River to the Lupar, Skrang, Saribas, Layar and Rejang rivers in Sarawak (Pringle 1970). On the other hand, the Kayan migrated from the Kayan River to the Balui basin by the 1780s (Rousseau 1990). These population flows from the south (Iban) and the east (Kayan) pushed the people along the Rejang River northward to the Tatau and Kemena basins. The Iban engaged in bloody conflicts and peacemaking with the Kayan, Kenyah and Kajang in Rejang until 1924 (Reece 1982). Therefore, Iban expansions were limited in the lower Balui, owing to Kajang domination in the middle Balui and Kayan expansion from the upper Balui River. However, the Iban expanded into the relatively upper reaches of the Kemena and Tatau basins. They were prevented from entering the upper Jelalong and Kakus rivers during the colonial era, though the ban was lifted after Malaysia was formed. There is no expansion of the Kayan into the Tatau basin and no strong Kajang domination in the Kemena basin. This expansion of the Iban into the upper reaches has affected the population flow and the formation of a multiethnic society in the basins.

The third reason is population growth in Sarawak, which is now four times what it was in the 1960s. It is one reason for the frequent splits and conjunctions among longhouses. Population growth also contributed to the high population density in river basin longhouses. Thus much face-to-face contact occurs daily between various ethnic groups.

5.5.2 Coexistence of Multiple Ethnic Groups Within a Community

Another feature of the multiethnic society around the Kemena and Tatau rivers is the coexistence of people with multiple ethnic backgrounds living together within a single community. In addition to many villages of various ethnic groups living together in the river basins, the individuals in one village alone often have diverse ethnic backgrounds. Generally, various factors drive people from diverse backgrounds to live together in one longhouse, as Peter Metcalf (2010) points out. A community is made up of members with various family and personal histories, religions and languages. Naturally, every community has a variety of peoples, including Penan, Vaie Segan, Tatau, Malays, Melanau, Punan Bah, Bekatan, Chinese, Kayan, Iban, Kenyah and so on. Various configurations shape multiethnic communities. These tend to happen through two main processes: intermarriage and the conjunction of families or groups with other ethnic groups.

The first phenomenon is generally observed in the basins. For example, intermarriage with the Vaie Segan is common among the Penan along the Miri–Bintulu road and the confluence of the Labang and Kemena rivers (Nicolaisen 1976). Intermarriage with Chinese is predominant in Lugat (Kedit and Chang 2005). The Tatau and Iban or Punan Bah have common affinal relations (Kedit and Chang 2005). The second phenomenon is observed among the Penan in Jelalong and among the Kenyah in Tubau. A group of Kejaman from along the Balui River and Iban from Saribas conjucted and lived together with the Penan community along the Jelalong (Cramb and Dian 1979). The Kayan and Kenyah from along the Balui River formed a longhouse together on the upper Tubau River. In short, the coexistence of several groups in a community may be observed in many places in Borneo (Rousseau 1990; Egay 2008; Metcalf 2010; Kato 2011). This situation means that multiple religions, languages, family histories and ethnicities coexist within a community. In other words, each ethnic group (as well as language) has a high variation according to the diversity of its members and the effects from neighbouring communities.

Individual people also have multiple ethnic identities owing to the high percentage of intermarriage and the frequent splits and conjunctions of communities. It is more difficult therefore for ethnic categories to be used to stereotype a particular group. Meanwhile, there is also variety and syncretism within individuals. This phenomenon of coexistence cannot be described by the political ideology of an ethnic category. Nonetheless, it is necessary to consider the consequences of coexistence between peoples who have many different but some shared histories, languages, religions and identities.

Acknowledgements This research was conducted with the permission of the Sarawak Planning Unit. We thank the Institute of East Asian Studies at Universiti Malaysia Sarawak for supporting this research. Research funds were provided by Grant-in-Aid for Scientific Research (S) 22221010 'Planted Forests in Equatorial Southeast Asia: Human-nature Interactions in High Biomass Society' from the Japan Society for the Promotion of the Science. An earlier version of this paper was published in 2014 (Kato et al. 2014). We greatly appreciate the people in the villages we studied for their understanding and help with this research.

References

Alexander, Jennifer. 1989. Culture and ethnic identity: The case of the Lahanan of Ulu Belaga. *Sarawak Museum Journal* 40 (61): 51–59.

Armstrong, Rita. 1991. People of the same heart: The social world of Kenyah Badeng. PhD thesis, University of Sydney.

Bintulu District Office. 2011. *Profil Daerah Bintulu*.

Brooke, Charles Vyner. 1907. Report on Rejang Dyak affairs. *Sarawak Gazette* 37 (502): 245.

Brosius, J. Peter. 1986. River, forest and mountain: The Penan Gang landscape. *Sarawak Museum Journal* 36 (57): 173–184.

———. 1990. Penan hunter-gatherers of Sarawak, East Malaysia. *AnthroQuest* 42: 1–7.

———. 1992. The axiological presence of death: Penan Gang death-names. PhD thesis, University of Michigan.

Buck, Q.A. 1887. Bintulu monthly report, 1 June 1. *Sarawak Gazette* 257: 107–109.

Cramb, Rob A., and J. Dian. 1979. *A social and economic survey of the Bintulu extension region—Report no. 8*. Kuching: Department of Agriculture, Planning Division.

Chew, Daniel. 1990. *Chinese pioneers on the Sarawak frontier, 1841–1941*. Singapore: Oxford University Press.

Clayre, Iain. 1971. The Kajang kingdom: All the Melanau peoples, where do they all come from? *Sarawak Gazette*, 31 August.

Conley, William Wallace. 1973. The Kalimantan Kenyah: A study of tribal conversion in terms of dynamic cultural themes. DPhil thesis, Fuller Theological Seminary.

Department of Statistics Malaysia, Sarawak Branch. 2011. *Yearbook of statistics Sarawak 2010*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

Egay, Kelvin. 2008. The significance of ethnic identity among the Penan Belangan community in the Sungai Asap resettlement scheme. In *Representation, identity and multiculturalism in Sarawak*, ed. Zawawi Ibrahim, 155–157. Kuching: Dayak Cultural Foundation and Kajang: Persatuan Sains Sosial Malaysia.

Freeman, J.D. 1970. *Report on the Iban*. London: Athlone Press, LSE Monographs on Anthropology 41.

Ichikawa, Tetsu. 2014. Nettai baiomasu shakai ni okeru kajin community no tokucho ni kansuru oboegaki: Kemena Jelalong suikei no chosa kara. Nettai baiomasu shakai [Note on the features of Chinese community in tropical biomass society: Cases in Kemena Basin]. *Equatorial Biomass Society* 20: 1–8.

Ishikawa, Noboru. 2010. Rekishi no naka no baiomasu shakai—nettai ryūiki shakai no dansei to isō ten'i [Tropical biomass society in history: Resilience and transformation of riverine communities]. In *Chikyū-ken seimei-ken ningen-ken: jizoku-tekina seizon kiban o motomete* [Geosphere/biosphere/humanosphere: Seeking a sustainable and survival base], ed. Kaoru Sugihara, Shuichi Kawai, Yasuyuki Kōno, and Akio Tanabe, 251–280. Kyoto: Kyoto University Academic Press.

Kato, Yumi. 2011. Malaysia Sarawak ni okeru shuryo saishumin shakai no henka to jizoku: Sihan jin no jirei kenkyu [Change and resilience of a hunter-gatherer society in Sarawak, Malaysia: A case study of the Sihan]. DPhil thesis, Kyoto University.

Kato, Yumi, Hiromitsu Samejima, Ryoji Soda, Motomitsu Uchibori, Katsumi Okuno, and Noboru Ishikawa. 2014. Ethnoscape of riverine society in Bintulu Division. *Equatorial Biomass Society* 8: 1–14.

Kedit, Peter Mulok, and William Wei Say Chang. 2005. *The peoples of the planted forest in Sarawak*. Kuching: Forest Department Sarawak.

Khoo, Khay Jin. 2000. The Begetan: A preliminary profile. Paper presented at a seminar on Community Profile of Ethnic Minorities, Centre of Modern Management, Kuching, 25–27 May.

Langub, Jayl. 1975. Distribution of Penan and Punan in the Belaga district. *Borneo Research Bulletin* 7 (2): 45–48.

———. 1990. A journey through the nomadic Penan country. *Sarawak Gazette* 117 (1514): 5–27.

———. 1996. Penan response to change and development. In *Borneo in transition: people, forests, conservation, and development*, ed. Christine Padoch and Nancy Lee Peluso, 103–120. Kuala Lumpur: Oxford University Press.

———. 2003. *The Orang Ulu of Belaga district*. Kuching: Majlis Adat Istiadat, Chief Minister's Office.

Langub, Jayl, and Noboru Ishikawa. 2017. Community, river and basin: Watersheds in northern Sarawak as a social linkage. In *Borneo studies in history, society and culture*, ed. Victor T. King, Zawawi Ibrahim, and Noor Hasharina Hassan, 365–384. Singapore: Springer.

Lewis, M. Paul, ed. 2005. *Ethnologue: Languages of the world*. 16th ed. Dallas: SIL International.

Linggang, Francis. 2008. Early Iban migration to Bintulu. Iban Cultural Heritage. https://gnmawar.wordpress.com/jerita-lama/iban-migration-peturun-iban/early-iban-migration-to-bintulu/. Accessed 17 June 2018.

Low, Hugh Brooke. 1882. Journal of a trip up the Rejang. *Sarawak Gazette*, 1 July, 7 (189): 52–54.

———. 1884. Mr. Low's November [1883] diary. *Sarawak Gazette*, 1 April, 14 (219): 30–33.

Lumenta, Dave. 2008. The making of a transnational continuum: State partitions and mobility of the Apau Kayan Kenyah in central Borneo, 1900–2007. DPhil thesis, Kyoto University.

Metcalf, Peter. 2010. *The life of the longhouse: An archaeology of ethnicity*. New York: Cambridge University Press.

Morris, H.S. 1953. *A report on a Melanau sago producing community in Sarawak*. Vol. 9. London: Her Majesty's Stationery Office, Colonial Office Research Study.

———. 1976. The coastal Melanau. In *Essays on Borneo societies*, ed. Victor T. King, 37–58. Oxford: Oxford University Press.

———. 1993. Melanau. In *Encyclopedia of world cultures*. Volume 5: *East and Southeast Asia*, ed. Paul Hockings, 177–181. New York: G.K. Hall.

Needham, Rodney. 1965. Death-names and solidarity in Penan society. *Bijdragen tot de Taal-, Land- en Volkenkunde* 121 (1): 58–76.

Nicolaisen, Ida. 1976. Form and function of Punan Bah ethno-historical tradition. *Sarawak Museum Journal* 24 (45): 63–95.

Noakes, J.L., ed. 1947. *A report on the 1947 population census (Sarawak and Brunei)*. Kuching: Government Printing Office.

Owen, D.A. 1905. Bintulu annual report (February 1905). *Sarawak Gazette* 35 (471): 81.

Pringle, Robert. 1970. *Rajahs and rebels: The Ibans of Sarawak under Brooke rule, 1841–1941*. London: Macmillan.

Reece, R.H.W. 1982. *The name of Brooke: The end of White Rajah rule in Sarawak*. Kuala Lumpur: Oxford University Press.

Rensch, Calvin. 2012. *Melanau and the languages of central Sarawak*. Dallas: SIL International.

Rousseau, Jérôme. 1990. *Central Borneo: Ethnic identity and social life in a stratified society*. Oxford: Clarendon Press.

Sandin, Benedict. 1967. *The Sea Dayaks of Borneo: Before White Rajah rule*. London: Macmillan.

———. 1968. The Bukitans—II. *Sarawak Museum Journal* 16: 111–121.

———. 1970. The Tatau people of the Kakus and Anap rivers, Fourth Division, Sarawak. *Sarawak Museum Journal* 18 (36–37): 162–164.

———. 1980. *Living legends: Borneans telling their tales*. Kuala Lumpur: Dewan Bahasa dan Pustaka Malaysia, Cawangan Sarawak.

Sarawak Gazette. 1879. Bintulu. 23 May. 153: 31–40.

Soda, Ryoji, Jayl Langub, Okuno Katsumi, Osamu Kozan, Hidetoshi Yanagihara, and Noboru Ishikawa. 2012. Intaa ribarain sosaiety ron no kochiku ni mukete: Suai Jelalong kan no ekusupedishon. Nettai baiomasu shakai. [Toward the construction of inter-riverine society study: Expedition between the Suai and the Jelalong]. *Equatorial Biomass Society* 10: 1–6.

Tatau District Office. 2011. *Profil Daerah Tatau.*

Uchibori, Motomitsu. 2004. Rivers and ridges: Changes in perception of natural environment among the Iban of Sarawak. In *Comparative study on the local perception of natural environment and landscapes among peoples of Sarawak*, ed. Motomitsu Uchibori, 1–25. Report on the research conducted in Sarawak with grant-in-aid for scientific research, Japan Society for the Promotion of Science (2000–2003).

Wagner, Ulla. 1972. *Colonialism and Iban warfare*. Stockholm: OBE-Tryck Sthim.

Chapter 6
Commodified Frontier: Jungle Produce Trade and Kemena Basin Society, Sarawak, in History

Mayumi Ishikawa and Noboru Ishikawa

Abstract This chapter elucidates that the interior regions of Borneo have long been incorporated into the world economy through jungle produce trade, contrary to the naive presumption that they were inhabited by isolated forest dwellers. Through an analysis of colonial government documents and reports from the 1880s, it chronicles the status of the changing trade in commodities such as rattan, jelutong and *belian* (ironwood) prior to the advent of the exploitative timber economy along the Kemena River and its tributaries. Records of local events and interactions among different ethnic groups, merchants, officials, migrants and others show how people exercised agency, and employed strategies to respond to changing market trends, fluctuating prices and regulations imposed by the nascent colonial state. The riverine commons functioned as a critical interface linking global commodity chains with the peoples in the interior. The local history of the river basin illuminates trajectories through which Sarawak has become what it is today.

Keywords Sarawak · Kemena basin · Jungle produce trade · Rattan · Jelutong · *Belian*

6.1 Introduction

The phrase 'jungle produce trade' may evoke exotic sentiments in some, while others may imagine dwellers in pristine rainforests, isolated except for brief, measured contacts with traders from the outside world. A careful look into the history of jungle produce trade in Sarawak, Malaysian Borneo, however, reveals rational economic undertakings of local people and resource utilisation and management by the

M. Ishikawa (✉)
Center for Global Initiatives, Osaka University, Osaka, Japan
e-mail: ishikawa@iai.osaka-u.ac.jp

N. Ishikawa
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_6

colonial state. Contrary to the naive presumption of isolation, the interior regions of Borneo had long been incorporated into maritime networks of Malay *nakodah* traders and subsequently Chinese mercantile spheres (N. Ishikawa 1999, 2010; M. Ishikawa 2005). Local people engaged in trade were thus not mere collectors of jungle produce but rather workers in the jungle. Their labour was marshalled in pursuit of commodities that, despite chronic fluctuations, commanded high prices at times in international markets.

This chapter narrates the historical and ethnographic meanings of the jungle produce trade by focusing on the formation and development of Kemena basin society in central Sarawak. Unlike many earlier studies, we do not deal with jungle produce trade solely from an economic perspective. Rather, the discussion recounts the interaction between local people and the environment over time and, from such a micro-level analysis, assesses the impact of the colonial authorities over resources. As the trade had much to do with the development of the riverine society, attention is also given to the issues of migration, labour mobilisation and social relations among various ethnic groups.

6.2 The Kemena Basin Society

Figure 6.1 shows an overview of the Kemena River in central Sarawak. Starting from the coastal area, there are the local communities of Sebauh and Tubau, and the smaller villages of Pandan and Labang, with government offices, small government clinics and primary schools. There were once express boat services from Bintulu to Sebauh and Binyo. It took about three and a half hours by regular express boat (or 1 h by a boat with a 250 cc outboard engine) from Bintulu to Tubau and 2 h from Bintulu to Binyo. With the completion of the Bakun–Bintulu road in 2001, it now takes only one and a half hours by car from the central market of Bintulu to local communities adjacent to Tubau market. Travelling upriver by road quickly became the norm and express boat services were terminated in 2005.

Kemena basin society is ethnically diverse, with each ethnic group occupying a particular niche specific to their way of life. Major social groups of the state of Sarawak are represented in the basin: Malays, Vaie Segan, Melanau, Iban, Orang Ulu (Kayan, Kenyah, Punan Bah and Penan) and Chinese (Fuzhou, Teochew, Cantonese and Hakka) (Table 6.1).

With the exception of multiethnic Bintulu township, where numerous ethnic groups live side by side, each particular ethnic group occupies an identifiable segment of the riverine society as if to form a gradation from downriver to upriver. The exception are the Iban who now occupy almost all segments of the Kemena River and its tributaries (Fig. 6.2). There are no Orang Ulu communities downriver from the Punan Bah settlement in Pandan.

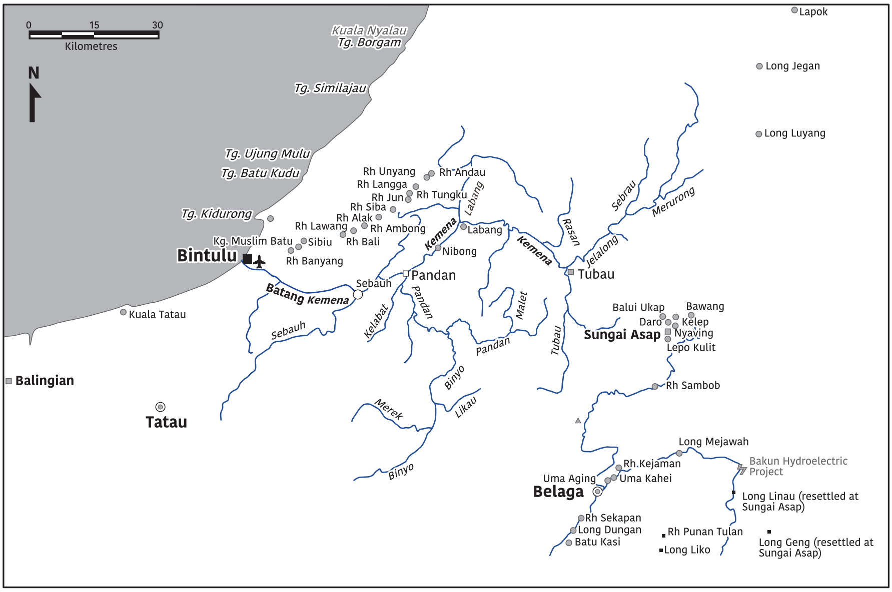


Fig. 6.1 Villages and towns in the Kemena basin

Table 6.1 Population of Sebauh subdistrict by ethnic group

Ethnic group	Population	Percentage
Iban	13,722	54.0
Malay	1035	4.2
Bidayuh	151	0.6
Melanau	987	3.8
Orang Ulu	3183	12.5
Chinese	1081	4.3
Indian	34	0.1
Others	89	0.3
Foreigners	5132	20.2
Total	25,414	100.0

Source: Department of Statistics Malaysia, Sarawak Branch (2010). Courtesy of Sebauh Subdistrict Office
Notes: Foreigners are mostly plantation workers from outside Malaysia. Sebauh was upgraded to a district in 2015

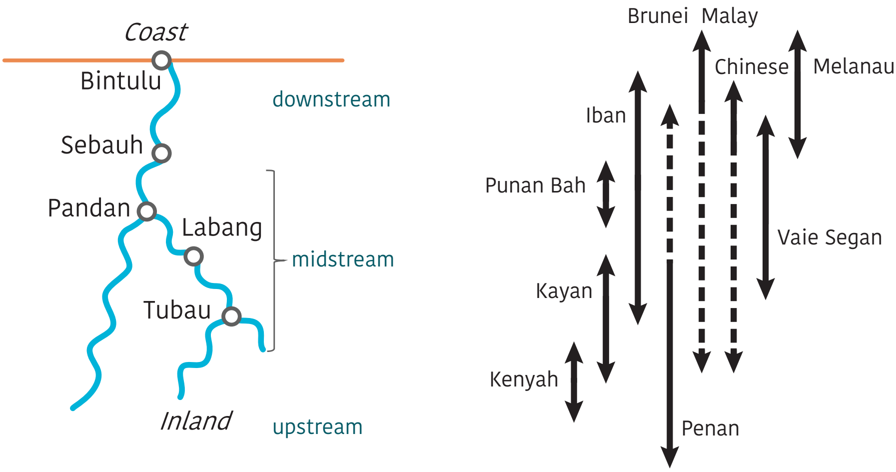


Fig. 6.2 Ethnic groups in the Kemena basin

6.3 Chronology of Jungle Produce in the Kemena Basin

This section details the early trade of jungle produce that had been important for the economy of the communities in the Kemena river basin. This early trade left deep and lingering impacts on the area's social relations and formations prior to the advent of the timber economy in the 1970s. After briefly reviewing older, more 'traditional' jungle produce trade from the Brunei sultanate and Brooke colonial periods, three jungle products—namely rattan, jelutong and *belian*, which were the major items of pre-timber trade in the area (and transitioned from one item to the other)—are discussed in more detail.

6.3.1 Early Trade with Brunei Malay Traders

Historically speaking, the downriver development of the Kemena basin is a relatively recent phenomenon. Earlier development started in the interior over a century ago, when coastal Bintulu was plagued with rampant piracy. At that time, people searched for wealth upriver and commodities were accumulated in the upriver Tubau bazaar, which is now considered part of a hinterland. Tubau was in fact the most important trade centre in the basin as all trade between Brunei and the upper Rejang River passed through the area (Nicolaisen 1976: 85). The Jelalong tributary also connected the Kemena River with the Baram River, which James Brooke, the first rajah, called 'the great camphor producing area of Sarawak' (Pringle 1970: 45n). Malay traders from Brunei were actively involved in trading with local people in the area. As noted by Hugh Low (1968: 323), ‘bees-wax and camphor are reported to be so plentiful, that the Dayaks never collect them until the arrival of the trader from the sea’. The extraction of jungle produce for trade was thus first initiated by ‘the trader from the sea’ and later carried out ‘in response to the demands of the European market’ (Hose and McDougall 1912: 200).

6.3.2 The Brooke Government and the New Jungle Produce

Sarawak acquired Bintulu and the interior rivers beyond from Brunei in 1861. With the erection of a fort and bazaar in Belaga in 1884, the control of the trade within central Sarawak, which the Sultan of Brunei had exercised for centuries, collapsed and was taken over by the Brooke administration (Nicolaisen 1983: 197). Trade in the upper Rejang thereafter ceased to pass through Tubau although it continued to function as a juncture for the Kemena river trade and as an alternative trade route from the upper Rejang to the coast.[1]

Over time, major items of trade in the Kemena riverine society changed from older traditional produce such as beeswax, camphor, India rubber, raw sago and gutta-percha to rattan, jelutong and then timber (starting with hardwood such as *belian* ironwood for roofing). Although jungle products such as camphor, raw sago and gutta-percha were already reported as scarce in the 1880s, trade in these items continued, albeit on a smaller scale, at times commanding high prices and supplementing the regional commodity trade. Subsequently, rattan became the major item of trade in the Kemena basin from the 1880s, with a peak period in the early twentieth century. Rattan retained its importance in the regional economy up to the First World War, when its price surged with an increased demand for shell baskets in European battlefields. The focus of trade, however, gradually shifted to jelutong and ironwood from the beginning of the twentieth century. By 1917 it was reported that ‘jungle products such as gutta percha, India rubber, etc. are nearly worked out except in a few districts where the trees are conserved’ (*Sarawak Gazette* 1917: 59).

6.3.2.1 Rattan

The rattan trade was reportedly already brisk in the 1880s (Drage 1883: 24). It was expected to provide impetus to the upriver trade while other jungle produce became scarce (Drage 1886: 26). However, it did not always thrive; the earlier rattan trade provided little hope to traders in the deserted Tubau bazaar with only two shops operating in 1882 (Drage 1883: 24). Shortly afterwards, the number of rattan shops increased to nine, only for four of them to close down soon after, while two others were on the verge of bankruptcy within a year (Gueritz 1884: 13). This kind of

[1] For a detailed discussion on the riverine networks of central–northern Sarawak, see Jayl Langub and Noboru Ishikawa (2017).

uncertainty seems typical of all jungle produce trade up to the age of timber commerce. The unsteady yet rampant nature of the rattan trade affected and characterised the whole Kemena economy from Tubau down to coastal Bintulu during this period. In the case of the early rattan trade, the unsteady market trend was due partly to high transport costs, the negative effects of the 'advance system', in which loans were often not paid back in kind through delivery of jungle produce, and rivalry among traders, especially between Brunei Malays and Chinese, as well as price fluctuations.[2]

By the late 1880s rattan profits lured other inhabitants of the upriver area. More local people including the Kayan and Kenyah started to collect rattan. The Kayan brought rattan daily to Tubau bazaar (*Sarawak Gazette* 1884: 120). The Kenyah, who had up to then traded chiefly in items such as gutta-percha, bezoar stones, rhinoceros horns, *parang* machetes and mats, expressed a willingness to bring rattan to the Bintulu bazaar if en route safety and fair trade were assured by the government (*Sarawak Gazette* 1885: 24; Drage 1886: 59).

A real boost to the rattan trade was the influx of the Iban to the Kemena region in the early 1900s. The migration of the Iban to the Kemena tributary, which started in 1900 and continued up to early 1903, completely changed the ethnic landscape in the region. The *Sarawak Gazette* (1900: 210) reported:

> 'This influx of Dyaks will soon affect a great change up-river, the merest fringe of jungle along the bank having been cleared in past years. Numbers of them have been buying rice from Bazaar which they are to re-pay in gutta or rattans. I calculate the number of Dyaks here at over 2000 men, women, and children,' according to H. R. A. Day, the Resident in Bintulu in 1900.[3]

Prior to this mass immigration, the Brooke government had long prohibited the unauthorised movement of the Iban. It was only in the early twentieth century that the government finally allowed the Iban to move to the Bintulu area following their population explosion in the Second Division (Iban areas around Batang Lupar and Saribas). Iban migration was said to be permitted and condoned by the Brooke government with the Iban being described as better jungle produce collectors in the interior. Unlike the Kayan, whom British officials considered 'too indolent to work produce in the interior themselves', 'hardworking and ubiquitous Dyaks' were expected to trek into the interior en masse, as if on a culturally instituted *bejalai* journey to search for jungle produce (*Sarawak Gazette* 1895: 195).[4]

The Iban first reached Sibu, then journeyed up to coastal Mukah and Oya to Bintulu. From the Bintulu coast they moved upwards, following tributaries of the Kemena River. They soon occupied the river banks and built longhouses in Sebauh, Pandan and upriver in Labang. Some settled as far up as the Tubau and Jelalong rivers. Due to the sudden population increase, rice was in short supply in bazaars, and

---

[2] The rivalry between Brunei Malays and Chinese traders led to a riot in Bintulu bazaar in 1881. Not only 'ill feelings remained' but it also negatively affected the district economy (Gueritz 1883: 96).

[3] Unless otherwise noted, 'Dyak' in quotations from the *Sarawak Gazette* refers to the Iban.

[4] See Peter Mulok Kedit (1993) and Ryoji Soda (2001) for further information on the *bejalai* tradition and Iban migration, both old and new.

jars and brassware for new households were sold in large quantities. New settlers were to repay the debt in kind with gutta-percha and rattan (Day 1900: 210). Consequently, the annual export of rattan more than doubled in dollar terms ($28,730 in 1899 to $65,105 in 1900), and the volume was expected to increase further as 'there is such a large number of Dyaks now settled' there (Day 1901: 34).

As a result of this rattan boom, the jungle was cleared 'for miles on either bank' of the Kemena and the bazaars all the way upriver are 'overflowing with bundles' (Owen 1903a: 36). 'Natives' in the Kemena basin naturally ceased to fetch gutta-percha and rubber, only obtainable far away from the river and tributaries, available only in small quantities and sold at low prices (Owen 1903b: 54).

In 1903 Tubau bazaar was flooded with some 10,000 bundles of rattan, brought in from Belaga, whose market was earlier destroyed by fire. Rattan was thereafter brought downriver to Bintulu, while a large quantity of silver went up to Belaga for payment, causing a money shortage (Owen 1903c: 204).

The rattan boom in the early 1900s was short-lived. The year 1904 turned out to be 'one of the worst years yet experienced' for jungle produce trade (*Sarawak Gazette* 1905: 81–82), and 'great number of traders have made losses this year owing to the fall in value of jungle produce' (Owen 1904a: 166). Prices of gutta-percha, rattan and sago all collapsed with the exception of jelutong (Owen 1904b: 70–71, 128, 218; *Sarawak Gazette* 1904: 82). Thus, a major shift to jelutong and the extraction of ironwood started. Unlike the Rejang basin to the south, where timber exports to Hong Kong were already well under way by this time, the Kemena commodity trade was until then 'almost entirely confined to jungle produce' (*Sarawak Gazette* 1905: 81). In terms of the timber trade, the Kemena basin was also behind the Baram basin to the north, where a French company started extraction before the turn of the twentieth century.

6.3.2.2 Jelutong

Jelutong (*Dyera costulata*) is a species of tree which grows to approximately 60 m with a diameter of 2 m. Jelutong can be tapped for latex and was exploited as an important source of chewing gum.[5] The increased importance of this commodity brought about qualitative change to the trade in the Kemena basin. Compared to numerous other natural latexes collected from the forest, jelutong was subjected to increased control by the government with regard to its extraction, quality and marketing. Unlawful processing of this natural rubber became a source of grave concern for the government in the 1910s. In Bintulu district, various policies regarding the exploitation of jelutong were implemented, and detailed monthly reports were sent to Rajah Charles Brooke.

Control over jelutong preceded that over Pará rubber (*Hevea brasiliensis*), which would be strictly regulated by the Stevenson Restriction Scheme and the International

[5] Jelutong is a species of wild rubber commonly found in swampy areas. The latex is primarily used in the manufacture of chewing gum.

Rubber Regulation Agreement as well as many domestic regulations in the interwar period.[6] Under these regulations, those involved in the illegal planting, exploitation, selling, possession and adulteration of jelutong were subjected to serious penalties. Those who extracted jelutong without a licence were sentenced to 6 months' imprisonment (Boult 1917a: 7). Those in violation of illegal possession and selling received six rattan strokes in addition to 6 months' imprisonment (Boult 1918: 21). As most people in Kemena who engaged in jungle produce trade were unfamiliar with the government's restrictions, which were typically imposed on 'cultivated' commodities, cases of violation were common. A colonial report from Pandan shows that the local people quickly started 'abusing the jelutong regulations' for 'making a pleasant and easy living' out of this commodity.

> Certain persons, particularly at Pandan, have been making a pleasant and easy living out of jelutong working without doing a hand's turn themselves. They have taken out permits to work in certain streams, used these to reserve all jelutong there to themselves as owners, and then go other man to work, each on a path of his own for which he pays a monthly rent, varying according to the number of trees from $1 to $4 to the proprietor. This method of abusing the jelutong regulations came to light while hearing certain cases, which arose through disputes about the working of jelutong, and has now been stopped. (Lawrence 1920: 9)

With the introduction of the permit system, jelutong ceased to be a natural forest produce for the commons, which any collector was free to exploit. But it was not easy for government officials to enforce their regulation.

> The Labang people again complaining of Penghulu Merdan and the damage done by him and his Dyaks in Sungei Labang, I sent P.C. Latip to make a through examination of jelutong and fruit etc. In a previous examination made by P.C. Mat there were shown some 79 jelutong trees in 11 clearings; and consequently the Dyaks were forbidden to farm in that locality. The second inspection, however, shows instead of 79 trees there were over 300 trees in these 11 farms, and that the Dyaks have actually felled and burnt over 200 trees. Penghulu Merdan stated that on his proposed farm there were 3 large and 5 small trees, and this was borne out by the examination made by P.C. Mat: he was therefore allowed to fell these trees upon paying $40 compensation to Government. Instead of these 8 trees, however, the second inspection shows that he felled 44. P.C. Mat has been dismissed from the Force, as it is admitted that he never inspected the farms at all, but merely wrote down what the Penghulu told him. (Kortright 1922: 233)

In addition, ensuring the high quality of processed jelutong also became part of the duties of colonial officers. On hearing of the declining reputation of 'Bintulu jelutong, which formerly ranked amongst the first quality in the country, now takes about the third place on its arrival in Kuching, owing to the continued adulterating by the workers', one official blamed the Chinese for not exercising caution and purchasing inferior or adulterated jelutong. It was also reported that a trader was caught for selling adulterated jelutong and sentenced to a fine of $100 or 6 months in prison, the maximum penalties for this offence (Cunynghame 1917: 165).

[6] For the implementation of the International Rubber Regulation Agreement of 1934 and the reaction of local peasants through their cross-border activities in Sarawak and Dutch Borneo, see Noboru Ishikawa (2010).

Along the Kemena River and its tributaries, jelutong retained its important economic role well into the 1920s, replacing rattan to a certain extent. Thereafter, the trade continued at a reduced scale. Over the years jelutong became one of the major trading items not only for the Kemena basin but for Sarawak as a whole, especially after Charles Brooke, the second rajah, granted a monopoly to the United Malaysian Rubber Company.

According to Robert Pringle (1970: 267n), between 1876 and 1910 jungle produce regularly accounted for about a third of Sarawak's total exports, only to lose its relative importance after 1910. While traditional jungle produce trade lost its saliency, new items such as jelutong emerged and were subjected to stricter government control. Around the same time, the *attap belian* trade also came into prominence. After this period, the upriver Tubau bazaar, which was 'once a lively centre for Kayans from the far interior' that thrived as a crossroads for goods and people both from upriver and downriver, never regained its former glory. Due to a 'steady drop in prices of all jungle produce', even the number of police constables was reduced from two to one in Tubau in 1917 (Boult 1917b: 225).

6.3.2.3 *Belian*

The *belian* (*Eusideroxylon zwageri*) trade flourished in the 1910s and 1920s, somewhat coinciding with jelutong in its earlier trade period. *Belian* was processed as a roofing material (*attap*) and its exploitation continued up to the late 1950s. Heavy and highly durable, *belian* ironwood was much sought after and first traded by Iban and Teochew settlers. *Attap belian* functioned as the second currency within the Kemena basin and was the most important jungle produce in elevating the local economy. As with jelutong, colonial officers were much concerned with the quality of *belian* shingles marketed in the Kemena basin.

> There were 829,910 of these [*belian attap*] exported during the month, and there are large quantities arriving daily from up river for export. I regret that the quality is again falling off. This is entirely the fault of the Chinese agents up river who are buying from the Kayans without examining before sending down to their tawkays. I hope to be able to remedy this to some degree when I visit Tubau in the near future. If the Chinese would only examine the attaps as they were forced to do to jelutong to prevent its adulteration; but no, they take anything and if the attaps are too obviously below standard they will put first-class attaps on the outside of the bundle. (Kortright 1926: 270)

In 1927 a Malay established a sawmill in Bintulu (Kortright 1927: 18, 99), but the monopoly ended the next year when the first Fuzhou sawmill was built (Aplin 1928: 123). It was one of the earliest cases of Fuzhou entry into the timber business, heralding their dominance in later years. As early as the mid-1930s, the Fuzhou timber business expanded to the interior of the Kemena basin where 'real complaint emanated from the Tubau Kayans, who said that Foochows were working *belian* everywhere, so much as, in fact, that soon there would be none left for the natives' (*Sarawak Gazette* 1935: 188).

The Fuzhou were newcomers compared with early Chinese settlers such as the Teochew who were engaged in trade in major Kemena tributaries. The Brooke government promoted Fuzhou migration to the lower Rejang just after the turn of the twentieth century in the hope that they would plant rice and vegetables for domestic consumption. They never became agriculturalists, however, finding ‘it more profitable to spend their time looking for jelutong gutta or working timber’ (Hose 1905: 80). Due to high rubber prices in the late 1910s and the 1920s, more Fuzhou peasants from southern China flocked to the lower Rejang region to cultivate rubber; some started moving north to the Kemena basin and subsequently became major players in the *belian* trade.

Today’s dominance of the Fuzhou, particularly in timber trading, has later roots in the rubber boom during the Korean War in the 1950s. The Fuzhou from Sibu moved first to Sebauh, then to Bintulu or upriver to Pandan, Labang onto Tubau, ousting Teochew merchants. These Fuzhou settlers, after accumulating considerable capital in *attap belian* and sawn timber, started to play a vital role in the post-forest produce period in the Kemena basin by establishing a monopoly in the timber business. Their economic supremacy in today’s downriver industries in Bintulu in part originated in the forest.

6.4 Commodified Frontier

The forest produce trade prevailed in the Kemena basin society for more than 100 years. Opportunities to obtain goods and cash brought by Brunei Malay *nakodah* and subsequently by Chinese merchants attracted people from afar. The flows and movements of people also generated new social relations. The riverine commons functioned as an interface linking global commodity chains with the peoples in the interior. The Kemena River and its major tributaries of the Binyo, the Tubau and the Jelalong rivers as well as numerous other streams were the blood vessels and capillaries of the forest that provided nourishment to the lives of local people (cf. Langub and Ishikawa 2017).

Earlier, the basin society was part of the Malay maritime trade networks under a socioeconomic sphere of influence that was loosely ruled by the Brunei sultan. The subsequent emergence of the Brooke colonial administration and its preference for assigning local and regional trade to Chinese merchants rather than Malay merchants led to the demise of Malay trade. The nascent colonial regime vigorously, though often unsuccessfully, introduced measures to enforce strict resource management and regulate the market. As a result, the Kemena basin economy became increasingly incorporated in the international commodity market.

Contrary to the image of jungle dwellers who lived in isolation, the basin society has long been part of global commodity chains. When a certain commodity commanded a high price in the international market the local economy evolved around it. A substantial number of local people became labourers in the jungle, collecting commodities and selling them to merchants. The prices of these treasures in the forest fluctuated considerably even over relatively short periods of time. If one examines how people responded to such price fluctuations it is similar to reactions to today's stock market. Local people who had lived along the Kemena River were practical, responsive and manoeuvring in terms of reacting to the supply and demand of jungle produce. They strategically articulated a cash economy and swidden cultivation, prioritising one over the other in response to the market trends, shifting from one commodity to another to maximise profit. The very formation and survival of the riverine society were closely aligned with the expansion of international trade networks to the frontier. The dynamics of commodity trade there were shaped and altered by the agency of local residents. Through the chronology of jungle produce trade we see trajectories of Sarawak's past. Forest paths people trod were part of wider networks encompassing longhouses, bazaars, townships, local and distant markets overseas, connecting local people, migrants, traders, colonial officers and others. Such local histories illuminate the journey through which the community of the Kemena basin has become what it is today.

References

Aplin, H.D. 1928. Bintulu report. *Sarawak Gazette*.

Boult, F.F. 1917a. Bintulu report, November 1916. *Sarawak Gazette*.

———. 1917b. Bintulu report, July 1917. *Sarawak Gazette*.

———. 1918. Bintulu report, November 1917. *Sarawak Gazette*.

Cunynghame, S. 1917. Bintulu report, May 1917. *Sarawak Gazette*.

Day, H.R.A. 1900. Bintulu report, September 1900. *Sarawak Gazette*.

———. 1901. Bintulu report, December 1900. *Sarawak Gazette*.

Department of Statistics Malaysia, Sarawak Branch. 2010. *Yearbook of statistics*. Kuching: Department of Statistics Malaysia.

Drage, Fred. 1883. Bintulu report dated November 30, 1882. *Sarawak Gazette*.

———. 1886. Bintulu monthly report, *Sarawak Gazette*.

Gueritz, Geo. 1883. Bintulu monthly report for September 1883. *Sarawak Gazette*.

———. 1884. Bintulu report for November 1883. *Sarawak Gazette*.

Hose, Charles. 1905. Rejang report, February 14, 1905. *Sarawak Gazette*.

Hose, Charles, and William McDougall. 1993. *The pagan tribes of Borneo*. Oxford: Oxford University Press. (orig. publ. 1912).

Ishikawa, Mayumi. 2005. The story of *Nakoda Hitam*: Her life and ventures at maritime crossroads at the turn of the twentieth century. *Sarawak Museum Journal* 61 (82): 247–262.

Ishikawa, Noboru. 1999. The social history of coconuts in Sematan, southwestern Sarawak. *Sarawak Museum Journal* 54 (75): 239–251.

———. 2010. *Between frontiers: Nation and identity in a Southeast Asian borderland*. Singapore/Copenhagen/Athens: NUS Press/NIAS Press/Ohio University Press.

Kedit, Peter Mulok. 1993. *Iban bejalai*. Kuala Lumpur: Ampang Press for the Sarawak Literary Society.

Kortright, H.H. 1922. Bintulu report, May 1922. *Sarawak Gazette*.

———. 1926. Bintulu report, July 1926. *Sarawak Gazette*.

———. 1927. Bintulu report, October 1926 and January 1927. *Sarawak Gazette*.

Langub, Jayl, and Noboru Ishikawa. 2017. Community, river and basin: Watersheds in northern Sarawak as a social linkage. In *Borneo studies in history, society and culture*, ed. Victor T. King, Zawawi Ibrahim, and Noor Hasharina Hassan, 365–383. Singapore: Springer.

Lawrence, A.E. 1920. Bintulu report, October 1919. *Sarawak Gazette*.
Low, Hugh. 1968. *Sarawak, its inhabitants and productions: Being notes during a residence in that country with H.H. the Rajah Brooke*. Singapore: Oxford University Press. (orig. publ. 1848).
Nicolaisen, Ida. 1976. Form and function of Punan Bah ethno-historical tradition. *Sarawak Museum Journal* 24 (45): 63–95.
———. 1983. Change without development: The transformation of Punan Bah economy. *Sarawak Museum Journal* 32 (53): 191–203.
Owen, Donald A. 1903a. Bintulu report, December 1902. *Sarawak Gazette*.
———. 1903b. Bintulu report, February 5, 1903. *Sarawak Gazette*.
———. 1903c. Bintulu report, June and July 1903. *Sarawak Gazette*.
———. 1904a. Bintulu report, June 1904. *Sarawak Gazette*.
———. 1904b. Bintulu report, March and September 1904. *Sarawak Gazette*.
Pringle, Robert. 1970. *Rajahs and rebels: The Ibans of Sarawak under Brooke rule, 1841–1941*. Ithaca: Cornell University Press.
Sarawak Gazette. 1884. Bintulu report.
———. 1885. Bintulu report (communicated).
———. 1895. Committee of Administrators report dated October 12, 1895.
——— 1904. Report of the Treasury and Trade Departments.
———. 1905. Bintulu annual report, dated February 9, 1905.
———. 1917. Extracts from annual reports 1916, Sibu.
———. 1935. Fourth Division news, July 1935.
Soda, Ryoji. 2001. Rural–urban migration of the Iban of Sarawak and changes in long-house communities. *Geographical Review of Japan* 74 (1): 92–112.

Chapter 7
The Penan of Jelalong River, Sarawak: A Narrative of Migration and Adaptation

Jayl Langub

Abstract This is a narrative, based on oral testimonies and contemporary documents, of the migration of four groups of formerly nomadic Penan from the Usun Apau in the interior of Belaga district and Apau Julan in the upper Baram River, Baram district, to the Jelalong River in Sebauh district around the beginning of the 1800s. The Jelalong River was unoccupied and the Penan groups became its first occupants. Soon after their arrival, they adopted a settled mode of life, traded with Brunei traders and Chinese merchants at the confluence of the Tubau and Jelalong; they also bartered with the Vaie Segan who paddled up the Jelalong to the Penan settlements. Intense interactions with neighbouring groups resulted in several intermarriages, while the settlements have retained their identity as Penan places.

Keywords Sarawak · Penan · Jelalong River · Migration · Adaptation

7.1 Introduction

The Penan are traditionally hunter-gatherers. On the basis of dialect, Rodney Needham (1972) divides them into Eastern Penan and Western Penan. The Eastern Penan are found on the right bank of the Baram River in Baram district as well as in Limbang district, while the Western Penan are located in Belaga district and along the banks of the Silat River, which is a branch of the Baram River. As hunter-gatherers, bands of nomads moved constantly within a certain territory in search of food and they used to collect jungle products for barter trade. In the early 1800s groups of Western Penan in the Usun Apau in Belaga district and the Apau Julan in Baram district took an unprecedented venture in long-distance migration to the Tinjar River in Baram district, coastal areas of Miri and Bintulu divisions, and the Labang and Jelalong rivers in Sebauh district. On reaching their destinations, they created permanent settlements and cultivated food and later cash crops. This chapter

J. Langub (✉)
Institute of Borneo Studies, Universiti Malaysia Sarawak, Kota Samarahan, Malaysia

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_7

is an oral historical narrative of the groups of Penan that migrated from the Usun Apau as well as the Apau Julan to the Jelalong River and decided to settle and cultivate the land in this area. It is also a narrative of their adaptation to a more settled life and their relationships with other ethnic groups.

7.2 Waves of Migration from the Usun Apau

The Usun Apau plateau used to be occupied by a large number of groups that included the Berawan, Sebop and Lirong, and various subgroups of the Kenyah and Penan (Needham 1953, 1954, 1972; Harrisson and Leach 1954; Arnold 1956, 1959; Gockel 1974; Seling Sawing 1974; Metcalf 1976, 2002, 2010; Rousseau 1990; Vom Roy 1993). The first group to move out of the Usun Apau were the Berawan, and they established four settlements along the Tinjar River (Metcalf 1976: 89, 2010: 74). We do not exactly know when the Berawan moved to the Tinjar and can only speculate that it was in the late 1700s or at the beginning of the 1800s.

There were three waves of Sebop migration into the Tinjar. The first wave occurred in the early 1800s (Metcalf 2010: 92–93). The second wave took place in the first half of the 1800s and involved the Lirong who settled in the upper Tinjar and the Long Wat Kenyah who made their permanent home at Long Lapok in the lower Tinjar (Metcalf 2010: 75–76). The third and final wave of Sebop migration came as a result of Iban raids that accompanied the Brooke government's punitive expedition in 1863 that was officially known as the 'great Kayan expedition' (Arnold 1956: 166, 171, 1959: 115–125; Gockel 1974: 325–328; Seling Sawing 1974: 331–340; Vom Roy 1993). The Sebop took a route from the Luar River, up the Menavan northwards to the Kemawang pass, then down the Dapoi into the Tinjar. From historical records and archaeological evidence, remnants of Sebop settlements are found along the Plieran River and its tributaries, the Luar, the Menapun and the Menavan (Needham 1953: 59–60; Harrisson and Leach 1954; Arnold 1956, 1959; Seling Sawing 1974: 331–340).

The Western Penan trace their origins to the Luar, a tributary of the Plieran in the Usun Apau. From there they migrated along different routes. Three groups moved northwards: the first group moved via the Menavan–Dapoi watershed into the Tinjar; the second moved via the Menavan–Nyivung watershed; and the third moved over the Dulit range, west of the Tinjar (Needham 1953: 65–68). Figure 7.1 shows the migration routes of the ancestors of the Penan Saoh and Penan Mekapan from the Apau Julan and the Usun Apau to the Jelalong.

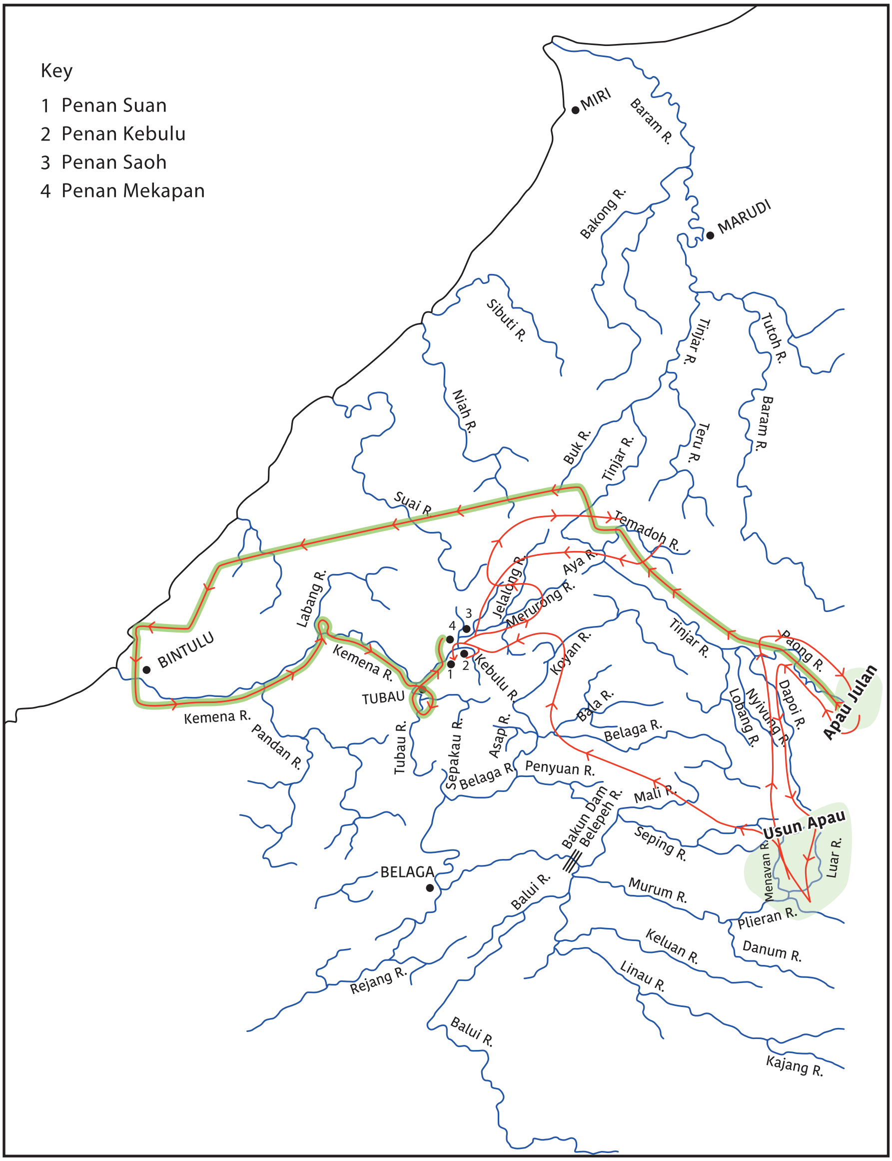


Fig. 7.1 Penan migration routes from the Apau Julan and the Usun Apau to the Jelalong

7.3 Penan Groups in Jelalong

Of the groups of Penan that migrated from the Apau Julan and the Usun Apau, four groups decided to settle permanently in the Jelalong: the Penan Kebulu, Penan Suan, Penan Saoh and Penan Mekapan. The focus of this chapter is on the Penan

Saoh and Penan Mekapan, with a brief description of those in the Kebulu and the Suan.

The Penan Kebulu and Penan Suan migrated from the Luar in the Usun Apau to the Jelalong as one group. From the Luar they travelled by way of the Seping, crossing the Belaga to the upper Koyan, then over the steep Sekalap pass to the Kebulu, a tributary of Jelalong (Needham 1953: 67). From there they split into two, with one group settling along the Kebulu and becoming known today as the Penan Kebulu. The other group moved down into the Jelalong, settled at the confluence of the Jelalong and the Suan and became known as the Penan Suan. Both groups share similar population characteristics in that they have a large number of Iban residents. The ratios given are 60% Penan and 40% Iban for the Penan Kebulu, and 40% Penan and 60% Iban for the Penan Suan.[1] Marriages between the Penan and Iban are quite common in both communities.

In both settlements, inhabitants are fluent in both Penan and Iban languages, irrespective of their ethnicity. Within each household, either Penan or Iban is used. Outside the household, when socialising occurs on the gallery of the longhouse, either Penan or Iban or both may be used, with fluid code switching occurring as conversation moves from one topic to another.

7.4 Penan Saoh

The Penan Saoh were originally from the Usun Apau. Their ancestors moved to the Apau Julan in search of trade items, but stayed there for an extended period. The leader of the ancestors of the Penan Saoh we are concerned with here was Semalong Julan who was born in the Apau Julan.

When Semalong Julan became the leader, he led the group back to the Luar in the Usun Apau and from there to the Jelalong (see Appendix 7.1 for details). From the Luar they moved over to the Seping River. They settled there for a short while before crossing the Belaga River into the Koyan. They moved up the Koyan River to a point where they took a left turn towards the Sekalap pass. They climbed the Sekalap pass, descended the hill to the Kebulu River and lived there for a short while. They moved again, this time down the Kebulu to its confluence with the Jelalong. At the confluence, they took a right turn, moving up the Jelalong into the Merurong River, a left bank tributary of the Jelalong, where they lived for some years. It was here that they became known as the Penan Merurong.

Semalong Julan died in Merurong and the leadership passed to his younger brother, Semuling Julan. The Penan Merurong continued to live in the Merurong until the death of Semuling Julan. Upon his death, the leadership passed to his nephew, Sesian Semalong. He led the group to the headwaters of the upper Jelalong, then onward to the Tinjar and the Temadoh (a tributary of the Tinjar) where they lived for a number of years with another group of Western Penan. Here, they became

[1] Interview with Tuai Rumah Julaihi Keti, Long Saoh, 2 August 2014.

known as the Penan Temadoh. After some years in the Temadoh, they moved back to the Jelalong and reverted to their old name, the Penan Merurong.

Sesian Semalong died in upper Jelalong and his cousin Menyakit Semuling became the new leader. He led the group down the Jelalong, and at the confluence of the Jelalong and the Saoh they took a right turn, moved up the Saoh and established a settlement in the Sekuan, a tributary of the Saoh.

After the death of Menyakit Semuling, the leadership changed hands several times, and they continued to stay at the Sekuan until Tugang Menyakit took over the leadership from his older brother, Labi Menyakit. While they were still at the Sekuan, a Vaie Segan man named Bibeng came to live with them and married a Penan woman of the village. Upon the death of Tugang Menyakit, Bibeng became the leader of the group. Bibeng led the group down the Saoh into the Jelalong and established a longhouse at the Liuk, some 30 min upstream by paddling from the mouth of the Saoh. Bibeng was a good leader and knowledgeable in the activities of Brunei traders. He advised his fellow villagers not to be outwitted by cunning Brunei traders.

When Bibeng died, the leadership passed to Seniang. He led the group up the Jelalong to Sengayah and established a settlement there. When Seniang died, Luton then assumed leadership of the group which at the time was still known as the Penan Merurong. It was under the leadership of Luton that they established a more permanent settlement at Long Saoh and became known as the Penan Saoh.

Luton's father was a Melanau from Mukah who married Mawen, who was the daughter of a Kejaman father and Penan mother. When Luton died his remains were preserved in a typical Kejaman mortuary post known as *kliering*.

After Luton's death, the leadership of the group changed many times. They moved their longhouse from one site to another until Keti Jemat was appointed *tuai rumah* or headman of the community. He led the group back to Long Saoh, where they still live today. When Keti Jemat became old, he retired and his son Julaihi Keti took over in 2009 as the current *tuai rumah* and the longhouse is also known as Rumah Julaihi.

The Penan language is the main mode of communication between individuals in Long Saoh. It is used when villagers get together to discuss community activities even though a large number of the population is fluent in Iban. When government officials visit the village, Iban is sometimes used as well as Malay to communicate with the people. There is a sizeable number of Kayan living in Long Saoh and so the language is also spoken in the village with some Penan having remarkable fluency in Kayan.

7.5 Penan Mekapan

Oral history has it that Ngambung led the Penan Mekapan out of the Apau Julan in the upper Baram to Tanjung Kidurong, Bintulu (see Appendix 7.2). From the Apau Julan they moved down the Paong into the Tinjar. At some distance below the confluence of the Temadoh and the Tinjar they took a left turn and walked overland to cross the Niah River to the Suai. From the Suai they continued their overland journey to Tanjung Kidurong.

After living in Tanjung Kiduong for a few years, the group moved to the Sibiu River. Ngambung died in the Sibiu and his brother Madang took over as leader. The group moved again. This time they moved up the Kemena to the Labang, a right bank tributary of Kemena, where they lived for a number of years. While they were in the Sibiu and the Labang, the group had a lot of contact with the Vaie Segan people and intermarried with them. Madang died and was buried along the Labang.

After the death of Madang, their new leader, Tekulah, continued their migration up the Kemena into the Tubau, another branch of Kemena. Not long after occupying the Tubau, the first group of Kayan, the Uma Awai, arrived. The Uma Juman came immediately after the Uma Awai built their first longhouse in the Tubau. As more groups of Kayan were moving into the Tubau, the Penan decided to move up the Jelalong. By this time, Tekulah had died and was buried in Tubau. Their new leader, Lengaut, led the group up the Jelalong and settled at the Kebulu for a short while. From the Kebulu they moved again to the Darui, a small stream below the confluence of the Jelalong and the Kebulu. They lived there for many years under three successive leaders: Nayang, Balan and Sedaya.

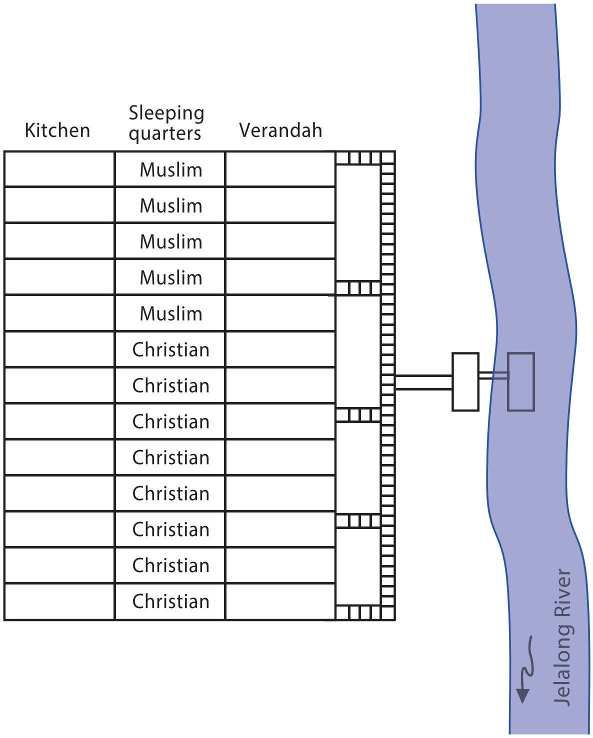
When Sedaya died, Mengejau became the leader and led the group to the Saoh. Mengejau was sick for a long time and there seemed to be no cure for his illness. One day a Vaie Segan trader who was gifted with the ability to cure illness came to the Saoh to trade. Mengejau informed the trader of his predicament and vowed to convert to Islam if the trader could cure him of his illness. Miraculously, Mengejau was cured and so he converted.

When Mengejau died, the government appointed Dangan as the *tuai rumah* of the Penan Mekapan in 1958. Under his leadership, he led the group back to the Darui. When Dangan died in 1977, Jadong was appointed as the new *tuai rumah*. Like all his predecessors, he led the group to Long Mekapan, slightly downriver below the Darui, on the right bank of the Jelalong. This is the current site of the longhouse of the Penan Mekapan. Jadong converted to Islam, changed his name to Mahmud bin Gani and left Long Mekapan to live in Bintulu. In 1984 Resa Tungun was appointed the *tuai rumah* of the Penan Mekapan and still holds the position today.

The Penan Mekapan settlement at Long Mekapan is a modern 12-door longhouse on the banks of the Jelalong River. Like most longhouses in Sarawak, the Penan Mekapan settlement here is a multiethnic community comprising non-Penan, such as Iban, Vaie Segan and Mirek, who married into the community. Another interesting thing about the Penan Mekapan longhouse is that eight family apartments are Christian while four are Muslim (see Fig. 7.2).

Penan and Vaie Segan are used interchangeably as modes of communication between individuals in Long Mekapan. When there is a village meeting to discuss community activities, individuals may elect to speak in either language. Vaie Segan is used in Long Mekapan because a large number of Penan in the village have Vaie

Fig. 7.2 Twelve-door Penan Mekapan longhouse beside the Jelalong



Segan ancestors. Iban is also spoken in Long Mekapan and virtually all adults are reasonably fluent in the language.

7.6 Life as a Settled Community

On their long journey from the Usun Apau and the Apau Julan to the Jelalong, each group of migrants depended on hunting and gathering to survive. This was exactly what the descendants of the Penan migrants said when asked about the livelihood their ancestors had on their way to the Jelalong. On their journey to the Jelalong they survived on wild sago and game. When they decided to settle down the first food crops they cultivated were tapioca and then rice.[2]

[2] Interviews with Penan elders at Long Saoh, 25 August 2012; and elders at Long Mekapan, 26 February 2012, with regard to food crop and cash crop cultivation.

7.6.1 Food Crops

The exact year each group first cultivated food crops is not certain. Needham (1965: 62–66) suggests that the Penan Kebulu and Penan Suan settled down in the 1820s while the Penan Saoh settled in the 1850s. One can then assume that the four groups of Penan would have had their first cultivation of food crops in the 1820s or 1850s. As noted above, Penan elders that I spoke with in August 2012 suggested that when their ancestors arrived in the Jelalong the first crop they cultivated was tapioca that was supplemented with wild sago and game. They then began to cut the forest to plant rice, slowly graduating into quite efficient swidden farmers. They did this all on their own, applying their knowledge of what they observed their Sebop swidden farmer neighbours doing in the Usun Apau. The Penan used to be called upon to help their Sebop relatives and close friends in farm work. The Penan therefore did have some basic knowledge of farming. Over the years, they became self-sufficient in growing and harvesting food. However, in lean times which they reported sometimes occurred, they resorted to wild sago. Sago was sustainably harvested by only removing mature trunks to leave young trunks for future growth.

7.6.2 Cash Crops

Towards the end of the Brooke era and during British colonial rule, the Penan of the Jelalong ventured into the cultivation of cash crops, such as rubber and pepper. Then as independence from British rule approached, a number of households also tried their hand at cocoa gardening. Today a few households have also become oil palm smallholders. By their own account, they believe they are doing as well as their Kayan, Punan Bah and Iban neighbours.

7.6.3 Trade with Brunei Traders

The Penan elders suggested that their ancestors and those of the other ethnic groups such as the Berawan, Sebop and Lirong moved out of the Usun Apau because it was remote and difficult to access from the outside world. Some of the Penan groups that moved out of the Usun Apau and the Apau Julan decided to move to the Jelalong because it was empty without any occupants, with abundant forest resources and with easy access to trading centres.[3] One important and easily accessed trading centre from the upper Jelalong was Tubau which is located at the confluence of the Tubau and Jelalong rivers. The other trading centre was Kebulu, located at the con-

[3] Conversations with Tuai Rumah Ogus Sugun, Jambatan Suai, 21 August 2012; Penan elders at Long Saoh, 25 August 2012; and elders at Long Mekapan, 7 February 2013.

fluence of the Kebulu and Jelalong. In the early years, the main traders were Malays from Brunei.

Prior to the extension of Brooke rule to the Rejang and Baram basins in the second half of the nineteenth century, Brunei Malay traders had extensive trade networks with the indigenous people of these two large river systems (de Crespigny 1881, 1882; Gueritz 1882; Low 1884a, b; Bampfylde 1893; Nicolaisen 1976; Metcalf 2010: 138–177). Peter Metcalf (2010: 161) informs us 'that the exchange of commodities occurred at communities in the hinterland', while Punan Bah oral narratives indicate that Brunei traders 'went from tribe to tribe on safe conduct', albeit with the backing of the Sultan of Brunei.

When the Rejang and Baram basins came under Brooke administration, government officials not only allowed the Brunei traders to continue their trade but also ensured their safety. In the October 1881 issue of the *Sarawak Gazette*, Claude Champion de Crespigny, the resident based at Mukah, made the following statement:

> I again spoke to Tama Laang and Tama Sulalang. I said the [Brunei] traders had complained to him that the Sepengs were very slow in paying their debts. I pointed out the example of the Kenniah who make not debts but purchase all they require with ready money or produce and I particularly demanded of them that in future they should protect all traders and other strangers that might visit Belaga.

While the trading centre at Tubau served the surrounding area, the Belaga and Balui rivers, the trading centre at Kebulu was convenient for people from the Suai and the upper Tinjar to travel to. The four groups of Penan took advantage of the two trading centres and traded large quantities of jungle products such as dammar (a resin), jelutong (wild latex), *ketepe* (a type of wild rubber), rattan as a raw material and bezoar stones (gallstones which the Chinese believe have medicinal properties, see Okuno and Ichikawa, Chap. 23) for Bruneian goods such as brassware of all descriptions, jars, beads, cloth and kitchen utensils. Some of these Bruneian trade goods such as large and small trays, wick lamps, boxes for betel nut and lime, and kettles are still kept as family heirlooms.

7.6.4 Trade with the Vaie Segan

The Vaie Segan also paddled up the Jelalong to trade with the Penan. They brought with them *ikan masin* (salted fish), *belacan* (prawn paste), *garam apong* (nipah salt), *gula apong* (nipah sugar) and cakes which they bartered for Penan rice, corn and vegetables. These vegetables were normally planted between rice, fruit trees and sugar cane.

7.6.5 Trade with the Chinese

When the Chinese traders established themselves in Tubau, the Brunei Malay traders began to fade out. The trading post at the Kebulu closed down when the last Brunei Malay trader left. The Penan continued to trade more and more with the Chinese. They continued to collect dammar, jelutong, rattan and bezoar stones as well as *engkabang* (illipe nuts from *Shorea* spp.), which they then sold for cash. With the cash they bought goods of their choice from Chinese shops. Ordinary household needs included working tools, kitchen items and cloth.

Another commodity they sold to the Chinese traders was wild boar lard. Lard was sold in large biscuit tins at $20 per tin. Some Penan families already had rubber and pepper gardens, and these commodities were sold to add to the family income. Another source of cash income for some households was *belian* ironwood, which was converted into posts, planks and slabs for roofing. Families with good sources of income, especially those with cash crop gardens or working on *belian*, bought outboard engines for their boats, sewing machines, transistor radios and kerosene pressure lamps.

7.6.6 Timber Companies

The first timber company to come into the area to log their forest arrived in 1978. The Penan of the Jelalong did not respond to it the way the Penan in Baram did, when the latter erected barricades across roads to stop logging. This does not mean that the Penan of the area were supportive of logging activities. In fact, they were opposed to logging and silently admired the courage of their fellow Penan in Baram for their non-violent protests.

Older people, who relished going into the forest, found the effects of logging shocking. It destroyed non-forest products such as rattan, herbs, wild vegetables and fruit trees that they valued highly, drove game away, polluted streams and rivers, and caused immense landslides and bank erosion. Yet, when the timber company people went around the longhouses to recruit workers, some young men signed up for jobs as drivers, timber cutters, surveyors, security guards, mechanics and manual workers of various kinds. A few women were employed as cooks and house cleaners in timber camps as well. Some workers made good money and were able to buy cars and other luxury items such as televisions and generators to produce electricity to light their longhouses. The money they made from working with timber companies was much needed to renovate or build better longhouses, despite the impacts of logging. Like most longhouse dwellers during the height of logging activities in Sarawak, the Penan in the Jelalong had a mixed reaction to it.

7.6.7 Education

Realising the importance of education, the Penan in the Jelalong sent their children to school when one was accessible. According to Tuai Rumah Julaihi Keti, his father, Keti Jemat, was the first Penan in Jelalong to get a formal education.[4] Keti Jemat later became the *tuai rumah* of Penan Saoh. He studied at the government primary school at Labang and was fortunate as he had relatives to stay with there. Some years later more Penan sent their children to school when schools were established at the Tubau bazaar and at Long Kebulu.

7.7 Neighbouring Communities and Settlements

Figure 7.3 is a representation showing the four Penan settlements and those of their neighbours in the Jelalong and the Tubau. When they first came to the Jelalong, the area was completely empty. Years after the Penan occupied the Jelalong, other groups began to move into the area; the Kayan and Punan Bah came almost at the same time, followed immediately by the Chinese and Vaie Segan, and finally the Iban in the late 1950s.

7.7.1 Kayan

It is not known exactly when the Kayan moved into the Tubau. When the first Kayan group, the Uma Awai, came, the Penan under the leadership of Tekulah were already there. More Kayan groups came—the Uma Juman, Uma Pako and Uma San. Lengaut (who became the head of the Penan Mekapan upon the death of Tekulah) met the Kayan leaders to inform them that they, the Penan, had decided to move to the Jelalong. This was much welcomed by the Kayan. Some years later the Uma San Kayan moved into the lower Jelalong not far above the Tubau bazaar.

The relationship between the Kayan and the Penan is cordial, with a number of intermarriages. Administratively, the Penan are under the same *penghulu* (area chief) jurisdiction as the Kayan and Punan Bah. Currently the *penghulu* for the area is a Kayan.

7.7.2 Punan Bah

The first group of Punan Bah to venture up the Jelalong comprised four individuals: Baran, Uyai, Ule and his son Abai. They were part of a larger group of Punan Bah that moved out of Belaga to Pandan along the Kemena River via the Sepakau–Tubau

[4] Interview with Tuai Rumah Julaihi Keti, Long Saoh, 2 August 2014.

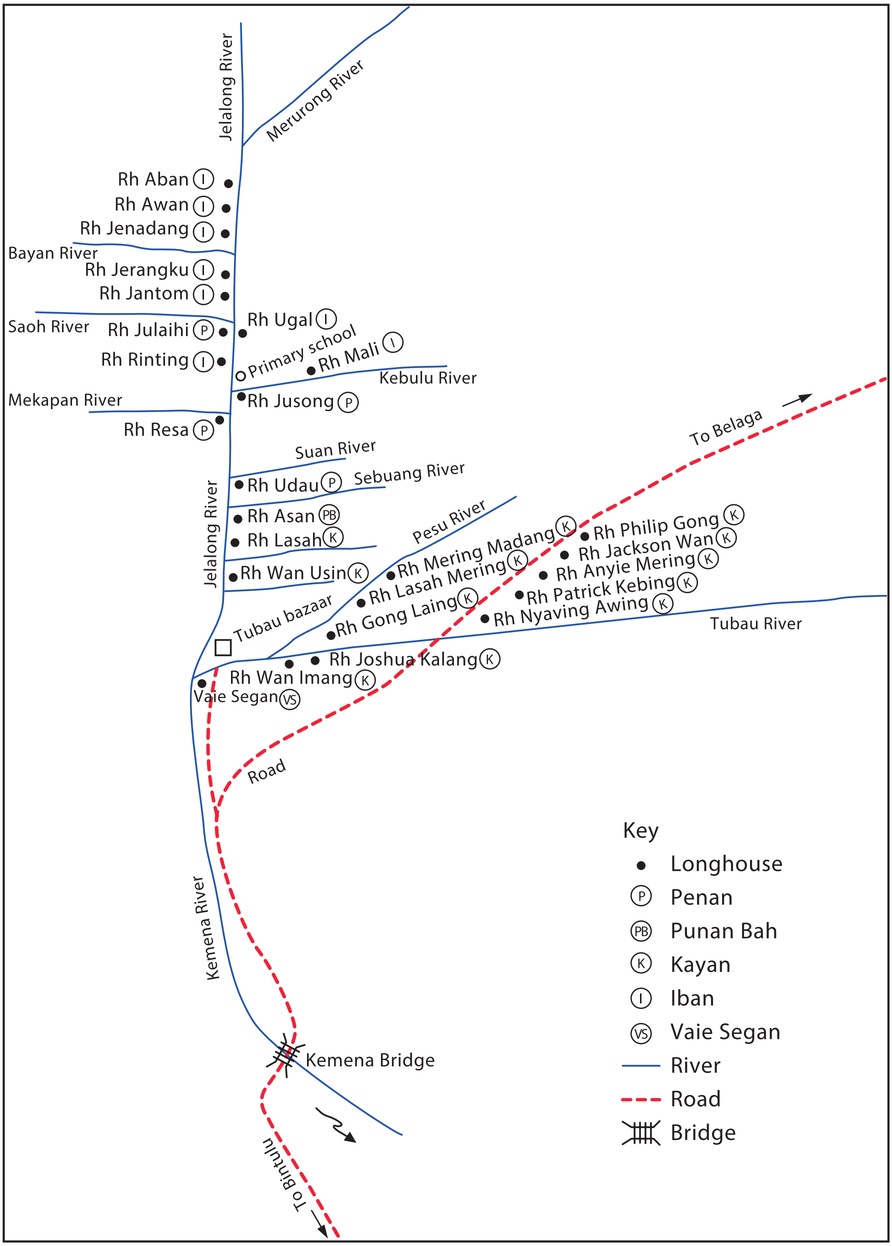


Fig. 7.3 Four Penan settlements and their neighbours along the Jelalong and Tubau rivers

watershed during 1863 when the Brooke government launched its punitive expedition in the upper Rejang. Initially the four individuals went up the Jelalong, above Long Saoh, after consultations with groups of Penan in the area, to collect jungle products for trade. A year later they ventured into the Kebulu and asked permission from the Penan Kebulu to farm rice for 1 or 2 years. Their family members then joined these four individuals. After 2 years, and following a discussion between them and the four groups of Penan on the Jelalong River, the Punan Bah moved down to Long Sebuang, some distance below the Penan Suan settlement at Long Suan, on the Jelalong (Nicolaisen 1976: 87). They were joined by a number of new Punan Bah families from the Pandan, today forming a community of a 17-door longhouse. Being close neighbours, the Penan and Punan Bah visit each other quite often especially during cultural festivals, weddings and funerals.

7.7.3 Vaie Segan

The Vaie Segan formed a small community of not more than a dozen families, slightly below the confluence of the Tubau and the Jelalong after the Tubau bazaar became an important trading centre. In the early days, the Vaie Segan barter traded with the Penan as well as with the Kayan and Punan Bah. Today the Vaie Segan continue to maintain contact with the Penan, especially with the families at Long Mekapan, who have converted to Islam.

7.7.4 Chinese

The Chinese moved up to the Tubau immediately after Bintulu came under Brooke rule in 1861, slowly dominating business activities as the Malay traders from Brunei faded from the scene. As the main traders in the Tubau bazaar, the Chinese had regular interaction with the Penan coming over to the bazaar to trade. A few Chinese have married Penan.

7.7.5 Iban

Tuai Rumah Tengom and his followers were the first group comprising Iban families to move to the Jelalong toward the end of 1959.[5] Long before this there were Iban living in the Jelalong, but married to Penan and living in Penan settlements (Needham 1965: 67). Originally, Tengom and his followers approached the district officer in Bintulu, asking for permission to move to the Tubau, but the Kayan *peng-*

[5] Interview with Tuai Rumah Julaihi Keti, Long Saoh, 2 August 2014.

hulu of the Tubau, Penghulu Ding Adang, explained that there was not enough space to accommodate new settlers.

They then applied to move to the Jelalong. The Penan voiced their reluctance to accept newcomers, but the district officer said that the Jelalong was sparsely populated and there was enough space to accommodate new settlers. The group was allowed to move in on condition that they occupy an area outside the traditional territory of early settlers. Tengom and the group settled along the Bayan, a branch of the Jelalong, some distance upriver from the Penan Saoh settlement at Long Saoh. Over the years more Iban groups applied to move into the Jelalong; today there are eight Iban longhouses in the Jelalong overwhelming the small groups of Penan in the area.

As the first group to occupy the Jelalong, the Penan are recognised as the pioneer settlers with extensive historical knowledge of the area and of land use. Newcomers acknowledge this fact, and whenever they want to open up land for cultivation they normally consult the Penan first as a matter of courtesy.

7.8 Migration and Marriage

When nomadic Penan were asked why they kept moving from one place to another, they replied 'in search of food' (Needham 1953: 79). Their staple food, wild sago, was supplemented with meat, fish and wild vegetables. They also moved to distant places in search of trade items such as dammar, jelutong and *ketepe*, but they would return to the Usun Apau, which they consider as their ancestral home, *daleh puu'*.

The migration of the four groups of Penan in the Jelalong and those that moved to other places, such as the Tinjar, the Niah, the Suai and the Labang in the early 1800s or earlier from the Usun Apau and the Apau Julan, was unprecedented. As noted earlier, various settled groups in the Usun Apau were moving out of the area. These settled groups considered the Usun Apau isolated and, at that point of time, overpopulated, and there was a compelling need to move. The Tinjar was sparsely populated, if not completely empty, with a huge amount of land to farm and coastal trading centres easily accessible via river transport.

The four groups of Penan decided to move to the Jelalong because they heard that the area was empty and rich in jungle products.[6] The Penan groups left in the Usun Apau continued to lead a nomadic existence, some as late as the 1970s, but the four groups that moved to the Jelalong decided to settle down in the 1820s and 1850s. How and where did they get the skills to till the land and build houses and boats? Contact with coastal people and trade is generally assumed to have influ-

[6] Interviews with Tuai Rumah Julaihi Keti, Long Saoh, 25 August 2012; and Tuai Rumah Resa Tungun, Long Mekapan, 7 February 2013. See also *Profil kampung Long Mekapan* (Long Mekapan village profile) and *Profil kampung Long Saoh* (Long Saoh village profile) for short accounts of the migration of the Penan Saoh and Penan Mekapan ancestors.

enced them to settle as soon as they arrived in the Jelalong.[7] However, while they were still living in the Usun Apau they were in close touch with settled Sebop people whose language is closely related to Penan. Intermarriages between the two ethnic groups had been going on for a long time. Although the Penan did not live in permanent settlements, farm or build houses and boats, they had some basic knowledge of the skills required for these endeavours as the Sebop occasionally invited the Penan to assist them in both farming and building.

How did the Penan manage to get through the long journey from the Usun Apau to the Jelalong, crossing and travelling along large rivers without adequate tools such as adzes and axes? These tools were a rare commodity in the village in those days and it would seem unlikely that they would be taken by a group for expeditions and long-distance travel to build boats. Penan elders interviewed at Jambatan Suai, Long Saoh and Long Mekapan believe their ancestors had several options.[8] They probably built rafts or canoes known as *bung*, which were fashioned out of the thick bark of a large tree called *kayeu' bungau* (*Glochidion obscurum*) and intricately sewn with rattan, or instead walked along the banks of large rivers.

Once they reached their destinations, they settled, tilled the land and engaged in trade. Other groups then began to visit, marry their members and live in their villages. The process was slow, beginning with one individual, followed by others. Over the years, newcomers would outnumber the original settlers, as in the case of Penan Suan and Penan Kebulu.

When the anthropologist Rodney Needham (1965: 66–67) visited the Penan Suan in the early 1950s, he found that '[t]hey formerly shared a house with some Iban, with whom they intermarried; most of the latter have moved away or died, but two Iban men remain'. Today the Iban outnumber the Penan Suan by 24%. Needham also visited the Penan Kebulu and there was no mention of outsiders in the community. Today the Iban make up 40% of the population of the Penan Kebulu.

In all four settlements, the *tuai rumah* is normally a Penan individual. Interestingly, in the 1960s the *tuai rumah* of Penan Suan was an Iban man named Ajan.[9] The current *tuai rumah* of Penan Kebulu is Jusong Pileng, an offspring of a Chinese Teochew father from the Tubau bazaar and an Iban mother, and whose Chinese name is Tan Pee Leng. Jusong Pileng was adopted as an infant by Punai who was then the *tuai rumah* of Penan Kebulu. Jusong Pileng took over the role of *tuai rumah* when Punai became too old. The interesting thing about Jusong Pileng is that he does not speak any Chinese dialects, including Teochew, but speaks perfect Penan and lives his life like a Penan. Like his Chinese father, he married an Iban woman

7 Interviews with Tuai Rumah Ogus Sugun, Jambatan Suai, 21 August 2012; Tuai Rumah Julaihi Keti, Long Saoh, 25 August 2012; and Tuai Rumah Resa Tungun, Long Mekapan, 1 February 2013.

8 Interviews with elders at Jambatan Suai, 21 August 2012; Long Saoh, 25 August 2012; and Long Mekapan, 7 February 2013.

9 Interviews with Penan elders at Long Saoh, 25 August 2012; and Penan elders at Long Mekapan, 26 August 2012.

and speaks Iban fluently. He still maintains relationships with his siblings in the Tubau and communicates with them in Penan, Iban or Malay.

With regard to the Penan Saoh, a number of outsiders have come to their settlements to look for potential brides or to visit. The first intermarriage that took place at Long Saoh was between a Kejaman man from Belaga named Belingan with a Penan woman whose name has faded into obscurity. This was followed by the intermarriage between a Melanau man named Sanen and Mawen, the daughter of a Kejaman father and Penan mother. Another important intermarriage in the history of Penan Saoh was that between a Vaie Segan man, Bibeng, and a Penan Saoh woman. Bibeng was said to be a prominent Vaie Segan from the Segan River in Bintulu. Oral narratives suggest that Bibeng fled Bintulu for the upper Jelalong to escape paying dues to the Brunei sultanate, lived with the Penan and married a Penan woman. Not long after his marriage he became a prominent leader of the Penan Saoh.

Today, of the 32 marriages recorded at Long Saoh given to me by Tuai Rumah Julaihi Keti, only six are between Penan individuals while 26 are with other ethnic groups such as the Iban, Kayan, Kenyah, Chinese, Vaie Segan, Malay and the offspring of mixed marriages (Langub and Ishikawa 2017: 376; see Table 7.1).

Long Saoh is registered as a Penan village longhouse in the Sebauh district office, but there are more people of other ethnicities as well as offspring of intermarriages than there are Penan in the village. This brings us to the important point that Metcalf (2010: 2) highlights: 'that there is no neat fit between longhouse communities and "tribes"'. He elaborates:

Table 7.1 Marriage profile of Penan Saoh families at Long Saoh (Rumah Julaihi)

Marriages	Number	Percentage
Penan married to Penan	6	18.750
Penan married to Iban	6	18.750
Penan married to Kenyah	4	12.500
Penan married to Kayan	3	9.375
Penan married to Chinese	1	3.125
Penan married to Vaie Segan	1	3.125
Penan married to Malay Indonesian	1	3.125
Penan married to offspring of Penan mother and Iban father	1	3.125
Penan married to offspring of Penan mother and Chinese father	1	3.125
Penan married to offspring of Penan mother and Kejaman father	1	3.125
Offspring of Penan mother and Iban father, married to Kayan	3	9.375
Offspring of Penan mother and Iban father, married to Iban	1	3.125
Offspring of Penan mother and Chinese father, married to Punan Bah	1	3.125
Offspring of Penan mother and Chinese-Punan Bah father, married to Bekatan	1	3.125
Offspring of Penan mother and Chinese-Punan Bah father, married to offspring of Iban mother and Chinese father	1	3.125
Total	32	100

Source: Langub and Ishikawa (2017: 376). Reprinted by permission from Springer Nature 2017

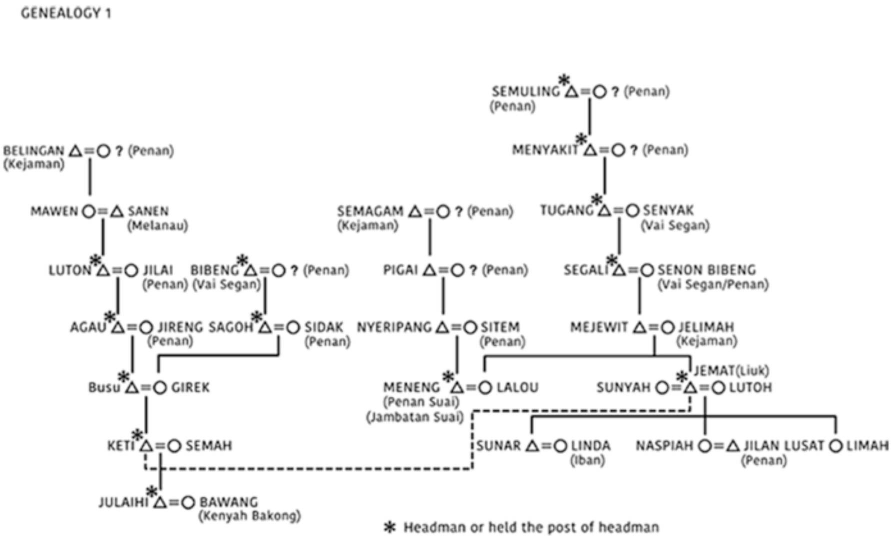


Fig. 7.4 Genealogy of Julaihi Keti
Source: Langub and Ishikawa (2017: 377). Reprinted by permission from Springer Nature 2017

> Elements of any one ethnic population are never neatly bounded. Instead, there are some here, some there, scattered among peoples of other ethnicities. Moreover, multiple ethnicities are represented even *within* longhouse communities and that any discussion of community invariably becomes entangled in the complexities of ethnicity. (Emphasis in original)

In other words, and as Metcalf (2010: 3) aptly puts it, 'we are [here] dealing with heaps of tribes'. Another important feature of the Penan Saoh is the genealogy of Tuai Rumah Julaihi Keti whose ancestors comprise Penan, Kejaman, Melanau and Vaie Segan. Figure 7.4 shows a Kejaman ancestor, Belingan, coming from the Balui through the Belaga River, up the Sepakau stream to the Sepakau–Tubau watershed, down the Tubau to the Jelalong to take a Penan bride. The offspring of the union, Mawen, married a Melanau man, Sanen, from Mukah and begat Luton. Luton married a Penan woman and begat Agau whose son Busu married Gireng the granddaughter of Bibeng, the famous Vaie Segan who became leader of Penan Saoh. Busu and Gireng had a number of children one of whom is Keti, adopted by Jemat. Keti married Semah and they have eight children, one of whom is Julaihi Keti, the current *tuai rumah* of Penan Saoh. I asked the *tuai rumah* how he defines himself ethnically. He smiled and said:

> I am the *tuai rumah* of the village of Penan Saoh, registered at the district office, Sebauh as a Penan longhouse, so I am a Penan; but I am also a Kejaman, a Melanau and a Vaie Segan, and they are an important part of my diverse and rich cultural heritage.

At Long Mekapan, the *tuai rumah* gave me a list of 17 marriages kept in the village profile record. The compositions of these marriages are similar to those at Long Saoh, but less diverse. Of the 17 marriages only five are between Penan individuals;

nine between Penan and Iban (involving seven Penan men to seven Iban women and two Iban men to two Penan women); one between a Penan man and a Malay woman; and one between a Penan woman and a Vaie Segan man.

As noted earlier, the interesting fact about Long Mekapan is that of the 12-door longhouse, eight apartments are Christian (seven Evangelical and one Catholic) and four Muslim. During Christmas the longhouse organises a community dinner with the Christians having an open house for visitors. Similarly, on Hari Raya Aidilfitri the longhouse organises a community dinner with the Muslims hosting and offering food to guests. A community dinner is also organised with an optional open house for the annual Dayak Gawai harvest festival held on 1 June.[10]

The village profile record also contains a list of ten households living and working in the urban areas of Bintulu, Tatau and Miri. Of the ten households, six are Muslim and four are Christian. Irrespective of beliefs, all households contribute to the longhouse events and activities, and send money for festival celebrations and funerals. If they get leave from work they normally come and participate in the events, especially funerals. During school holidays they normally take their families back to Long Mekapan to familiarise the children with life in the longhouse. Asked whether these households would come back to live in Long Mekapan upon retirement of the breadwinners, Christian households said they would, even if they already owned houses in urban areas, judging from their frequent visits to Long Mekapan, visiting land given to them by their parents or planting fruit trees on the land. They were not certain whether the Muslim households would and no reason was given.

Of interest to linguists is the variety of Western Penan dialects spoken in the Jelalong. Western Penan spoken in Jelalong is quite different from the original spoken in the Usun Apau, Belaga and Silat River. After 200 years in the Jelalong, the Western Penan dialect seems to have been influenced by other languages spoken along the Kemena River and the coastal area of Bintulu. According to Penan elders in Jambatan Suai, Long Saoh and Long Mekapan, over the years they have adopted a number of foreign words from the Vaie Segan and Melanau, especially the former, through intermarriages and frequent contact.[11] However, the Penan from Belaga and the Usun Apau say that they have no problem understanding the dialect of Western Penan spoken in the Jelalong and surrounding areas, indicating that Western Penan spoken in the Jelalong is still intelligible with the original Penan spoken in Belaga and elsewhere.[12]

As already highlighted, the first Penan to get a formal education was Keti Jemat of Long Saoh. Today there are ten university graduates from Long Saoh, most of them being children from mixed marriages. Four siblings, two brothers and two sisters of a Chinese–Penan intermarriage, have university degrees. One of the broth-

[10] Interview with elders of Long Mekapan, 26 August 2012.

[11] Interview with Penan elders in Jambatan Suai, 21 August 2002; Long Saoh, 25 August 2012; and Long Mekapan, 26 August 2012.

[12] Conversations with Penghulu Pau Tului, Long Wat, 25 April 2010; Pengajau Uma Along Joo, Long Singu, 30 April 2010; Pengajau Uma Matu Tugang, Long Jek, 2 May 2010.

ers is a dentist working in Kapit, the other an engineer working in Miri while the two sisters are teachers in peninsular Malaysia. One of Tuai Rumah Julaihi Keti's brothers is a university graduate who holds a key position in the Sarawak civil service and another sister holds a master's degree in education and is a teacher. The other three Penan settlements have yet to produce a university graduate. However, three youths (one from each village) are now pursuing tertiary education in various institutions of higher learning in the country.

7.9 Conclusion

The migration of the four groups of nomadic Penan from the Usun Apau in Belaga district and the Apau Julan in Baram district took place in the early 1800s. They adopted a settled life in the 1820s and 1850s. Once they established permanent villages, other ethnic groups came to marry and live with them, creating a multiethnic society within the confines of each longhouse.

Intense interaction with other groups has influenced their language to the extent that it created a variation of Western Penan distinctively identified with groups that migrated to the Suai, the Labang and the Jelalong. Their transition from hunter-gatherers to food cultivators and cash crop farmers has been smooth and self-driven. As a pioneer group, they have earned the respect of later migrants for their historical knowledge of the land and its resources, enhancing in them a sense of self-confidence and identity.

Appendices

Appendix 7.1: Movements of Penan Saoh Ancestors from the Apau Julan and the Usun Apau to the Jelalong

Leader	Movement of the Penan Mekapan	Remarks
Semalong Julan	Moved back from Apau Julan to the Usun Apau (their place of origin); moved to the Seping; crossed the Mali and the Belaga to the Koyan; journeyed upstream of the Koyan, took a left turn, climbed the steep Sekalap pass and went downhill to the Kebulu; remained in the Kebulu; moved downstream and at the mouth of Kebulu took a right turn up the Jelalong to the Merurong, a tributary of the Jelalong; remained here and Semalong passed away	Penan had a tribal existence, outside state control; leadership passed to Semuling Julan
Semuling Julan	Remained in the Merurong	Leadership passed to his nephew, Sesian Semalong

Leader	Movement of the Penan Mekapan	Remarks
Sesian Semalong	Moved to the upper Jelalong; then the Tinjar; lived in the Temadoh, a tributary of the Tinjar; moved back to the upper Jelalong	Leadership passed to Menyakit Semuling
Menyakit Semuling	Moved down the Jelalong and took a right turn up the Saoh; established a settlement in the Sekuan	Leadership passed to Turung Semuling
Turung Semuling	Remained in the Sekuan	Leadership passed to Labi Menyakit
Labi Menyakit	Remained in the Sekuan	Leadership passed to Tugang Menyakit
Tugang Menyakit	Remained in the Sekuan	Leadership passed to Segali Tugang
Segali Tugang	Remained in the Sekuan	Leadership passed to Bibeng
Bibeng	Moved down the Saoh and took left turn; established a settlement at the Liuk, a tributary of the Jelalong	Penan aware of Brunei rule; leadership passed to Seniang
Seniang	Moved up the Jelalong; established a settlement at Sengayah	Leadership passed to Luton
Luton	Moved down the Jelalong: established a settlement at Long Saoh	Luton's remains put in a *kliering*; leadership passed to Nayang
Nayang	Moved to Long Kebulu	Leadership passed on to Sagoh Bibeng
Sagoh Bibeng	Remained in Long Kebulu	Sarawak under Brooke rule; leadership passed to Surei Luton
Surei Luton	Moved to Sengoloi, at the upper Kebulu	Sarawak still under Brooke rule; leadership passed to Agau Luton
Agau Luton	Moved to the Ma'au, at the upper Saoh	Leadership passed to Leng Luton
Leng Luton	Moved to the Vadeu, a tributary of the Jelalong	Japanese forces occupied Sarawak (1941–1945); leadership passed to Busu Agau
Busu Agau	Remained in the Vadeu	Leadership passed to Jemat Mejiwit
Jemat Mejiwit	Moved back to the Liuk	British colonial (from late 1945); leadership passed to Avit Busu

Leader	Movement of the Penan Mekapan	Remarks
Avit Busu	Remained in the Liuk	Sarawak became part of the Federation of Malaysia (1963); leadership passed to Keti Jemat as appointed *tuai rumah*
Keti Jemat	Moved back to Long Saoh	Retired from *tuai rumah* position in 2009
Julaihi Keti	Remained at Long Saoh	Appointed *tuai rumah* in 2009

Source: *Profil kampung Long Saoh* [Long Saoh village profile]

Appendix 7.2: Movement of the Penan Mekapan Ancestors from the Apau Julan to the Jelalong

Leader	Movement of the Penan Mekapan	Remarks
Ngambung	Moved from the Apau Julan to the Paong, went down the Tinjar to below the Temadoh, took a left turn and made overland crossings of the Niah and the Suai to reach Tanjung Kidurong; later moved to the Sibiu	Tribal existence was outside state control; Ngambung was buried in the Sibiu; leadership was passed to Madang
Madang	Moved up the Kemena; lived at the mouth of the Labang	Madang died and was buried in the Labang; leadership passed to Tekulah
Tekulah	Moved up the Kemena; lived in Tubau	Kayan arrived in the area; Tekulah died and was buried at Tubau; leadership passed to Lengaut
Lengaut	Moved up the Jelalong; established a settlement at the Darui	Was buried at the Darui; leadership passed to Nayang
Nayang	Stayed put in the settlement at the Darui	Was buried at the Darui; leadership passed to Balan
Balan	Moved up the Jelalong to the Liuk River	Was buried at the Darui; leadership passed to Sedaya
Sedaya	Moved back to the Darui	Was buried at the Darui; leadership passed to Mengejau
Mengejau	Moved to Long Saoh	Was sick for long time before being cured by a Vaie Segan trader; converted to Islam; was buried at the Darui; leadership passed to Dangan
Dangan	Moved to Long Mekapan and established a settlement there	Appointed by the colonial government as *tuai rumah* 1958; died in 1977 and buried at the Darui; leadership passed to Jadong

Leader	Movement of the Penan Mekapan	Remarks
Jadong	Long Mekapan settlement became permanent	Appointed *tuai rumah* in 1977; converted to Islam and moved to live in Bintulu; Resa Tungun appointed *tuai rumah* in 1984
Resa Tungun	Built a modern longhouse at Long Mekapan	Current *tuai rumah*

Source: *Profil kampung Long Mekapan* [Long Mekapan village profile]

References

Arnold, Guy. 1956. Prehistory of Usun Apau. *Sarawak Museum Journal* 7 (7): 166–181.

———. 1959. *Longhouse and jungle: An expedition to Sarawak*. London: Chatto and Windus.

Bampfylde, C.A. 1893. Rejang. Monthly report. *Sarawak Gazette* 23: 28.

de Crespigny, C.A.C. 1881. Visit to Belaga. *Sarawak Gazette* 11 (180): 4–7.

———. 1882. Journal from Mukah. *Sarawak Gazette* 12 (188): 40–45.

Gockel, Guido. 1974. The Long Pekun Sebop. In *The peoples of central Borneo,* ed. Jérôme Rousseau, 325–328. *Sarawak Museum Journal*, special issue, 22 (43).

Gueritz, George. 1882. Bintulu. Monthly report for March 1882. *Sarawak Gazette* 12 (187): 36.

Harrisson, Tom, and D.L. Leach. 1954. Towards the Usun Apau. *Sarawak Museum Journal* 6 (4): 65–95.

Langub, Jayl, and Noboru Ishikawa. 2017. Community, river and basin: Watersheds in northern Sarawak as a social linkage. In *Borneo studies in history, society and culture*, ed. Victor T. King, Zawawi Ibrahim, and Noor Hasharina Hassan, 365–384. Singapore: Springer.

Low, Hugh Brooke. 1884a. Mr. Low's November [1883] diary. *Sarawak Gazette*, 1 April, 14(219):30–33.

———. 1884b. Mr. Low's December [1883] diary. *Sarawak Gazette* 14 (220): 41–44.

Metcalf, Peter. 1976. Who are the Berawan? Ethnic classification and the distribution of secondary treatment of the dead in central north Borneo. *Oceania* 47: 85–105.

———. 2002. *They lie, we lie: Getting on with anthropology*. London: Routledge.

———. 2010. *The life of the longhouse: An archaeology of ethnicity*. Cambridge: Cambridge University Press.

Needham, Rodney. 1953. The social organisation of the Penan: A Southeast Asian people. DPhil thesis, Oxford University.

———. 1954. Penan and Punan. *Journal of the Malayan Branch of the Royal Asiatic Society* 27 (1): 173–183.

———. 1965. Death-names and solidarity in Penan society. *Bijdragen tot de Taal-, Land- en Volkenkunde* 121 (1): 58–76.

———. 1972. Penan. In *Ethnic groups of insular Southeast Asia*, ed. Frank M. LeBar, vol. 1, 176–180. New Haven: Human Relations Area Files Press.

Nicolaisen, Ida. 1976. Form and function of Punan Bah ethno-historical tradition. *Sarawak Museum Journal* 24 (45): 63–95.

Profil kampung Long Mekapan [Long Mekapan village profile]. Long Mekapan. n.p.

Profil kampung Long Saoh [Long Saoh village profile]. Long Saoh. n.p.

Rousseau, Jérôme. 1990. *Central Borneo: Ethnic identity and social life in a stratified society*. Oxford: Clarendon Press.

Seling Sawing. 1974. The flight from the Usun Apau to the headwaters of the Tinjar. In *The peoples of central Borneo,* ed. Jérôme Rousseau, 331–348. *Sarawak Museum Journal,* special issue, 22 (43).

Vom Roy. 1993. *The migration of Kenyah Badeng: A study based on oral history.* Edited with an introduction by Tan Chee Beng. Kuala Lumpur: Institute of Advanced Studies, Universiti Malaya.

Part II
Inflection Points of Nature

Chapter 8
Diversity of Medium- to Large-Sized Ground-Dwelling Mammals and Terrestrial Birds in Sarawak

Hiromitsu Samejima and Jason Hon

Abstract While Borneo is a global biodiversity hotspot, its species-rich natural rainforests have been degraded and deforested in the past few decades by unsustainable shifting agriculture, commercial logging and the rapid development of industrial tree and oil palm plantations. Populations of some wildlife species have decreased drastically due to landscape changes, while other species may be adapting to the new mosaic landscape. To understand the current condition of biodiversity distribution in a heterogeneous landscape, it is necessary to develop a sustainable plan for various land uses in order to maintain the rich biodiversity and preserve ecosystem services for local communities. Camera trap surveys for medium- to large-sized ground-dwelling mammals and terrestrial birds were conducted in lowland areas of Sarawak that were under different management regimes: logging concessions, land used for shifting agriculture and oil palm plantations. Using the mean trapping rate as an abundance index, the wildlife population in logging concessions seems to have recovered 4 years after harvesting. The composition of endangered or medium-sized species in secondary forests around villages in lowland areas is low, but this habitat still remains favourable for major game species for local communities.

Keywords Sarawak · Biodiversity · Ground-dwelling mammals · Terrestrial birds · Sustainable forest management · Camera trap survey

H. Samejima (✉)
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

J. Hon
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_8

8.1 Introduction

The island of Borneo is a global biodiversity hotspot. It supports around 221 mammal species, including a number of endangered species (Payne and Francis 2005; Ceballos and Ehrlich 2006; Schipper et al. 2008). Some of the wild mammal species are important sources of protein for local communities. Medium- to large-sized mammals, particularly bearded pig (*Sus barbatus*) and sambar deer (*Rusa unicolor*), are commonly hunted and consumed by indigenous communities (Bennett et al. 2000).

Most of the island was originally covered by natural forest. In 1973 the percentage cover stood at 75.7%; by 2010 this had declined to 52.8% (Gaveau et al. 2014). Selective logging, fires and conversion to industrial tree and oil palm plantations in recent decades have degraded and reduced the natural forest cover. In Sarawak, shifting cultivation for rice farming by local communities has taken place on an annual rotational basis over many generations, particularly along rivers and logging roads, and this has also changed the landscape by converting natural primary forests into secondary forests. In addition, small rubber plots and pepper farms have been established around villages. In the early 2000s villagers also began to plant oil palm, particularly in farms that were located along old logging roads (Soda et al. Chap. 15; Soda and Kato, Chap. 17).

To date, there have been very few studies on how mammal communities inhabit the mosaic landscape developed by these recent human activities. Many mammal species depend on natural forests, with their distribution ranges and population densities potentially declining following the degradation and fragmentation of the natural primary rainforests. Population decreases of important game species may threaten the food security of rural communities. On the other hand, some mammal species may be able to adapt to new environments, such as secondary forests after shifting agriculture or in industrial tree and oil palm plantations (Meijaard et al. 2005; McShea et al. 2009; Hon et al. 2012). For example, according to local communities in the lowland forests of Sarawak, agricultural damage caused by the southern pig-tailed macaque (*Macaca nemestrina*) has increased over the years (Kato and Samejima, Chap. 14), although this phenomenon could also be caused by a decline of food resources in the natural forest.

The remaining natural rainforests in Sarawak are mostly managed as logging concessions by private companies. While logging activity itself can be a severe threat to biodiversity, careful management of a production forest can maintain the natural biodiversity sustainably at a large spatial scale while still generating revenue from timber production at the same time. One approach to promoting sustainable forest management is forest certification schemes. The Forest Stewardship Council founded in 1993 and the Programme for the Endorsement of Forest Certification (PEFC) founded in 1999 are two major global certification schemes. Malaysia established the Malaysian Timber Certification Council (MTCC) in October 1998 and it is responsible for the Malaysian timber certification scheme which was endorsed by the PEFC in 2009. As of 2017, there is only one certified concession in

Sarawak, the Anap-Muput Forest Management Unit (AMFMU), certified by the MTCC and PEFC. Following the success of the AMFMU, the Sarawak state government is encouraging six of the major logging groups in Sarawak and the state's own Sarawak Timber Industry Development Corporation to get international forest management certification for one of their logging concessions. There is also the possibility that forest certification will be mandatory for all logging concessions in the state in the future (Ruekeith 2014).

However, the performance of certified logging concessions in biodiversity conservation has not been well demonstrated, especially in Sarawak (Putz et al. 2001; Meijaard et al. 2005; Samejima et al. 2012). From the perspective of logging companies, the benefits arising from the improved forest management have not been well utilised for the marketing of their products and attracting investments, although the implementation of the management practices requires additional costs.

Further, there is little information available on the mammal communities in secondary forests around villages and rural areas in Southeast Asia. Most of the previous studies on mammal distributions in Borneo were conducted inside protected areas, logging concessions or industrial tree plantations (Meijaard et al. 2005; McShea et al. 2009). Hunting activities by local communities have been blamed as a major factor leading to a decrease in diversity and a decline in the abundance of medium- to large-sized mammals, resulting in so-called 'empty forests' that lack seed dispersers for standing trees to germinate and maintain species diversity (Bennett et al. 2000; Harrison 2011). Even in protected areas, such as national parks, mammal populations are reduced and hunting is considered to be the main factor (Harrison 2011). Elizabeth Bennett et al. (2000) conducted line transects in primary forests as well as secondary forests, logged areas and plantation areas in Sabah and Sarawak, and reported a significant correlation between increased hunting pressure and decreased density of mammals across all habitats in the study. However, the population declines in primary forest may also be the result of habitat loss around the primary forests.

In this chapter, we investigate differences of mammal species composition and abundance in a productive forest certified by the MTCC and PEFC and secondary forests around villages and an oil palm plantation. We evaluate the effects of landscape, logging and hunting activities on medium- to large-sized ground-dwelling mammals and terrestrial birds using camera traps, which consist of an automatic digital camera with an infrared sensor.

8.2 Materials and Methods

8.2.1 Study Sites

The study area was located in Bintulu Division, central Sarawak, including the Anap Sustainable Development Unit (ASDU) and four village areas (Fig. 8.1). The ASDU covers an area of 1068 km^2 and is located in Tatau district in Bintulu Division. The ASDU includes the Anap-Muput Forest Management Unit (AMFMU), which covers an area of 835 km^2, and an area of Licence for Planted Forests (LPF/0039), which covers 232 km^2. Logging operations in the AMFMU began in 1977 and the site is currently undergoing its second harvest. The AMFMU has applied a reduced-impact logging method since 2008, has pursued the newly revised Malaysian timber

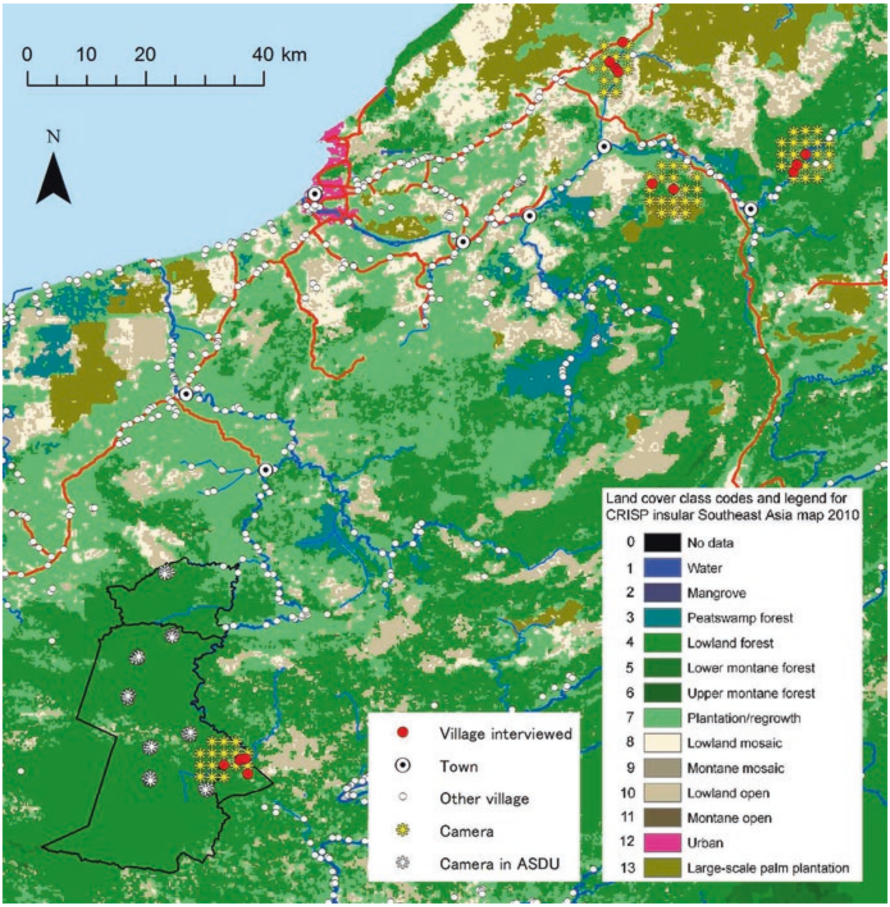


Fig. 8.1 Study plots in the Anap Sustainable Development Unit and the village study areas
Source: Vegetation map developed with permission from Miettinen et al. (2012)

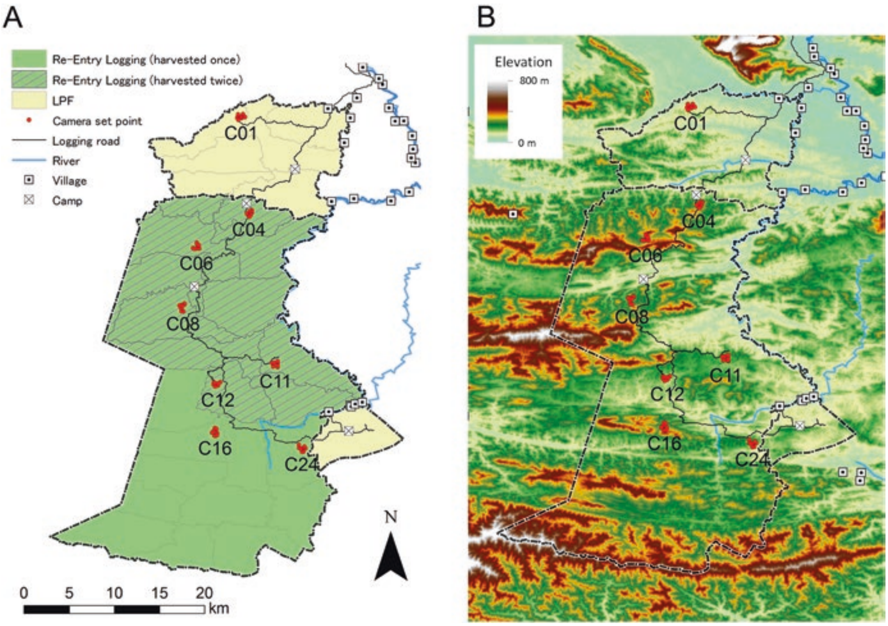


Fig. 8.2 Distribution of the eight study plots in the Anap Sustainable Development Unit with (**a**) management status and (**b**) elevation
Note: The green area in (a) is the AMFMU and the yellow areas were LPF/0039

certification scheme since 2012 and was successfully certified under the Malaysian Criteria, Indicators, Activities and Standards of Performance for Forest Management Certification under the natural forests category in 2013.

Eight study plots, each with a radius of 500 m, were established in the ASDU and were named after the operational coupes (Fig. 8.2, Table 8.1). One plot, C01, was inside the LPF/0039, whereas the other seven plots (C04, C06, C08, C11, C12, C16 and C24) were inside the AMFMU. Plots C04, C16 and C24 have been harvested once, whereas C12, C11, C08 and C06 have been harvested twice, ranging from 0 to 6 years since the last harvest. At the time of the survey, vegetation in plot C01 was a natural forest, but had been harvested more than three times. The vegetation type in all the plots was lowland mixed dipterocarp forest, except for plot C24 which contained kerangas forest (Samejima et al. Chap. 10).

The four village areas are Sujan, Lavang, Jelalong and Ulu Anap. The settlements of local people in this region are longhouses, a row house made up of a few to tens of independent units, known as *bilik*, of household families. In each village area, one longhouse was selected as a centre point and an 8 × 8 km study area was established with the centre point at the middle of the study area. Each study area included from one to four longhouses (Table 8.3).

The Sujan area is relatively flat and does not have a large river flowing through it. Natural forests dominated by dipterocarps are rarely found in this area. The study

Table 8.1 Habitat description of the study plots for camera traps in the Anap Sustainable Development Unit

Plot	No. of times harvested (last year harvested)	Average elevation of setting points (range of elevation) (m)	Remarks
C01	>3 (2008)	105.5 (94–118)	Repeatedly logged forest to be converted to industrial tree plantation in the future
C04	1 (1980s)	260.8 (186–323)	Area (38 ha) is used as a water catchment for the base camp; surrounding area was harvested in 2004
C06	2 (2005)	280.7 (247–366)	
C08	2 (2007)	253.8 (218–291)	
C11	2 (2010)	199.1 (184–218)	
C12	2 (2011)	174.5 (149–200)	Logged a few months prior to camera trapping
C16	1 (1990s)	277.8 (241–327)	
C24	1 (1990s)	188. 3 (165–222)	Kerangas forest

area encompasses two distinct land uses. The southern half is inside a large-scale oil palm plantation that we named Sujan plantation. The northern half consists of a mosaic landscape of secondary forest after slash-and-burn agriculture for rice cultivation and small-scale oil palm farms by the local people and that we named Sujan village (Hon 2014; Soda and Kato, Chap. 17).

The Lavang and Jelalong areas are mostly covered by secondary forests. There are some natural dipterocarp forests remaining inside the study areas, but these are located away from the longhouses. Large-scale oil palm and industrial tree plantations surround the Lavang area, whereas natural dipterocarp forests surround the Jelalong area. The Lavang and Jelalong rivers run through the respective areas with swamp forests along the rivers, which are submerged several times a year during periods of high rainfall.

The Ulu Anap area is located at the upper reaches of the Anap River and partly inside the ASDU. Most of the area is covered by dipterocarp-dominated natural forest, with narrow secondary forests along the Anap River. The area is relatively steep and there are no swamp forests within this study area.

8.2.2 Camera Trapping

We undertook camera trapping in the ASDU from May 2011 to June 2013. In each plot, we generated eight setting points for camera traps randomly using the statistical software R (version 2.15; R Development Core Team 2013) and arrived at the points using a handheld GPS. The elevations of the setting points ranged from 94 to 366 m, where plot C01 had the lowest elevation and plots C06 and C16 had the highest elevations (Table 8.1). The cameras used were Bushnell Trophy Cams, which were mounted on a tree near the GPS points, 50–100 cm above the ground. The field of view of each camera was approximately 2–7 m^2. The cameras were set to record in video mode for 10 seconds upon triggering, and were checked every 3–5 months.

We also conducted camera trapping in the village areas from June 2013 to November 2014. In the Sujan, Lavang, Jelalong and Ulu Anap village areas, 11–18 setting points were selected in a grid pattern 2 km apart from each other in the 8 × 8 km study area. We generated the coordinates of these setting points using the statistical software R 2.15 and arrived at each point using a GPS. At each setting point, a Bushnell Trophy Cam camera trap was installed. Camera traps were not installed at points inside oil palm and industrial tree plantations or in other forms of development except the Sujan plantation area because of the risk that these camera traps might be stolen. Camera traps in the Sujan plantation were secured by the staff of the oil palm plantation company.

Details of all the records captured by the camera traps from the ASDU and the village areas, such as date, time, animal species and the number of individuals in each image, were keyed into a database. The medium- and large-sized mammals and terrestrial birds were identified based on Junaidi Payne and Charles Francis (2005), Susan Myers (2009), and Quentin Phillipps and Karen Phillipps (2009). Rats, squirrels, tree shrews and bat species were difficult to identify and thus excluded from the analysis.

For each study plot in the ASDU and each village area we calculated the number of species captured. We also calculated the mean trapping rate (MTR) for each species as an abundance index (Samejima and Ong 2012). The formula used to calculate the MTR was: MTR = total number of image / total camera working days × 100. If the same species was captured within a 30-min time frame, this was treated as a single record. The number of camera working days at each sampling point was derived from the end date minus the installed date. If a camera malfunctioned, the date of the last record was treated as the end date.

In the Sujan plantation and the four village areas, MTR differences among the study areas were tested by bootstrapping as follows. The camera setting points from each area were resampled to allow for redundancy but keeping the number the same as the number of original camera setting points in the study area. New MTRs of a study area were generated from the resampled points and the new MTRs for two areas were compared. The process was repeated 1000 times to obtain a set of differences and we considered MTRs as significantly different between two areas if more than 95% of the difference was all positive or all negative.

8.2.3 Community Survey: Interviews About Hunting Activity

Interviews on hunting activities were carried out in the Sujan, Lavang, Jelalong and Ulu Anap areas from June to July 2014. As noted in other chapters of this volume (Kato and Samejima, Chap. 14; Kato and Soda, Chap. 16), many households in this area have migrated to towns or plantations for off-farm jobs while keeping their *bilik* in the longhouse. Other households usually stay in their huts near their oil palm fields along roads, which are sometimes far from their longhouse (Soda et al. Chap. 15).

Interviews about hunting activities were carried out in all longhouses inside the 8 × 8 km study area. The data collected included the numbers of inhabited *bilik* and the presence of active hunters. A *bilik* was considered to be inhabited if at least one member of the household stayed there every week, including weekend-only occupants. We defined an 'active hunter' as a person who goes hunting more than once a month on average. Some longhouses in Lavang and Jelalong had no occupants and thus were excluded from our survey.

Table 8.2 List and number of records for medium- and large-sized mammals and terrestrial birds captured by camera traps in the Anap Sustainable Development Unit

Class	Scientific name	Common name	Number of images	Threatened status
Mammalia	*Echinosorex gymnura*	Moon rat	25	
	Manis javanica	Sunda pangolin	134	EN
	Macaca fascicularis	Long-tailed macaque	20	
	Macaca nemestrina	Southern pig-tailed macaque	1945	VU
	Hystrix brachyura	Malayan porcupine	744	
	Trichys fasciculata	Long-tailed porcupine	222	
	Hystrix crassispinis	Thick-spined porcupine	69	
	Helarctos malayanus	Sun bear	131	VU
	Martes flavigula	Yellow-throated marten	25	
	Mustela nudipes	Malay weasel	1	
	Viverra tangalunga	Malay civet	401	
	Cynogale bennettii	Otter civet	2	EN
	Arctictis binturong	Binturong	16	VU
	Arctogalidia trivirgata	Small-toothed palm civet	3	
	Paguma larvata	Masked palm civet	58	
	Paradoxurus hermaphroditus	Common palm civet	7	
	Hemigalus derbyanus	Banded civet	458	VU
	Prionodon linsang	Banded linsang	8	
	Herpestes semitorquatus	Collared mongoose	31	
	Herpestes brachyurus	Short-tailed mongoose	25	
	Neofelis diardi	Sunda clouded leopard	2	VU
	Pardofelis marmorata	Marbled cat	9	VU
	Prionailurus bengalensis	Leopard cat	29	
	Catopuma badia	Borneo bay cat	5	EN
	Sus barbatus	Bearded pig	892	
	Tragulus kanchil	Lesser mouse deer	25	
	Tragulus napu	Greater mouse deer	52	
	Muntiacus muntjak	Southern red muntjac	440	
	Muntiacus atherodes	Bornean yellow muntjac	652	
	Rusa unicolor	Sambar deer	93	VU
Aves	*Rollulus rouloul*	Crested partridge	44	
	Lophura ignita	Crested fireback	1	
	Lophura bulweri	Bulwer's pheasant	73	VU
	Argusianus argus	Great argus	282	

Notes: The total sampling effort was 41,167 camera trap days
The threatened status of each species was classified according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species Version 2013.1—EN: endangered, VU: vulnerable

8.3 Results

8.3.1 Camera Trapping in the Anap Sustainable Development Unit

Overall, the working days of the camera traps in the ASDU ranged from 4442 to 6190 days in each plot, and the combined sampling effort for all plots was 41,467 camera trap days. A total of 30 medium- and large-sized mammals and four terrestrial bird species, including many elusive and endangered species, were recorded from a combined total of 6924 records (Table 8.2). All species recorded in the ASDU previously by Jason Hon (2011) and Hon and Shozo Shibata (2013) were recorded in this study. The southern pig-tailed macaque (*Macaca nemestrina*) was recorded the most times (number of images, N = 1945), followed by the bearded pig (*Sus barbatus*, N = 892) and the Malayan porcupine (*Hystrix brachyura*, N = 744). In contrast, the Malay weasel (*Mustela nudipes*, N = 1), the otter civet (*Cynogale bennettii*, N = 2), the small-toothed palm civet (*Arctogalidia trivirgata*, N = 3), the Sunda clouded leopard (*Neofelis diardi*, N = 2) and the crested fireback (*Lophura ignita*, N = 1) were recorded on less than five occasions each.

The number of species recorded in each plot was 20–27 in the ASDU (Fig. 8.3) and was lowest at C12, a plot that was harvested just 1 year prior to our camera trapping survey. The total MTR in a plot ranged from 7.2 to 20.1 and was lowest at C24, a kerangas forest site (Fig. 8.4). The total MTR for C12 was also lower than that at the other plots. However, the total MTR at other recently harvested plots (C06, C08

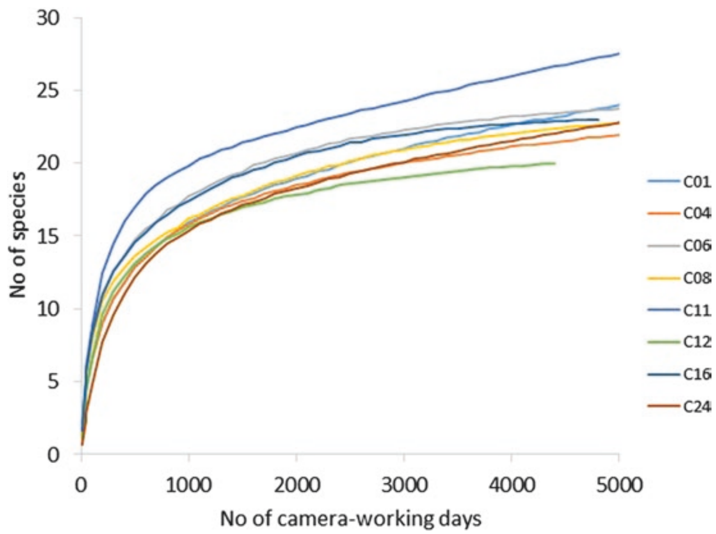


Fig. 8.3 Rarefaction curves of species richness at eight plots in the Anap Sustainable Development Unit

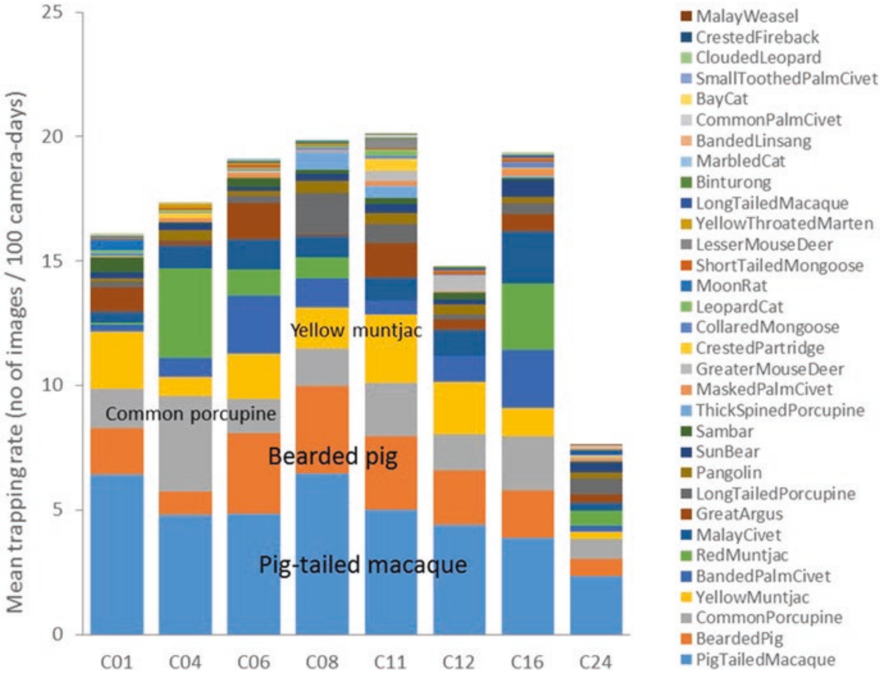


Fig. 8.4 Mean trapping rate for all the species recorded in the eight plots in the Anap Sustainable Development Unit
Note: The number above each bar is the total MTR for that respective plot

and C11) were not much different from the total MTR at the old forest plots (C04 and C16).

8.3.2 *Hunting Activities of Communities*

In total, we surveyed 377 *bilik* (households) of 14 longhouses, of which 231 (61.3%) were inhabited (Table 8.3). Of these, 39 households (16.9%) contained active hunters as the members, mostly just one person per household. The other villagers seldom went hunting but purchased wild meat from the active hunters in their own longhouse or from neighbouring longhouses.

Table 8.3 Study areas

Study area	Main vegetation type	Number of longhouses	Number of *bilik* (households)			Number of camera set points	Total camera trap days
			Total	Inhabited	With active hunters		
Sujan plantation	Oil palm plantation	0	–	–	–	9	2267
Sujan village	Secondary forests mixed with oil palm	2	48	46	8	8	1842
Lavang	Secondary forests surrounded by oil palm plantations	4	185	100	15	18	2260
Jelalong	Secondary forest surrounded by logged natural forest	3	69	38	8	11	4781
Ulu Anap	Secondary forest and logged natural forest	5	75	47	8	15	5103

Table 8.4 Species recorded by camera traps in the five study areas (Sujan plantation, Sujan village, Lavang, Jelalong and Ulu Anap)

Class	Scientific name	Common name	Number of images	Threatened status	Different among the five study areas
Mammalia	*Echinosorex gymnura*	Moon rat	14		*
	Manis javanica	Sunda pangolin	13	EN	*
	Macaca fascicularis	Long-tailed macaque	85		*
	Macaca nemestrina	Southern pig-tailed macaque	683	VU	*
	Hystrix brachyura	Malayan porcupine	58		*
	Trichys fasciculata	Long-tailed porcupine	89		*
	Hystrix crassispinis	Thick-spined porcupine	91		*
	Helarctos malayanus	Sun bear	34	VU	*
	Martes flavigula	Yellow-throated marten	3		
	Viverra tangalunga	Malay civet	44		*
	Arctictis binturong	Binturong	1	VU	
	Arctogalidia trivirgata	Small-toothed palm civet	3		
	Paguma larvata	Masked palm civet	1		
	Paradoxurus hermaphroditus	Common palm civet	12		*
	Hemigalus derbyanus	Banded civet	58	VU	*
	Prionodon linsang	Banded linsang	1		
	Herpestes semitorquatus	Collared mongoose	3		
	Herpestes brachyurus	Short-tailed mongoose	15		*
	Prionailurus bengalensis	Leopard cat	48		*
	Catopuma badia	Borneo bay cat	1	EN	
	Sus barbatus	Bearded pig	437		*
	Tragulus kanchil	Lesser mouse deer	125		*
	Tragulus napu	Greater mouse deer	64		*
	Muntiacus atherodes	Bornean yellow muntjac	164		*
	Rusa unicolor	Sambar deer	87	VU	*
Aves	*Rollulus rouloul*	Crested partridge	6		
	Lophura ignita	Crested fireback	61		*
	Lophura bulweri	Bulwer's pheasant	12	VU	*
	Argusianus argus	Great argus	54		*

Notes: Conservation status classified according to the IUCN Red List of Threatened Species Version 2013.1—*EN* endangered, *VU* vulnerable
*indicates that the MTR is significantly different among the five study areas ($p < 0.05$)

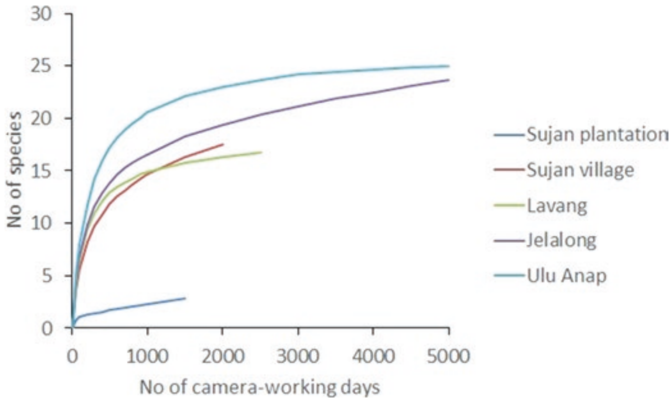


Fig. 8.5 Rarefaction curves of species richness at the Sujan plantation and the four village areas

8.3.3 Camera Trapping in Village Areas

A total of 2191 records of 25 species of medium and large mammals and 138 records of four terrestrial bird species were recorded in the Sujan plantation and the four village areas (Table 8.4). The total working effort was 17,326 camera trap days. All the 29 mammal and bird species are species that were recorded by camera trapping in the ASDU. Species richness was high in Ulu Anap and Jelalong and was lowest in the Sujan plantation (Fig. 8.5).

We compared the MTRs of 29 medium and large mammal and terrestrial bird species from the Sujan plantation, the four village areas and the eight plots in the ASDU. The MTRs of 21 species were significantly different among the areas. The other nine species were too rare to evaluate any effects due to landscape differences among village areas. The patterns of the 20 species can be categorised into seven groups (below), while Fig. 8.6 shows the MTRs of six major game species for local people in the Sujan plantation, the four village areas and the eight plots in the ASDU.

1. Abundant in oil palm plantations
   - *Prionailurus bengalensis* (Leopard cat)
2. Abundant in forested areas around a village (i.e. Sujan village, Lavang, Jelalong and Ulu Anap), but few recordings in the ASDU
   - *Hystrix crassispinis* (Thick-spined porcupine)
   - *Tragulus napu* (Greater mouse deer)
   - *Tragulus kanchil* (Lesser mouse deer)
   - *Rusa unicolor* (Sambar deer)
   - *Macaca fascicularis* (Long-tailed macaque)
   - *Lophura ignita* (Crested fireback)

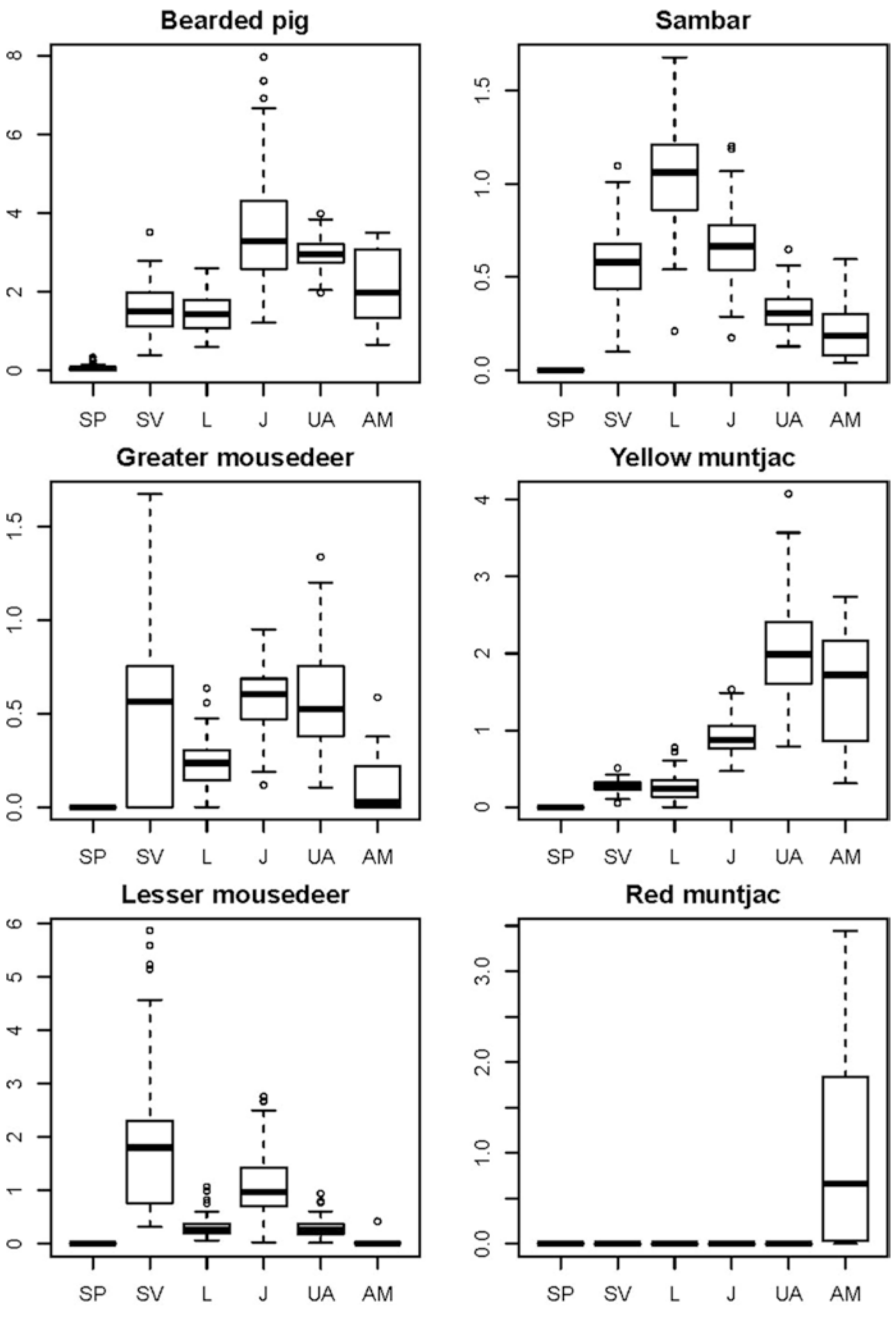


Fig. 8.6 Mean trapping rate of six major game species
Notes: *SP* Sujan plantation, *SV* Sujan village, *L* Lavang, *J* Jelalong, *UA* Ulu Anap, *AM* Anap Sustainable Development Unit
The boxplots for SP, SV, L, J and UA show the MTR distributions after 100 bootstraps
The boxplot for the ASDU shows the MTR distributions at the eight sampling plots

3. No significant differences among all forested areas (i.e. Sujan village, Lavang, Jelalong, Ulu Anap and the ASDU)

   – *Macaca nemestrina* (Southern pig-tailed macaque)
   – *Sus barbatus* (Bearded pig)

4. More abundant in the intact forest areas of Lavang, Jelalong, Ulu Anap and the ASDU

   – *Rollulus rouloul* (Created partridge)
   – *Argusianus argus* (Great argus)

5. More abundant in the intact forest areas of Jelalong, Ulu Anap and the ASDU

   – *Martes flavigula* (Yellow-throated marten)
   – *Paradoxurus hermaphroditus* (Common palm civet)
   – *Hemigalus derbyanus* (Banded civet)

6. More abundant in the intact forest areas of Ulu Anap and the ASDU, but also observed in degraded forest areas

   – *Helarctos malayanus* (Sun bear)
   – *Muntiacus atherodes* (Bornean yellow muntjac)

7. More abundant in the intact forest areas of Ulu Anap and the ASDU

   – *Lophura bulweri* (Bulwer's pheasant)
   – *Viverra tangalunga* (Malay civet)
   – *Manis javanica* (Sunda pangolin)

8. Only found in the intact forest areas only of the ASDU

   – *Mustela nudipes* (Malay weasel)
   – *Cynogale bennettii* (Otter civet)
   – *Neofelis diardi Sunda* (Clouded leopard)
   – *Pardofelis marmorata* (Marbled cat)
   – *Muntiacus muntjac* (Southern red muntjac)

8.4 Discussion

This study is one of the first in Southeast Asia to evaluate abundances of medium to large ground-dwelling mammals and terrestrial birds in human-disturbed landscapes, which include logging concessions and oil palm plantations. The results of this study show obvious differences of adaptability to human-disturbed landscapes among the animal species.

The species richness of medium- and large-sized mammals is highest in the large natural primary forest of the ASDU. Here, we recorded 30 out of the 38 known ground-dwelling or semi-ground-dwelling medium to large mammal species in Borneo (Payne and Francis 2005). The remaining eight species not recorded in this study include the following:

1. Species for which the current known distribution ranges do not include the surveyed areas, such as the Bornean ferret badger (*Melogale everetti*), the Malay badger (*Mydaus javanensis*) and the Borneo elephant (*Elephas maximus borneensis*), which are distributed only in northern Borneo.
2. Locally extinct species, such as the Sumatran rhinoceros (*Dicerorhinus sumatrensis harrissoni*) and the banteng (*Bos javanicus*) (Payne and Francis 2005; Giman and Jukie 2012).
3. Three other species, the Bornean orangutan (*Pongo pygmaeus*), Hose's civet (*Diplogale hosei*) and the flat-headed cat (*Prionailurus planiceps*). Hose's civet has only been recorded at elevations of 325–1800 m (Samejima and Semiadi 2012), and has only been rarely recorded in other regions of Borneo (Wilting et al. 2010; Samejima et al. 2012). The flat-headed cat is strongly associated with wetlands and preys primarily on fish (Wilting et al. 2010). Its nearest published record to our study sites is Bukit Sarang, a peat swamp forest area about 20 km away (Giman et al. 2007).

On the other hand, our study recorded only four species out of the 15 known terrestrial bird species in Borneo (Myers 2009; Phillipps and Phillipps 2009). The low coverage ratio of terrestrial bird species may be because of the smaller and exclusive distribution range of the species.

In the ASDU, the total MTR was lowest at C24, inside a kerangas forest. These are heath forests that are low in soil nutrient content and this limits plant productivity and growth, resulting in lower densities of ground-dwelling mammals and terrestrial birds due to the limited available resources.

According to the MTR index, current logging practices in the AMFMU can be interpreted as making little impact upon the abundance of medium to large ground-dwelling mammals and terrestrial birds. While the plot logged in previous year (C12) had a low total MTR value and a low number of recorded species, plots logged between 1 and 4 years ago (C11 and C08) had the highest total MTR values and contained the largest number of species. Furthermore, they differed little from plots harvested between 20 and 30 years ago (C04 and C16). We therefore suggest that the total MTR values and number of species in recently logged areas can recover within only a few years. Nevertheless, continuous monitoring is necessary to confirm the recovery of species composition and abundance in recently logged areas.

On the other hand, the result of camera trapping including villages areas shows many species were recorded only in intact forest areas. These species included the yellow muntjac, red muntjac, small carnivores such as the yellow-throated marten, the common palm civet, the banded civet and the Malay civet, the sun bear, members of the Felidae family (the clouded leopard and the marbled cat), the Sunda pangolin and Bulwer's pheasant. The yellow muntjac and many small carnivore species such as the Malay civet and banded civet are vulnerable to intensive logging activity (Samejima et al. 2012). The results suggest only natural primary forests can provide the essential habitats required for these species.

Lowland forests in Borneo are at a high risk of being converted to large-scale oil palm and industrial tree plantations. Therefore, a sustainable land-use concept must be promoted and large conversions of remaining natural forest should be reduced. Wildlife conservation cannot only rely upon existing protected areas, which represent a very small area in terms of size, that is approximately 650,000 ha of terrestrial land in Sarawak (5.2% of total area). As most of the natural forests in Sarawak are allocated as production forests, these production forests must be managed in a sustainable manner to maintain the rich biodiversity as is currently done in the AMFMU.

Some species were abundant in the degraded forests surrounding villages compared to upstream natural primary forests. These species were the thick-spined porcupine (*Hystrix crassispinis*), the long-tailed macaque (*Macaca fascicularis*), the greater mouse deer (*Tragulus napu*), the lesser mouse deer (*Tragulus kanchil*), the sambar deer (*Rusa unicolor*) and the crested fireback (*Lophura ignita*). To explain this, we propose three nonexclusive hypotheses. The first hypothesis is that these species prefer human-disturbed habitats, which are more open compared to intact natural forests. The sambar deer is known to prefer foraging on young shoots of trees and grass on the forest floor, which are more abundant in degraded forests where the canopy is more open and plant productivity is high (Meijaard et al. 2005). Such conditions in degraded forests may also be favourable to some herbivorous or generalist species, such as the long-tailed macaque. The second hypothesis is that these species prefer swamp forests along the rivers, which are more often found in lowland areas. These swamp areas may have more fertile soils that are more favourable for many plant and animal species. For example, the crested fireback and mouse deer are known to be more abundant in the freshwater swamp forest environment in a logging concession in Sabah (Samejima et al. 2012; Samejima and Ong 2012). The third hypothesis is that the MTR values of arboreal and semiarboreal species can be increased in degraded forests even if the density of the species is the same as primary forests. Since mobility between tree canopies is restricted in degraded forests, arboreal and semiarboreal species, such as the long-tailed macaques, may have to descend to the ground more often in order to move between neighbouring trees. This behaviour change could increase the MTR value without a population change.

The MTR values for the bearded pig (*Sus barbatus*) and southern pig-tailed macaque (*Macaca nemestrina*) were not very different among the four forested areas, that is Sujan village, Lavang, Jelalong and Ulu Anap, and the ASDU. Bearded pigs and pig-tailed macaques feed on a large range of food resources and can adapt to a wide variety of habitats. We were informed by some local villagers of abundant populations of bearded pigs in forested areas near oil palm plantations due to the high availability of oil palm fruits that the pigs feed on (Kato and Samejima, Chap. 14). However, this was not supported by our study. The rates of encounters by local people with game species might have increased not because of species population changes but due to landscape changes, including easier access and habitat openness.

In degraded areas, hunters can use motorcycles to explore wider areas that they did not have access to in the past.

The leopard cat, was more frequently recorded inside the oil palm plantation compared to the natural forests. This is probably due to the high availability of their food resources in plantations, particularly rats that feed on the palm fruits. Rats were frequently recorded by our camera trap in the oil palm plantation.

We concluded that the hunting activity in this study area was not significantly affecting the population of major game species, such as the bearded pig, mouse deer and sambar deer, even though there was a sizable number of active hunters. The MTR values for the major game species were not low, but rather more abundant in the lowland village areas. However, this does not mean that hunting should be encouraged and allowed to be carried out excessively as uncontrolled hunting activity can severely decrease animal populations. In a camera trapping study by Jedediah Brodie et al. (2015) at seven locations in Sabah and Sarawak that covered both primary and logged natural forests, hunting pressure was shown to have an effect on many mammal species. Their results showed that the occurrence of many species, such as the bearded pig and muntjac (both *Muntiacus muntjak* and *Muntiacus atherodes*), was negatively correlated with hunting intensity. As hunting was once very active in Sarawak (Bennett et al. 2000), the Sarawak state government appointed a special select committee in 1984 to study and investigate the depletion of the flora and fauna, which led to the publication of the Wild Life Protection Ordinance in 1998. The trade in game licences and the issuance of permits for guns and ammunition were regulated in the 2000s. Such interventions might help to maintain the remaining populations of game species in village areas. Hunting activities by the villagers studied were mostly carried out only for their subsistence and not for commercial gain (Kato and Samejima, Chap. 14). As an exception, the low MTR values for the Sunda pangolin in the village areas may be the result of high poaching pressures. This species is protected by law, but is traded on the black market because it commands a high price, with pangolin meat and scales being illegally exported out of Southeast Asia. In species-rich areas such as the ASDU, strong management interventions are necessary to prevent illegal poaching and overhunting, both by the local communities and outsiders. The strict security systems in place, such as manned gates that restrict free access to the forest management unit, have helped prevent these hunting activities.

In conclusion, the long-term persistence of wildlife depends on the condition of the landscapes and the management interventions that can be enforced. Our study has indicated that timber concessions, when they practise sustainable forest management, can preserve Borneo's rich diversity of medium- and large-sized mammals and terrestrial birds. The state government should enforce strong management interventions to ensure that wildlife is not severely affected and animal populations can still recover after logging. Our study also shows that the degraded forest in village areas is still inhabited by several major game species for local communities. The ecosystem services should be taken into account when the forests are converted to oil palm or industrial tree plantations.

Acknowledgements This study was undertaken with the support of Zedtee Sdn Bhd who granted us permission to carry out research in the ASDU. In particular, we would like to thank Wong Ing Yung and the staff at the Anap-Muput Forest Management Unit for their kind assistance during the fieldwork. We also thank Abdul Aziz and George Mike of Keresa Plantations Sdn Bhd for permission and support that enabled us to complete this study. We also thank the villagers of Rumah Majang, Rumah Limai, Rumah Aying, Rumah Resa, Rumah Udau, Rumah Jusong and Rumah Mawang for their kind assistance in carrying out fieldwork. We are grateful to Hidemi Nagano of Kyoto University who helped with data entry. This research was approved by the Forest Department of Sarawak (NCCD.907.4.4 (Jld.7)-67) and financially supported by Grant-in-Aid for Scientific Research (S) 22221010 from the Japan Society for the Promotion of Science.

References

Bennett, Elizabeth L., Adrian J. Nyaoi, and Jephte Sompud. 2000. Saving Borneo's bacon: The sustainability of hunting in Sarawak and Sabah. In *Hunting for sustainability in tropical forests*, ed. John G. Robinson and Elizabeth L. Bennett, 305–324. New York: Columbia University Press.

Brodie, Jedediah F., Anthony J. Giordano, Elise F. Zipkin, Henry Bernard, Jayasilan Mohd-Azlan, and Laurentius Ambu. 2015. Correlation and persistence of hunting and logging impacts on tropical rainforest mammals. *Conservation Biology* 29 (1): 110–121.

Ceballos, Gerardo, and Paul R. Ehrlich. 2006. Global mammal distributions, biodiversity hotspots, and conservation. *Proceedings of the National Academy of Sciences of the United States of America* 103 (51): 19374–19379.

Gaveau, David L.A., Sean Sloan, Elis Molidena, Husna Yaen, Doug Sheil, Nicola K. Abram, Marc Ancrenaz, Robert Nasi, Marcela Quinones, Niels Wielaard, and Erik Meijaard. 2014. Four decades of forest persistence, clearance and logging on Borneo. *PLoS One* 9 (7): e101654.

Giman, Belden, and Alex Jukie. 2012. Distribution of Sunda stink-badger *Mydaus javanensis* in Sarawak, Malaysia. *Small Carnivore Conservation* 46: 12–16.

Giman, Belden, William J. McShea, Chad M. Stewart, and Megum Nyegang. 2007. Conservation of small carnivores in a planted forest: Towards a deeper understanding of small carnivore population dynamics in plantation forest. In *Proceedings of the regional conference of biodiversity conservation in tropical planted forests in Southeast Asia*, ed. Robert B. Stuebing, Joanes Unggang, Jodi Ferner, Jacinta Richard Seling, Belden Giman, John Ferner, and Kee Kum Ping, 158–163. Kuching: Forest Department, Sarawak Forestry Corporation and Grand Perfect Sdn Bhd.

Harrison, Rhett D. 2011. Emptying the forest: Hunting and the extirpation of wildlife from tropical nature reserves. *BioScience* 61 (11): 919–924.

Hon, Jason. 2011. A new record for the Borneo bay cat in central Sarawak, Malaysian Borneo. *Cat News* 55: 4–6.

———. 2014. Land use mapping exercise along Kemena River–Tubau–lower Jelalong. *Equatorial Biomass Society* 9: 10–16.

Hon, Jason, and Shozo Shibata. 2013. Temporal partitioning by animals visiting salt licks. *International Journal of Environmental Science and Development* 4 (1): 44–48.

Hon, Jason, Shoko Sakai, Choy Yee Keong, Miyako Koizumi, Keiko Kishimoto-Yamada, Masahiro Ichikawa, Yumi Kato, Kohei Takenaka Takano, Takao Itioka, Ryoji Soda, and Hiromitsu Samejima. 2012. Distribution and trend of animal abundance in the Rajang and Baram Regions, Sarawak, based on questionnaire survey. In *Collapse and restoration of ecosystem networks with human activity*, ed. Shoko Sakai, Reiichiro Ishii, and Norio Yamamura, 158–165. Kyoto: Research Institute for Humanity and Nature, RIHN Project Report.

International Union for Conservation of Nature [IUCN]. 2013. IUCN red list of threatened species version 2013.1. http://www.iucnredlist.org. Accessed 7 July 2018.

McShea, William J., Chad Stewart, Liesl Peterson, Peter Erb, Robert Stuebing, and Belden Giman. 2009. The importance of secondary forest blocks for terrestrial mammals within an acacia/secondary forest matrix in Sarawak, Malaysia. *Biological Conservation* 142 (12): 3108–3119.

Meijaard, Erik, Douglas Sheil, Robert Nasi, David Augeri, Barry Rosenbaum, Djoko Iskandar, Titiek Setyawati, Martjan Lammertink, Ike Rachmatika, Anna Wong, Tonny Soehartono, Scott Stanley, and Timothy O'Brien. 2005. *Life after logging: Reconciling wildlife conservation and production forestry in Indonesia Borneo*. Bogor: Centre for International Forestry Research.

Miettinen, Jukka, Chenghua Shi, Wee Juan Tan, and Soo Chin Liew. 2012. 2010 land cover map of insular Southeast Asia in 250 m spatial resolution. *Remote Sensing Letters* 3 (1): 11–20.

Myers, Susan. 2009. *A field guide to the birds of Borneo*. Singapore: Talisman.

Payne, Junaidi (John), and Charles M. Francis. 2005. *A field guide to the mammals of Borneo*. 3rd ed. Kota Kinabalu: The Sabah Society and WWF Malaysia.

Phillipps, Quentin, and Karen Phillipps. 2009. *Phillipps' field guide to the birds of Borneo: Sabah, Sarawak, Brunei and Kalimantan*. Oxford: Beaufoy Books.

Putz, Francis E., Geoffrey M. Blate, Kent H. Redford, Robert Fimbel, and John Robinson. 2001. Tropical forest management and conservation of biodiversity: An overview. *Conservation Biology* 15 (1): 7–20.

R Development Core Team. 2013. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Ruekeith, Geryl Ogilvy. 2014. Longer tenure for timber licence. *Borneo Post*, August 21.

Samejima, Hiromitsu, and Robert Ong. 2012. Distribution of mammals in Deramakot and Tangkulap forest reserves, Sabah, Malaysia. *Kyoto Working Papers Area Studies G-COE Series (2012)* 127: 1–55.

Samejima, Hiromitsu, and Gono Semiadi. 2012. First record of Hose's civet *Diplogale hosei* from Indonesia, and records of other small carnivores in the Schwaner Mountains, Central Kalimantan, Indonesia. *Small Carnivore Conservation* 46: 1–7.

Samejima, Hiromitsu, Peter Lagan, and Kanehiro Kitayama. 2012. Impacts of two different forest management practices on the abundance of mammals. In *Co-benefits of sustainable forestry*, ed. Kanehiro Kitayama, 89–111. Tokyo: Springer, Ecological Research Monographs.

Schipper, Jan, Janice S. Chanson, Federica Chiozza, Neil A. Cox, Michael Hoffmann, Vineet Katariya, John Lamoreux, Ana S.L. Rodrigues, Simon N. Stuart, Helen J. Temple, Jonathan Baillie, Luigi Boitani, Thomas E. Lacher Jr., Russell A. Mittermeier, Andrew T. Smith, Daniel Absolon, John M. Aguiar, Giovanni Amori, Noura Bakkour, Ricardo Baldi, Richard J. Berridge, Jon Bielby, Patricia Ann Black, J. Julian Blanc, Thomas M. Brooks, James A. Burton, Thomas M. Butynski, Gianluca Catullo, Roselle Chapman, Zoe Cokeliss, Ben Collen, Jim Conroy, Justin G. Cooke, Gustavo A.B. da Fonseca, Andrew E. Derocher, Holly T. Dublin, J.W. Duckworth, Louise Emmons, Richard H. Emslie, Marco Festa-Bianchet, Matt Foster, Sabrina Foster, David L. Garshelis, Cormack Gates, Mariano Gimenez-Dixon, Susana Gonzalez, Jose Fernando Gonzalez-Maya, Tatjana C. Good, Geoffrey Hammerson, Philip S. Hammond, David Happold, Meredith Happold, John Hare, Richard B. Harris, Clare E. Hawkins, Mandy Haywood, Lawrence R. Heaney, Simon Hedges, Kristofer M. Helgen, Craig Hilton-Taylor, Syed Ainul Hussain, Nobuo Ishii, Thomas A. Jefferson, Richard K.B. Jenkins, Charlotte H. Johnston, Mark Keith, Jonathan Kingdon, David H. Knox, Kit M. Kovacs, Penny Langhammer, Kristin Leus, Rebecca Lewison, Gabriela Lichtenstein, Lloyd F. Lowry, Zoe Macavoy, Georgina M. Mace, David P. Mallon, Monica Masi, Meghan W. McKnight, Rodrigo A. Medellín, Patricia Medici, Gus Mills, Patricia D. Moehlman, Sanjay Molur, Arturo Mora, Kristin Nowell, John F. Oates, Wanda Olech, William R.L. Oliver, Monik Oprea, Bruce D. Patterson, William F. Perrin, Beth A. Polidoro, Caroline Pollock, Abigail Powel, Yelizaveta Protas, Paul Racey, Jim Ragle, Pavithra Ramani, Galen Rathbun, Randall R. Reeves, Stephen B. Reilly, John E. Reynolds III, Carlo Rondinini, Ruth Grace Rosell-Ambal, Monica Rulli, Anthony B. Rylands, Simona Savini, Cody J. Schank, Wes Sechrest, Caryn Self-Sullivan, Alan Shoemaker, Claudio Sillero-

Zubiri, Naamal De Silva, David E. Smith, Chelmala Srinivasulu, Peter J. Stephenson, Nico van Strien, Bibhab Kumar Talukdar, Barbara L. Taylor, Rob Timmins, Diego G. Tirira, Marcelo F. Tognelli, Katerina Tsytsulina, Liza M. Veiga, Jean-Christophe Vié, Elizabeth A. Williamson, Sarah A. Wyatt, Yan Xie, and Bruce E. Young. 2008. The status of the world's land and marine mammals: Diversity, threat, and knowledge. *Science* 322 (5899): 225–230.

Wilting, Andreas, Andrew J. Hearn, Jim Sanderson, Joanna Ross, Sunarto Sunarto. 2010. *Prionailurus planiceps*. The IUCN red list of threatened species. https://doi.org/10.2305/IUCN.UK.2015-2.RLTS.T18148A50662095.en. Accessed 7 July 2018.

Chapter 9
Species Composition and Use of Natural Salt Licks by Wildlife Inside a Production Forest Environment in Central Sarawak

Jason Hon, Shozo Shibata, and Hiromitsu Samejima

Abstract The island of Borneo is regarded as one of the most biologically rich regions in the world, containing some of the oldest remaining tropical rainforests. However, it also suffers high levels of deforestation and degradation to meet the demands for timber extraction and agricultural activities. In Sarawak, areas designated as permanent forests account for 35.2% of the total land area, much of which have already been opened up for timber extraction. In contrast, protected areas constitute less than 7% of the land area and are mostly sparsely distributed. Forests outside these protected areas are crucial for the conservation of wildlife. For long-term wildlife conservation to be effective, attention must be focused on how logging activities are carried out and how habitats for wildlife within these logging concessions are managed. This study was carried out in a logging concession in central Sarawak where sustainable forest management is practised. The objectives were to document the composition of wildlife, their use of key habitat sites and the effects of forest disturbance. Camera trapping exercises were carried out from August 2010 to November 2011. Preliminary results indicate that older logged-over areas contained higher diversity of animal species. Overall, 32 species of terrestrial mammals and ground-dwelling birds were recorded, of which 19 species were recorded to have visited salt licks. Ungulates were recorded visiting salt licks with the highest abundance. In forests that were logged 7 years ago and left to recover, the Borneo bay cat (*Catopuma badia*), a globally significant species, was recorded. This result

J. Hon (✉)
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

S. Shibata
Graduate School of Global Environmental Studies and Graduate School of Agriculture, Kyoto University, Kyoto, Japan
e-mail: sho@kais.kyoto-u.ac.jp

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_9

indicates the importance of sustainable forest management and suggests some of the methods logging companies can undertake to conserve wildlife in a production forest environment.

Keywords Sarawak · Salt licks · Camera trap survey · Terrestrial mammals · Ground-dwelling birds

9.1 Introduction

The island of Borneo is regarded as one of the most biologically rich regions in the world, with high levels of endemism (MacKinnon et al. 1996; Wikramanayake et al. 2001). Tropical rainforests worldwide are rapidly disappearing as land is cleared for timber, agriculture, development and other uses (Meijaard et al. 2005; Meijaard and Sheil 2008). In the last three decades, Borneo has undergone high levels of deforestation and degradation, driven by the expansion of agricultural activities, forest conversion and logging (Curran et al. 2004; Langner et al. 2007). In the Malaysian state of Sarawak, less than 7% of the 12 million ha of the land area is protected. There are about 4.32 million ha or 35.2% of the land area that are designated as permanent forest estates. The current extent of terrestrial protected areas is never likely to be sufficiently large to protect viable populations of many wide-ranging and rare species (Bennett and Shebli 1999), such as the flying fox (*Pteropus vampyrus*), which covers extensive areas for feeding, even flying outside the boundaries of protected areas (Gumal et al. 2008). In contrast to production forests, totally protected areas are typically very small. The continued existence of wildlife will thus depend largely on how forests outside the totally protected areas are managed.

In Sarawak, logging has been and will continue to be a major economic activity. The export of logs from Sarawak accounts for huge proportion of Malaysia's total production, making the state a powerhouse for tropical log and timber production and earnings for the country. The export value of timber and timber products for Sarawak was RM5.9 billion (US$1.46 billion) in 2016 (though this figure is actually lower than those in the period 2012–2015) (STIDC 2016).

One of the key habitat areas for wildlife are natural salt licks, where minerals are deposited on the soil surface by spring water flowing through the soil. The distribution of some mammal species appears to be determined by the distribution of natural salt licks (Stark 1986; Payne and Andau 1991; Chanard et al. 1998; Laidlaw et al. 2000; Matsubayashi et al. 2007), and salt licks may affect movements and home ranges to some extent (Pages et al. 2005). The use of salt lick soils by wildlife has been shown to supplement poor nutrition (Holdø et al. 2000; Matsubayashi et al. 2007), to alleviate ailments (Mahaney et al. 1993, 1995a, b; Klaus et al. 1998;

Diamond et al. 1999; Krishnamani and Mahaney 2000), to absorb toxins and alkaloids from plant materials (Mahaney et al. 1995a; de Souza et al. 2002; Symes et al. 2006) or to alter food properties for easier digestion and palatability (Mahaney et al. 1995b; Diamond et al. 1999). In Deramakot Forest Reserve in Sabah, more than 78% of the known species that occur in the reserve were recorded to have visited salt licks for nutrient uptake (Matsubayashi et al. 2007). Salt licks are particularly important for herbivores and frugivores as they require sodium from naturally available resources, since plants are typically deficient in this element (Matsubayashi et al. 2007).

However, current knowledge of the use of salt licks by wildlife in Sarawak is still limited. Salt licks can easily be affected by logging activities, road construction or siltation from surface runoff. Forest managers who do not have adequate information on the protection of salt licks may inadvertently destroy them, affecting wildlife populations that use such resources in the forest.

9.2 Study Site

This study was carried out in a logging concession in central Sarawak. The site is called the Anap Sustainable Development Unit (ASDU) and encompasses 83,535 ha of logged natural forest, hereafter called the Anap-Muput Forest Management Unit (AMFMU). Some 19,270 ha (14,970 ha in the north and 4300 ha in the south) of the area are licensed for tree planting and a further 13,500 ha are government land. The AMFMU has begun its second cycle of harvesting, which started in 2000. In the early logging phase beginning in 1989, conventional logging methods were used before path logging methods were adopted under the Model Forest Management Area initiative by the International Tropical Timber Organisation in 1993, starting in coupe 15. A coupe is the annual operational area for the AMFMU. The reduced-impact logging (RIL) method was introduced in 2007 from coupe 6 onwards when the sustainable forest management exercise in preparation for certification was carried out.

In the AMFMU, riparian strips are protected and marked as stream bank reserves, which are at least 20 m wide. Sites such as naturally occurring salt licks are also protected. There are three known salt lick sites in the ASDU: Apan Sebedi, Apan Malat and Apan 11 (Fig. 9.1). *Apan* is the local term for salt licks. These salt licks are situated in forests with different periods of recovery after logging. Apan Sebedi is located in coupe 1, which was last logged in 2006. This site was earmarked for conversion into a tree plantation. Apan Malat is located in coupe 4, which was last logged in 2003. Apan 11 is named after coupe 11, which was last logged in 2010.

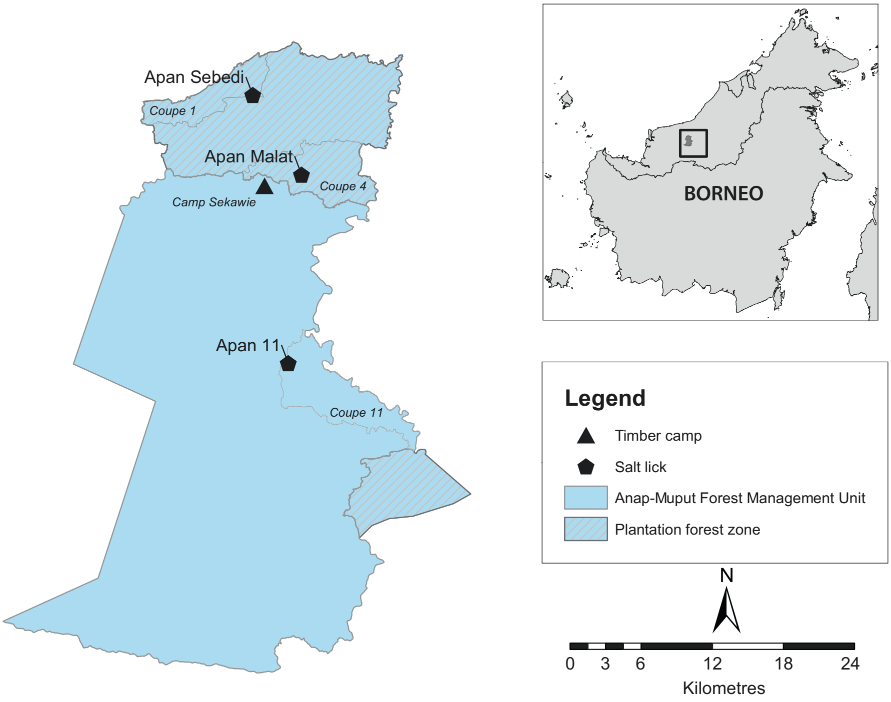


Fig. 9.1 Location of salt licks
Note: inset shows the location of the study site in Borneo

9.3 Methodology

Three plots were selected—Apan Sebedi, Apan Malat and Apan 11 (Table 9.1)—named after their respective salt licks. These salt licks are situated next to streams. Automatic trigger cameras, also known as camera traps, were set up along a linear transect from a salt lick to a point located 2 km from the salt lick, at intervals of 200 m. For each study plot, the distance from the respective stream edge to the respective salt lick point was standardised for all camera trapping points along the transect. The type of camera used was a Bushnell Trophy Cam, which captured

Table 9.1 Site description of study plots

Name of plot	Location	Vegetation type	Surrounding area last logged (year)	Remarks
Apan Sebedi	Coupe 1	Riparian; mixed dipterocarp forest	2006	Stream bank reserve
Apan Malat	Coupe 4	Riparian; mixed dipterocarp forest	2003	Stream bank reserve
Apan 11	Coupe 11	Riparian; mixed dipterocarp forest	2010	Stream bank reserve

colour and infrared images in digital format. The cameras were revisited between 1 and 5 months after they had been set up. The total sampling effort was 9270 camera trap days.

9.4 Results

The total number of terrestrial mammals, primates and medium- to large-sized ground-dwelling birds identified from camera trap images for all sites was 32 species. Small mammals of the orders Insectivora (with the exception of the moon rat, *Echinosorex gymnurus*), Scandentia, Dermaptera, Chiroptera and Rodentia (with the exception of porcupines) were omitted from this analysis. There were many records of mouse deer that could not be positively identified; hence, they were grouped under the genus *Tragulus*. The lesser mouse deer (*T. kanchil*) and the greater mouse deer (*T. napu*) both occur in Borneo. The highest number of species (N = 30) was recorded at the Apan Malat site, followed by Apan Sebedi (N = 23) and Apan 11 (N = 22). The highest number of carnivore species (N = 14) was also recorded at the Apan Malat site (Fig. 9.2). Approximately half of all species documented in the respective salt lick sites were recorded visiting the salt lick itself. The number of species recorded at the salt licks was 12 in Apan 11, 15 in Apan Malat and 11 in Apan Sebedi (Table 9.2). Overall, 19 species were documented visiting the salt licks, accounting for 59.4% of the total number of species recorded (Table 9.3).

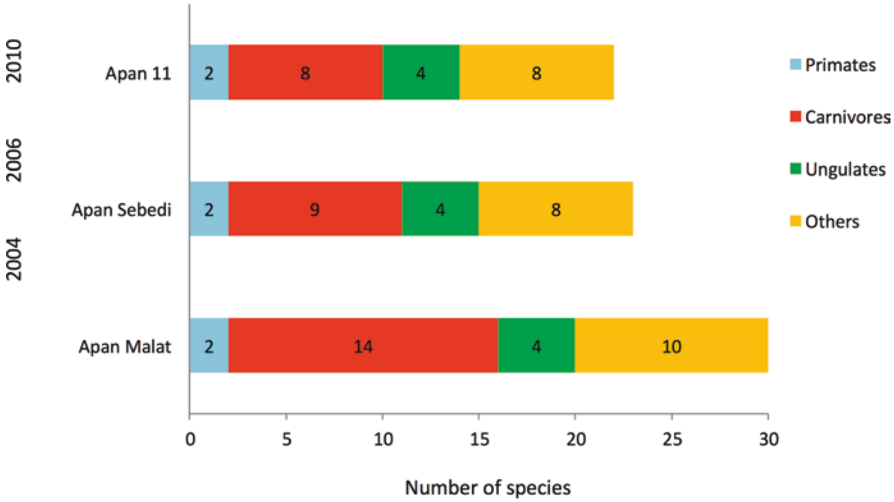


Fig. 9.2 Number of species recorded using camera traps in three salt lick plots
Note: The year associated with each plot refers to the time the surrounding area was last logged

Table 9.2 Number of species recorded in each sampling plot

	Apan 11	Apan Malat	Apan Sebedi	All plots combined
Total number of species recorded in entire plot	22	30	23	32
Species recorded at each salt lick	12 (54.5%)	15 (50.0%)	11 (47.8%)	19 (59.4%)

Table 9.3 Species recorded at each salt lick

	Common name	Scientific name	Apan 11	Apan Malat	Apan Sebedi
Insectivores	Moon rat	*Echinosorex gymnurus*	–	✓	–
Primates	Long-tailed macaque	*Macaca fascicularis*	✓	–	✓
	Pig-tailed macaque	*Macaca nemestrina*	✓	✓	✓
Pangolins	Pangolin	*Manis javanica*	✓	–	✓
Rodents	Malayan porcupine	*Hystrix brachyura*	–	✓	✓
Carnivores	Sun bear	*Helarctos malayanus*	✓	–	–
	Malay civet	*Viverra tangalunga*	✓	–	✓
	Banded linsang	*Prionodon linsang*	–	✓	–
	Common palm civet	*Paradoxurus hermaphroditus*	✓	✓	–
	Banded palm civet	*Hemigalus derbyanus*	–	✓	–
	Otter civet	*Cynogale bennetti*	–	✓	–
	Short-tailed mongoose	*Herpestes brachyurus*	✓	✓	✓
	Borneo bay cat	*Catopuma badia*	–	✓	–
Ungulates	Bearded pig	*Sus barbatus*	✓	✓	✓
	Mouse deer	*Tragulus* spp.	✓	✓	✓
	Muntjacs	*Muntiacus* spp.	✓	✓	✓
	Sambar deer	*Rusa unicolor*	✓	✓	✓
Cuculiformes/ cuckoos	Bornean ground cuckoo	*Carpococcyx radiceus*	✓	✓	–
Galliformes/ pheasants	Great argus	*Argusianus argus*	–	✓	✓

9.4.1 Visits to Salt Licks

Ungulates were the most frequently recorded species at salt licks, accounting for 80.7% of the 931 records from all salt licks. The sambar deer (*Rusa unicolor*) accounted for 46.9% of the 931 images recorded from all salt licks combined,

Table 9.4 Number of images for the most commonly recorded species at salt licks

Ranking	Species (Common name)	Apan 11	Apan Malat	Apan Sebedi	Total
1	Sambar deer	293	138	6	437
2	Bearded pig	35	56	59	150
3	Muntjacs	104	1	9	114
4	Pig-tailed macaque	22	15	72	109
5	Mouse deer	7	5	38	50
6	Malayan porcupine	–	4	29	33
	Total for all records	472	234	225	931

followed by the bearded pig (*Sus barbatus*) at 16.1% and muntjacs (*Muntiacus* spp.) (Table 9.4). There were 109 records (11.7%) of one primate species, the pig-tailed macaque (*Macaca nemestrina*).

9.5 Discussion

Natural salt licks are important sites visited by many wildlife species. In this study, at least half of the species recorded up to 2 km from the site actually visited the salt lick. Sambar deer and bearded pigs had the highest visitation rates. Studies in Sabah have also recorded similar patterns, with sambar deer and bearded pigs representing the top two species most frequently visiting salt licks (Matsubayashi et al. 2007). Camera trap recordings actually show that sambar deer, muntjacs and mouse deer visited salt licks to drink from water deposited there. Bearded pigs were also recorded burrowing at salt licks to forage. These results indicate the amount of use and hence the importance of salt licks for ungulates.

The high number of occurrences of sambar deer and bearded pigs may in fact reflect the high number of these species in the study area. Tracks of sambar deer, muntjacs and bearded pigs were frequently observed throughout the study area. Interviews conducted with the local communities revealed that the bearded pig was the most hunted species with high hunting success rates. The other species commonly hunted was sambar deer. There is no restriction on subsistence hunting for local communities residing inside the study area, although the rules of the National Parks and Nature Reserves Ordinance 1998 and Wild Life Protection Ordinance 1998 do apply to them, and these prohibit the hunting of both totally protected and protected species (National Parks and Wildlife Division 1998a, b).

Hunting pressures may have effects on the behaviour of wildlife, particularly species that are commonly hunted. Animals may come out less often or spend shorter amounts of time foraging. Sambar deer and muntjacs, for instance, have lower detection probabilities in Apan Malat as compared to Apan 11. Apan Malat is situated closer to villages and is more easily accessible, and therefore hunting may be more prevalent (Table 9.5). On the other hand, recently logged sites have a more

Table 9.5 Access to Apan Sebedi, Apan Malat and Apan 11 and levels of hunting pressure

Zone	Direct distance (km) from: Main logging road	Nearest settlement	Road access by local people	Level of hunting activities
Apan Sebedi	8	9	Good, 30 min from main road by vehicle	Low
Apan Malat	1	5	Very good, 5 min from main road by vehicle, also accessible on foot	High
Apan 11	3	3	Poor with restricted access, accessible on foot only	Very low

open canopy, a condition that encourages lower canopy and ground vegetation to regenerate. Such locations become favourable to browsers. Future analyses will determine the probability of occupancy by taking into account other habitat variables.

Eight of the 14 species of carnivores (57%) recorded from this survey visited salt licks. Hisashi Matsubayashi et al. (2007) recorded 13 species (87%) of all carnivores visiting salt licks. The high percentage indicates that salt licks also have important ecological roles for carnivores. Whether carnivores visit salt licks for their nutrient uptake or to prey on other animals is not known, as such studies have not yet been carried out.

In older logged-over forests that have been left to recover, the composition of wildlife species was higher than in recently logged sites. Although ungulates were recorded in all sites, older logged-over forests contained greater numbers of carnivore species. As carnivores are species at the top of the food chain, their presence can be used as an indication of the general health of the forest. However, it must be noted that this study was conducted in a forest concession which practises sustainable forest management and employs RIL methods. Because of the prescriptions and guidelines that are currently in place, such as the need for a detailed harvesting plan to minimise impacts on the environment, annual cutting limits that determine the quota of logs that can be extracted, as well as the creation of stream bank reserves and the preservation of high conservation value forests, the conditions of the logged-over forest may have remained favourable for wildlife to persist. The most significant finding is the presence of the endemic Borneo bay cat (*Catopuma badia*) in the riparian habitat of Apan Malat 7 years after logging ceased (Hon 2011). This result demonstrates the importance of creating and protecting stream bank reserves.

9.6 Conclusion

Salt licks are important habitat sites for wildlife. At least 50% of the wildlife recorded in the ASDU visited salt licks. The period of time since logging also affected the species composition, with older logged-over sites containing a higher number of species, including carnivores. The impacts of anthropological factors such as hunting pressure were evident in all sites and these may affect the behaviours of species that are commonly hunted. The management of wildlife and key habitat sites must take into consideration the protection of important sites such as salt licks. Riparian vegetation may provide a refuge for wildlife, particularly after the interior forests are affected by logging. Forest recovery programmes make a crucial contribution towards sustaining wildlife populations in production forests. Sound forestry practices that engage in RIL methods are important for the long-term survival of wildlife populations. Efforts must be enhanced to make sustainable forest management practices a critical and mandatory component for all logging operations in Sarawak.

Acknowledgements This project was funded by Kyoto University (Environmental Management Leadership Program), and was part of the Planted Forest in Equatorial Southeast Asia: Human-Nature Interactions in High Biomass Society Project, which was funded by the Grant-in-Aid for Scientific Research (S) by the Japan Society for the Promotion of Science. The first author was a recipient of the Japanese government (Monbukagakusho) Scholarship.

References

Bennett, E., and Z. Shebli. 1999. Sarawak's system of totally protected areas: Will it protect Sarawak's biodiversity? *Hornbill* 3: 38–45.

Chanard, Tanya, Thawon Posang, and Watsarak Wongkalasin. 1998. Distribution of wild Asian elephants (*Elephas maximus*) in Phu Luang wildlife sanctuary. *Thailand National History Bulletin of the Siam Society* 46: 17–26.

Curran, Lisa M., Simon Trigg, Alice McDonald, Dwi Astiani, Y.M. Hardiono, P. Siregar, I. Caniago, and Eric Kasischke. 2004. Lowland forest loss in protected areas of Indonesian Borneo. *Science* 303: 1000–1003.

de Souza, Luciane L., Stephen F. Ferrari, Marcondes L. da Costa, and Dirse C. Kern. 2002. Geophagy as a correlate of folivory in red-handed howler monkeys (*Alouatta belzebul*) from Eastern Brazilian Amazonia. *Journal of Chemical Ecology* 28 (8): 1613–1621.

Diamond, Jared, K. David Bishop, and James D. Gilardi. 1999. Geophagy in New Guinea birds. *Ibis* 141 (2): 181–193.

Gumal, Melvin, Jason Hon, and Daniel Kong. 2008. *Birds and bats of Loagan Bunut National Park, Sarawak, Malaysia*. Kepong: Peat Swamp Forest Project, Forest Research Institute Malaysia.

Holdø, Ricardo M., Joseph P. Dudley, and Lee R. McDowell. 2000. Geophagy in the African elephant in relation to availability of dietary sodium. *Journal of Mammalogy* 83 (3): 652–664.

Hon, Jason. 2011. A new record for the Borneo bay cat in central Sarawak, Malaysian Borneo. *Cat News* 55: 4–6.

Klaus, Gregor, Corinne Klaus-Hugi, and Bernhard Schmid. 1998. Geophagy by large mammals at natural licks in the rain forest of the Dzanga National Park, Central African Republic. *Journal of Tropical Ecology* 14 (6): 829–839.

Krishnamani, Ramanathan, and William C. Mahaney. 2000. Geophagy among primates: Adaptive significance and ecological consequences. *Animal Behaviour* 59 (5): 899–915.

Laidlaw, Ruth K., Mohd Taufik Abdul Rahman, and Zamiza Zainal. 2000. Large mammals. *Journal of Wildlife and Parks* 18: 75–106.

Langner, Andreas, Jukka Miettinen, and Florian Siegert. 2007. Land cover change 2002–2005 in Borneo and the role of fire derived from MODIS imagery. *Global Change Biology* 13 (11): 2329–2340.

MacKinnon, Kathy, Gusti Hatta, Hakimah Halim, and Arthur Mangalik. 1996. *The ecology of Kalimantan, Indonesian Borneo*. Singapore: Periplus Editions, Ecology of Indonesia Series.

Mahaney, William C., Ronald G.V. Hancock, and Mika Inoue. 1993. Geochemistry and clay mineralogy of soils eaten by Japanese macaques. *Primates* 34 (1): 85–91.

Mahaney, William C., Susan Aufreiter, and Ronald G.V. Hancock. 1995a. Mountain gorilla geophagy: A possible seasonal behavior for dealing with the effects of dietary changes. *International Journal of Primatology* 16 (3): 475–488.

Mahaney, William C., Anna Stambolic, Mary Knezevich, Ronald G.V. Hancock, Susan Aufreiter, Kandiah Sanmugadas, Matthew J. Kessler, and Marc D. Grynpas. 1995b. Geophagy amongst rhesus macaques on Cayo Santiago, Puerto Rico. *Primates* 36 (3): 323–333.

Matsubayashi, Hisashi, Peter Lagan, Noreen Majalap, Joseph Tangah, Jum Rafiah Abd. Sukor, and Kanehiro Kitayama. 2007. Importance of natural licks for the mammals in Bornean inland tropical rain forests. *Ecological Research* 22 (5): 742–748.

Meijaard, Erik, and Douglas Sheil. 2008. The persistence and conservation of Borneo's mammals in lowland rain forests managed for timber: Observations, overviews and opportunities. *Ecological Research* 23 (1): 21–34.

Meijaard, Erik, Douglas Sheil, Robert Nasi, David Augeri, Barry Rosenbaum, Djoko Iskandar, Titiek Setyawati, Martjan Lammertink, Ike Rachmatika, Anna Wong, Tonny Soehartono, Scott Stanley, and Timothy O'Brien. 2005. *Life after logging: Reconciling wildlife conservation and production forestry in Indonesia Borneo*. Bogor: Centre for International Forestry Research.

National Parks and Wildlife Division. 1998a. *National Parks and Nature Reserves Ordinance*. Sarawak: Sarawak Forest Department.

———. 1998b. *Wild Life Protection Ordinance*. Sarawak: Sarawak Forest Department.

Pages, Guillaume, Emily Lloyd, and Scott A. Suarez. 2005. The impact of geophagy on ranging behaviour in Phayre's leaf monkeys (*Trachypithecus phayrei*). *Folia Primatology* 76 (6): 342–346.

Payne, Junaidi (John), and Mahedi Andau. 1991. Large mammals in Sabah. In *The state of nature conservation in Malaysia*, ed. Ruth Kiew, 177–183. Kuala Lumpur: Malayan Nature Society.

Sarawak Timber Industry Development Corporation [STIDC]. 2016. *Export statistics of timber & timber product: Sarawak 2016*. Kuching: Sarawak Timber Industry Development Corporation.

Stark, M.A. 1986. Analysis of five natural soil licks, Benoue National Park, Cameroon, West Africa. *African Journal of Ecology* 24 (3): 181–187.

Symes, Craig, J.C. Hughes, Andrew L. Mack, and Stuart Marsden. 2006. Geophagy in birds of Crater Mountain Wildlife Management Area, Papua New Guinea. *Journal of Zoology* 268 (1): 87–96.

Wikramanayake, Eric, Eric Dinerstein, Colby J. Loucks, David M. Olson, John Morrison, John Lamoreaux, Meghan McKnight, and Prashant Hedao. 2001. *Terrestrial ecoregions of the Indo-Pacific: A conservation assessment*. Washington, DC: Island Press.

Chapter 10
Above-Ground Biomass and Tree Species Diversity in the Anap Sustainable Development Unit, Sarawak

Hiromitsu Samejima, Malcom Demies, Miyako Koizumi, and Shogoro Fujiki

Abstract With rapid deforestation and forest degradation ongoing in tropical regions, the maintenance of biodiversity and high biomass/carbon stocks can bring additional benefits to the sustainable management of natural forests along with sustainable timber production. However, the measures for improving the maintenance of biodiversity and high biomass are not well evaluated. For this study, we established vegetation plots in the Anap Sustainable Development Unit (ASDU) in Bintulu, Sarawak, including the Anap-Muput Forest Management Unit (AMFMU), in order to investigate the distribution of above-ground biomass and tree species diversity. Using a Landsat image, we mapped the distribution of above-ground biomass all over the ASDU as of 2009. This distribution of above-ground biomass inside the AMFMU was not well correlated with the time that had elapsed since the last cycle of logging. The topography of the area may in fact be a more important factor. In total, 986 tree species were recorded in 70 plots (covering 8.3 ha in total). The species richness was not obviously different between recently harvested forests and primary forests, demonstrating that it is not severely affected by logging activity. As the above-ground biomass and tree species richness cannot be predicted by the years after harvesting alone, adaptive management with continuous monitoring is necessary to maintain the benefits of sustainable forest management.

H. Samejima (✉)
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

M. Demies
Sarawak Forestry Corporation, Kuching, Malaysia
e-mail: malcom@sarawakforestry.com

M. Koizumi
Kyoto University, Kyoto, Japan

S. Fujiki
Kyoto University, Kyoto, Japan

Biome Inc., Kyoto, Japan

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_10

Keywords Sarawak · Above-ground biomass · Tree species diversity · Logging · Sustainable forest management · Biodiversity

10.1 Introduction

Natural tropical rainforests such as those in Borneo hold rich biodiversity as well as huge carbon stocks (Saatchi et al. 2011b). The above-ground biomass of intact tropical rainforests in Borneo ranges from 300 to 600 t ha^{-1} (Slik et al. 2013), while it is only 2.4–52 t ha^{-1} in oil palm plantations and 15–116 t ha^{-1} in timber plantations, with continued conversion of natural rainforests to both oil palm and timber plantations (Morel et al. 2011). The prevention of natural rainforests from further degradation and deforestation is thus a meaningful measure to reduce carbon emissions that accelerate global climate change. As most of the natural rainforests in Borneo are now managed as concessions for private companies to conduct selective logging, the application of sustainable forest management is an efficient and effective measure for the maintenance of both biodiversity and biomass. Therefore, sustainable forest management was approved as one of the five activities of Reducing Emission from Degradation and Deforestation in Developing Countries (REDD-plus) at the thirteenth session of the Conference of the Parties of the United Nations Framework Convention on Climate Change in 2007. In addition to revenue from timber production, sustainable forest management of natural rainforests can attract financial support to reduce greenhouse gas emissions in the future.

Tropical rainforests are well known for their rich biodiversity. For example, 1182 tree species were recorded in a plot of only 52 ha in Lambir Hills National Park, Sarawak (Zimmerman et al. 2008). As the species diversities of many of taxonomic groups are not severely reduced by selective logging, sustainable forest management could be a key component in maintaining the rich biodiversity of tropical rainforests (Berry et al. 2010; Putz et al. 2012). In addition to the local biodiversity (α-diversity), the dissimilarity of species composition (species turnover) among different locations and habitats (i.e. β-diversity) also contributes to the high regional species diversity. β-diversity increases following environmental differences and spatial distance (Chave 2008). Therefore, large concessions of natural forests can maintain the rich regional diversity as not only the high α-diversity is maintained but also the high β-diversity. The vast size of a logging concession allows for the existence of various environmental habitats which are adapted to by different species respectively. Additionally, this vast size also allows for long spatial distances among the various habitats and this may be enough to cause dispersal limitation and diverse species composition among the different habitats within a single concession. However, not many studies show species richness within vast logging concessions (Imai et al. 2012). Sustainable forest management includes preharvest mapping of commercial trees, reduced-impact logging to decrease collateral damage during harvesting and long-term cutting cycles which are sufficiently long to recover the standing stock. The management companies also establish totally protected areas inside each concession to maintain the high conservation value for the environment and the local society. To promote sustainable forest management, forest certification organisations such as the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification (PEFC) and the Malaysian Timber Certification Council (MTCC) were established in the 1990s. By 2014, 13 logging concessions in Kalimantan and three logging concessions in Sabah were certified by the FSC and one concession in Sabah was certified by the MTCC. In Sarawak, while the Anap-Muput Forest Management Unit (AMFMU) is the only certified logging concession so far (certified by the MTCC and PEFC), the state government has been promoting forest certification since 2014 (Ruekeith 2014).

However, the methodology to verify the performance of forest management techniques in maintaining biomass and biodiversity is not yet well developed (Pinard and Putz 1996; Pinard et al. 2000). Bronson Griscom et al. (2014) compared carbon emissions during harvesting in three FSC-certified concessions and in six noncertified concessions in East Kalimantan. They found the carbon emissions during harvesting were not significantly different between the certified and noncertified concessions. To improve performance via the reduction of carbon emissions through sustainable forest management, it is necessary to establish a procedure to monitor carbon stock change for all over-logging concessions. As a single logging concession can be quite large (from hundreds to thousands of square kilometres), mapping using remote sensing is necessary to monitor the carbon stocks and the temporal change (Morel et al. 2011), but these methodologies are still under development (Tangkia and Chappell 2008; Saatchi et al. 2011a). Various satellite images have been used for biomass estimation (Blackman 2013). Alexandra Morel et al. (2011) mapped and estimated the distribution of the above-ground biomass in eastern Sabah using imagery from the Advanced Land-Observing Satellite Phased Array type L-band Synthetic Aperture Radar (ALOS PALSAR) integrated with field data. Ralph O. Dubayah et al. (2010) also tried to estimate above-ground biomass using a light detection and ranging (LiDAR) system. The estimation of the above-ground biomass by LiDAR is more reliable and may prove to be a more accurate method than previous methods (Drake et al. 2003; Saatchi et al. 2011a), though this method may be too expensive for repeat monitoring. For implementation in forest management by the private sector, the application of low-cost satellite images, such as Landsat, is necessary for repeat monitoring (Hirata et al. 2012). However, even though standard vegetation indexes such as the normalised difference vegetation index are sensitive for low biomass vegetation, those conventional indexes are not strongly correlated with high biomass in tropical rainforests (Foody et al. 2001; Okuda et al. 2004). Using a model selection procedure, Andreas Langner et al. (2012) modelled above-ground biomass in an exploratory fashion from Landsat images combined with field data. Further studies are necessary to evaluate the adaptability of this estimation procedure.

Therefore, we estimated above-ground biomass based on ground vegetation plots and remote sensing and investigated the tree species richness in the Anap Sustainable Development Unit (ASDU) including a logging concession and adjacent plantation areas.

10.2 Materials and Methods

10.2.1 Study Site

The ASDU is located at 2°09′37.0″N 112°38′58.0″E in the district of Tatau in Bintulu Division, Sarawak, and is managed by a private company, Zedtee Sdn Bhd. The ASDU covers an area of 106,820 ha with altitude of 13–963 m (Fig. 10.1b). The forest within the ASDU can be classified into two types: lowland/hill mixed dipterocarp forest and kerangas forest. The mixed dipterocarp forest is the major forest type in both lowland Borneo (MacKinnon et al. 1996) and also in the ASDU. Kerangas forest is a type of heath forest that grows on sandy nutrient-poor soil and is distributed in the southeast part of the ASDU.

The ASDU is divided into three management units: the AMFMU (timber licence number T/4317), which forms the main unit covering 83,535 ha; the Licence for Planted Forests (LPF) area (licence number LPF/0039) in the northern region; and Anap-Belawit state land in the south (Fig. 10.1). The AMFMU originally included areas of the LPF and Anap-Belawit state land when first established, and was divided into 25 coupes and designed to manage a 25-year cutting cycle. Logging of indigenous and commercial tree species such as meranti (*Shorea* spp.) and *kapur* (*Dryobalanops* spp.) in the ASDU started in 1977. All the coupes have been harvested at least once and all coupes from C01 to C12 have been harvested again in the 12 years up to 2012. In the ASDU—seven protected areas, namely four high conservation value forests (HCVF) and three water catchment areas (WC)—have been established. The WCs were also originally listed as HCVFs in the previous forest management plan for Anap-Muput for 2006–2025. The AMFMU has been certified by the MTCC since 2008 and passed the initial audit (stage 1) of the Malaysian Criteria and Indicators for Forest Management Certification (MC&I) (2002) in 2009 under the Malaysian Timber Certification Scheme after its endorsement by the PEFC. On the other hand, the LPF area is allocated for intensive planting of fast-growing tree species (such as *Albizia falcata*) and the natural forest was repeatedly harvested, while most of the area had not yet been cleared to be converted into plantation as of 2013. In the ASDU, Malcom Demies and Julia Sang (2008) established 23 quadrate plots in the four HCVFs in 2008. Each quadrate was 50 × 50 m. They recorded all trees belonging to three genera of Dipterocarpaceae (*Dipterocarpus*, *Dryobalanops* and *Shorea*) with a diameter at breast height (dbh) of 10 cm and above. Hiromitsu Samejima and Jason Hon (2014) also set eight plots to conduct a camera trap survey targeting ground dwelling middle and large mammals from 2011 to 2013. Each plot was a circle with a 1 km diameter and with eight cameras set at randomly selected points within the plot. Hon (2011) and Hon and Shibata (2013) also set a 2-km line transect along three rivers located near natural salt licks (*apan* in the local Iban language) and conducted a camera trap survey from 2010 to 2011.

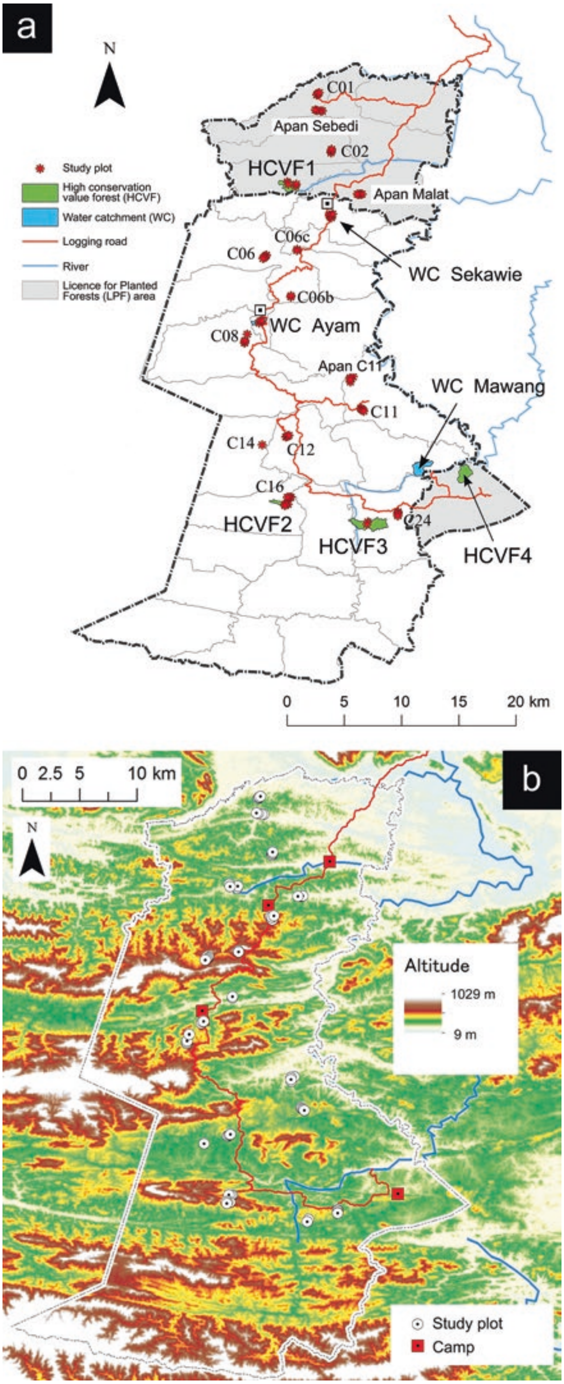


Fig. 10.1 (**a**) Locations of study areas and (**b**) altitude inside the Anap Sustainable Development Unit

10.2.2 Vegetation Plots

From 2011 to 2013 (but mostly during 2012), we established 19 study areas in the ASDU and set one to five circle vegetation plots in each area (Table 10.1; Fig. 10.2a; Koizumi 2012). In total we set 70 plots, with 61 plots having a radius of 20 m

Table 10.1 Study areas

Study area	Date study area was established	No. of plots	Forest type	Forest status	Camera trapping performed
C01	Feb 2012	4	Mixed dipterocarp forest	Logged multiple times	✓
C02	Apr 2012	4		Logged multiple times	
C06	Feb 2012	5		Logged 7 years ago	✓
C06b	Apr 2012	2		Logged 7 years ago	
C06c	Apr 2012	2		Primary forest (partly logged 7 years ago)	
C08	Feb 2012	4		Logged 5 years ago	✓
C11	Feb 2012	5		Logged 2 years ago	✓
C12	Mar 2012	4		Logged 1 year ago	✓
C14	Feb 2012	1		Logged 24 years ago	
C16	Feb 2012	4		Logged 22 years ago	✓
HCVF1	Feb 2012	4		Logged approx. 30 years ago	
HCVF2	Feb 2013	4		Primary forest	
WC Ayam	Feb 2012	3		Primary forest	
WC Sekawie (C04)	Feb 2012	5		Logged approx. 30 years ago	✓
C24	Aug 2012	4	Kerangas forest	Logged 14 years ago	✓
HCVF3	Feb 2013	2		Logged approx. 30 years ago	
Apan C11	Mar 2011 Aug 2012	4 (2)	Riparian forest	Logged 2 years ago	✓
Apan Malat	Mar 2011	5 (5)		Logged 9 years ago	✓
Apan Sebedi	Aug 2011 Mar 2012	4 (2)		Logged multiple times	✓

Note: Numbers in parenthesis indicate the number of plots with 15 m diameter in each study area

Fig. 10.2 Surveying of trees in the study area including (**a**) measuring diameter at breast height and marking of all trees in a plots; (**b**) measuring the diameter above the buttress when the trees had high buttresses; (**c**) attaching metal number tags on all suitable trees in the plots; and (**d**) preparing specimens of trees for further identification in Kuching

(0.13 ha each) and the remaining nine plots having a radius of 15 m (0.07 ha each). The distances between the neighbouring plots within an area were 100 m. The altitude of 70 plots ranged from 64 to 523 m.

Two study areas (HCVF2 and WC Ayam) were located in primary forests, and three study areas (HCVF1, HCVF3 and WC Sekawie) were located in old-growth forests that were harvested once during the 1980s. In these study areas, WC Sekawie was the area where Samejima and Hon (2014) conducted camera trapping and four plots in HCVF1 and two plots in HCVF3 overlapped with the quadrats established by Demies and Sang (2008). Outside the protected areas, seven study areas were where Samejima and Hon (2014) conducted camera trapping and three study areas were riparian sites where Hon (2011) and Hon and Shibata (2013) conducted camera trapping. In addition, two study areas in coupe C06 were positioned to cover diverse vegetation types. C06b was in a slightly swampy area where trees were harvested 7 years ago and C06c was in a remnant primary forest along a ridge. Most of the study areas were inside the mixed dipterocarp forest, but C24 and HCVF3 were in kerangas forests.

Inside each plot, the dbh (130 cm above ground) was measured and the height was estimated for all trees with a dbh of 10 cm and above. A red line was painted on each tree at the height where the dbh was measured (Fig. 10.2a) and a metal number tag was attached to the tree (Fig. 10.2c) for future repeat censuses. All trees were identified by staff of the Botanical Research Centre, Sarawak Forestry Corporation and one of the authors (Miyako Koizumi) by referring to the herbarium of the Sarawak Forest Research Centre, Kuching (Fig. 10.2d). The classification followed the Angiosperm Phylogeny Group III system.

To estimate the above-ground biomass of each plot, we applied the following three formulas to estimate the above-ground biomass of trees in tropical moist forests (FAO 1997; Chave et al. 2005):

$$\mathrm{AGB1} = \exp\left(-2.977 + \ln\left(\rho D^2 H\right)\right) \equiv 0.0509 \times \rho D^2 H$$

$$\mathrm{AGB2} = \rho \times \exp\left(-1.499 + 2.148\ln\left(D\right) + 0.207\left(\ln\left(D\right)\right)^2 - 0.0281\left(\ln\left(D\right)\right)^3\right)$$

$$\mathrm{AGB3} = \exp\left(-2.134 + 2.53\ln\left(D\right)\right)$$

$$\rho : \text{Wood specific gravity};\ D : \text{Diameter};\ H : \text{Total tree height}$$

Following these formulae, we obtained three estimations of the above-ground biomass of all trees (named AGB1, AGB2 and AGB3) and calculated the total above-ground biomass per hectare in each plot respectively. The specific gravity data of wood for each species that was used to calculate AGB1 and AGB2 was based on Nobuo Imai et al. (2012), Roeland Lemmens et al. (1995), Ishemat Soerianegara and Lemmens (1993), Djoen Seng Oey (1951) and Marcus Sosef et al. (1998). If the specific gravity data of wood for a particular species was not available, the averaged specific gravity data of wood for species of the same genus was used to calculate the AGB1 and AGB2. In the case that the specific gravity data of wood for any species of the genus was not known, the AGB3 of the tree was used as a substitute for the AGB1 and AGB2 of the tree to calculate AGB1 and AGB2 of the plot. As we did not measure tree heights in nine plots, we calculated only AGB2 and AGB3 for these plots.

10.2.3 Mapping Concession-Wide Above-Ground Biomass Using Remote Sensing

We used a Landsat Thematic Mapper image (path 120, row 58) on 31 July 2009 covering the ASDU and obtained from the US Geological Survey (2015) because only a small percentage of the area was covered by cloud (Fig. 10.3). Using bands

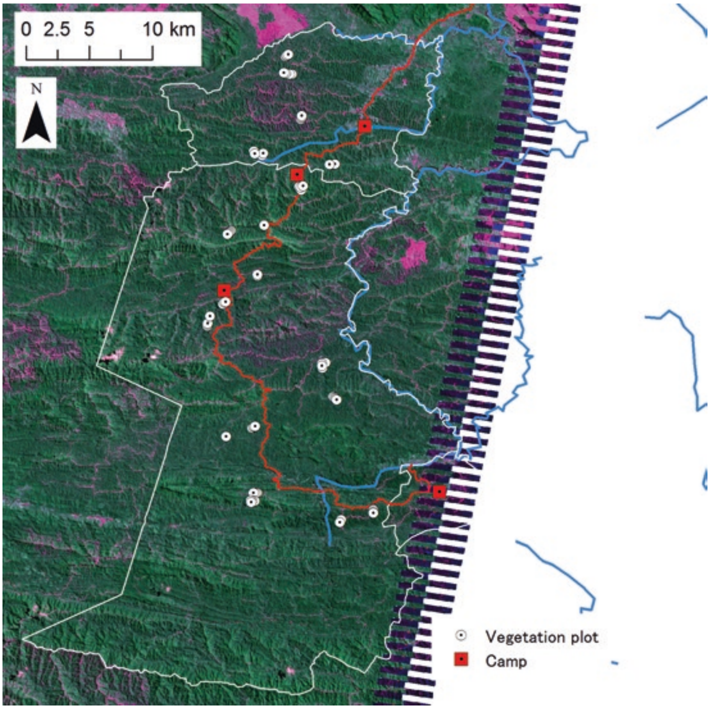


Fig. 10.3 Landsat Thematic Mapper (TM) image (path 120, row 58) covering the ASDU on 31 July 2009
Source: Developed with courtesy of US Geological Survey (2015)

1–5 and 7 of the Landsat image taken in 2009, topography data of the Shuttle Radar Topography Mission (SRTM) and ground truth data of the above-ground biomass per hectare (AGB2) of 62 plots that were largely collected during 2012, we estimated the distribution of the above-ground biomass all over the ASDU as of 2009.

As a pre-processing step of the Landsat image, raw digital numbers of the six bands were first converted into top-of-atmosphere radiance, from which the atmospheric correction was conducted using the Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) module of ENVI (version 5.1; Exelis Visual Information Solutions 2013).

Subsequently, the effects of differential illumination due to topography were reduced using the method described by Sam Ekstrand (1996). We used the SRTM data to obtain the altitude values of all the pixels and also to calculate the slope. As each plot covered several pixels of Landsat and SRTM data, we used the weighted arithmetic mean for the final value of the plot.

There is approximately a three-year time-lag between the year the Landsat image was captured (2009) and the years the vegetation data were collected (mostly 2012). To estimate the above-ground biomass in each plot as of 2009 from the above-ground biomass data as of 2012, we applied an equation of annual accumulation of the above-ground biomass in old-growth tropical forest (Clark et al. 2001; Langner et al. 2012) as below:

$$\mathrm{AGByear}_{-1} = \mathrm{AGByear} - \left(1.05^{*} \log\left(\mathrm{AGByear}\right) - 2.91\right)$$

As coupe C11 and coupe C12 were logged between 2009 and 2012, we excluded the ground truth data in the eight plots in these two coupes for the analysis. Therefore, we used the above-ground biomass data of the remaining 62 plots for the modelling. To estimate the above-ground biomass from the Landsat image, we made a generalised liner model with AGB2 in each plot as of 2009 (AGB2_2009) as the objective values:

$$\begin{aligned}&\mathrm{AGB2\_2009} \sim \mathrm{band\,1} + \mathrm{band\,2} + \mathrm{band\,3} + \mathrm{band\,4} + \mathrm{band\,5} + \mathrm{band\,7} + \log\left(\mathrm{band\,1}\right)\\&+ \log\left(\mathrm{band\,2}\right) + \log\left(\mathrm{band\,3}\right) + \log\left(\mathrm{band\,4}\right) + \log\left(\mathrm{band\,5}\right) + \log\left(\mathrm{band\,7}\right) + \mathrm{alt}\\&+ \log\left(\mathrm{alt}\right) + \mathrm{slope} + \log\left(\mathrm{slope}\right)\end{aligned}$$

We selected the most appropriate set of the explanation variables from this full model based on Akaike information criterion (AIC). Assigning Landsat band values and topographic values of each pixel of Landsat image (30 m × 30 m) to the selected model, we estimated the above-ground biomass per hectare of the all pixels inside the ASDU. In case the estimated above-ground biomass per hectare of some pixels were less than zero or more than 1000, we assigned either zero or 1000 respectively for these pixels that did not posses a realistic value. From the Landsat image, bare ground, mostly dirt logging roads, could be identified by supervised classification and we assigned zero to these pixels.

Finally, we calculated average of the above-ground biomass per hectare in each coupe and the AMFMU. We also calculated the average the above-ground biomass of the AMFMU using a bootstrap procedure (Manly 2007) as follows: we randomly resampled the 62 plots with replacements and modelled the above-ground biomass of the 62 new plots with the Landsat bands and the topographic data. Applying each final model selected based on AIC, we derived the average above-ground biomass per hectare in the AMFMU; and we repeated this trial 1000 times and calculated the average and standard deviation of the average the above-ground biomass per hectare in the AMFMU.

10.2.4 Tree Diversity

To evaluate the impact of logging on the species richness, we compared species richness among 12 study areas where more than three plots were established. We randomly selected one to three plots in each area and derived a species rarefaction curve for each study area.

J.W. Ferry Slik et al. (2009) compared the diversity of tree genera with a dbh greater than 10 cm among vegetation plots at 46 locations all over Borneo (Fig. 10.4). For each location, they randomly sampled 400 trees from all trees inside the vegetation plots five times and calculated the average and the standard deviation of the number of genera. Among the 19 plots established in our study, six study areas had more than 400 trees. Therefore, we also derived the average and standard deviation of generic richness of the six areas by the random selection of 400 trees 1000 times and compared them with those of the 46 locations in Slik et al. (2009).

All the statistical and remote sensing analyses and mapping were implemented using statistical software R (version 3.0.0; R Development Core Team 2013), ArcGIS (version 10.1; Esri 2012), ENVI (version 5.1; Exelis Visual Information Solutions 2013) and ERDAS IMAGINE (version 11.0.1; Hexagon Geospatial 2011).

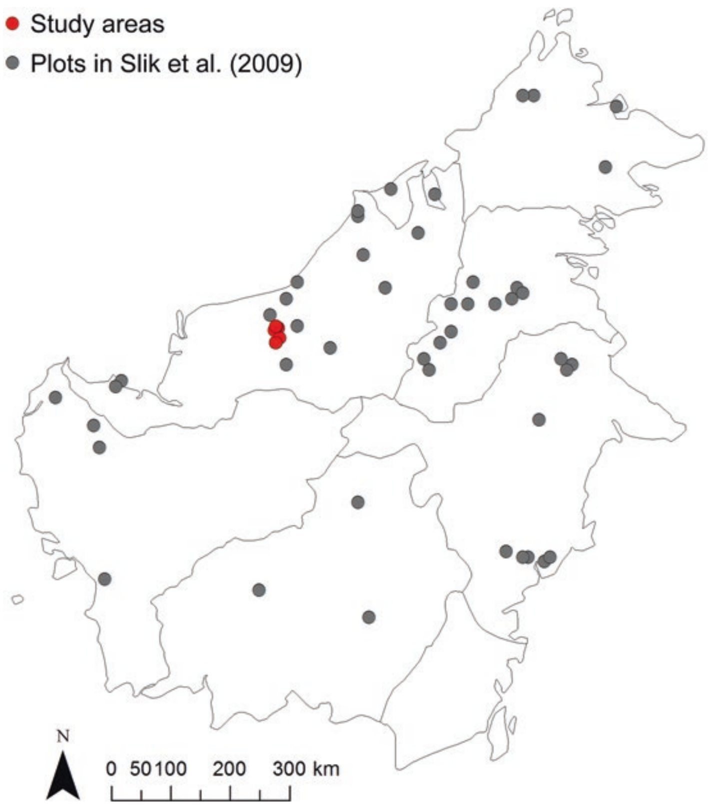


Fig. 10.4 Distribution of 46 locations of the study areas in Slik et al. (2009) and in this study with more than 400 trees recorded

10.3 Results

10.3.1 Vegetation Plots

We recorded 6381 trees with a dbh of greater than 10 cm in the 70 plots of 8.3 ha in total (Table 10.2). These included 967 species belonging to 221 genera and 69 families (Table 10.3), while 78 trees could not be identified, even at the genus level. Among the families documented, Dipterocarpaceae (1989 trees of 131 species) was the most prevalent family and represented 31.6% of all trees recorded.

10.3.2 Estimated Above-Ground Biomass in Vegetation Plots

The mean and standard deviation of AGB2 of all vegetation plots was 338.8 ± 197.1 t ha^{-1}. The above-ground biomass per hectare was high in primary forests and old-growth forests inside the protected areas, HCVFs and WCs (AGB2: 595.0 ± 157.1 t ha^{-1}). The above-ground biomass was also high in C06c which was not in the protected area but located in a remnant primary forest on a steep ridge. The estimated above-ground biomass values across all 19 study areas are as in Fig. 10.5.

In the normal harvesting areas, the AGB2 was 227.8 ± 32.4 t ha^{-1} in C12 where harvesting had been performed 1 year before. The values of AGB2 in C11, C08 and C06 (where 2–7 years have passed after harvesting) were higher than in C12, with the values being 274.7 ± 92.9, 331.4 ± 129.5, and 315.5 ± 154.5 t ha^{-1} respectively. The AGB2 was even higher (493.1 ± 120.5 t ha^{-1}) in HCVF1 and WC Sekawie, where about 30 years have passed since harvesting. However, the AGB2 in C14 and C16 (where harvesting occurred 22–24 years ago) was only 266.4 ± 119.6 t ha^{-1}, clearly not higher than the more recently harvested coupes C06–C12.

10.3.3 Biomass Mapping in the ASDU

The stepwise procedure based on AIC derived a set of variables. The coefficients that predict AGB2 as of 2009 (AGB2_2009) most appropriately is shown below:

$$
\begin{aligned}
&\mathrm{AGB2\_2009} \sim 1.9^{*}\,\mathrm{band}\,3 + 1.2^{*}\,\mathrm{band}\,4 - 6.2^{*}\,\mathrm{band}\,5 + 3.6^{*}\,\mathrm{band}\,7\\
&-2568.7^{*}\log(\mathrm{band}\,4) + 6504.9^{*}\log(\mathrm{band}\,5) - 2074.8^{*}\log(\mathrm{band}\,7)\\
&+2.6^{*}\,\mathrm{alt} - 256.2\log(\mathrm{alt}) + 51.6^{*}\log(\mathrm{slope}) - 10263.0
\end{aligned}
$$

The above-ground biomass of the 62 plots estimated by this model is well correlated with the above-ground biomass of ground truth data (r = 0.81, Fig. 10.6). Applying

Table 10.2 Number of trees, species and volume of above-ground biomass in each plot

Forest type	Area	Plot ID	Number of trees	Number of species	AGB1 ($t\ ha^{-1}$)	AGB2 ($t\ ha^{-1}$)	AGB3 ($t\ ha^{-1}$)
Plot radius: 20 m							
Mixed dipterocarp forest	C01	C01 V1	62	37	105.9	144.2	123.6
		C01 V2	64	34	150.4	233.3	238.5
		C01 V3	67	29	63.7	93.1	91.2
		C01 V4	101	44	205.9	229.1	223.7
	C02	C02 V1	114	41	196.5	219.3	214.0
		C02 V2	83	51	163.1	177.0	157.3
		C02 V3	113	61	258.4	292.0	277.4
		C02 V4	60	37	166.0	198.4	176.7
	C06	C06 V1	104	39	340.9	446.4	469.6
		C06 V2	53	27	48.5	63.0	77.0
		C06 V3	74	40	295.2	400.1	408.8
		C06 V4	97	56	255.3	275.9	260.1
		C06 V5	86	46	338.9	392.1	384.2
	C06b	C06b V1	80	21	204.7	227.2	221.0
		C06b V2	78	39	266.6	272.9	251.9
	C06c	C06c V1	114	56	917.6	1018.7	914.1
		C06c V2	117	65	413.7	454.0	423.5
	C08	C08 V1	118	66	407.7	523.3	505.5
		C08 V2	85	47	249.5	295.4	279.4
		C08 V3	51	33	220.4	251.2	248.6
		C08 V6	92	31	218.9	255.6	263.5

(continued)

Table 10.2 (continued)

Forest type	Area	Plot ID	Number of trees	Number of species	AGB1 (t ha^{-1})	AGB2 (t ha^{-1})	AGB3 (t ha^{-1})
	C11	C11 V1	82	56	179.6	231.0	222.8
		C11 V2	82	44	224.3	281.4	239.5
		C11 V3	150	50	336.4	379.2	331.6
		C11 V4	88	52	302.9	339.3	326.4
		C11 V5	60	44	128.8	142.4	123.1
	C12	C12 V2	94	46	253.9	266.8	256.3
		C12 V3	95	49	177.7	203.9	188.7
		C12 V4	98	54	169.0	198.5	192.2
		C12 V5	112	56	169.9	241.8	214.2
	C14	C14 V1	70	34	184.3	211.2	224.6
	C16	C16 V1	109	48	112.7	136.6	147.6
		C16 V2	139	51	367.1	455.9	460.8
		C16 V3	143	67	247.6	290.7	317.9
		C16 V4	97	62	182.7	237.4	228.6
	HCVF1	HCVF1 P2	100	57	438.1	565.8	503.1
		HCVF1 P3	104	49	777.7	753.0	828.3
		HCVF1 P4	117	43	473.9	523.4	442.0
		HCVF1 P5	119	38	287.5	355.2	338.5
	HCVF2	HCVF2 P1	87	52	721.8	777.8	740.0
		HCVF2 P2	96	54	512.1	672.4	687.2
		HCVF2 P3	129	57	643.0	754.1	732.0
		HCVF2 P4	119	58	446.9	643.4	622.4
	WC Ayam	WC Ayam P1	109	53	429.7	473.1	446.1
		WC Ayam P2	99	52	643.0	718.2	627.1
		WC Ayam P3	82	44	712.3	733.7	624.4

	WC Sekawie	C04 V1	84	61	366.4	426.3	414.7
		C04 V2	139	45	453.1	545.1	505.7
		C04 V3	99	50	361.5	420.6	381.1
		C04 V6	142	62	370.1	397.7	336.7
		C04 V7	120	59	387.7	450.5	387.2
Kerangas forest	C24	C24 V1b	117	57	206.6	259.1	229.7
		C24 V2	53	43	167.1	199.8	207.0
		C24 V3	99	47	287.2	318.2	271.7
		C24 V4	130	57	486.5	497.3	432.4
	HCVF3	HCVF3 P3	147	73	389.7	407.1	377.1
		HCVF3 P8	136	56	326.7	358.1	340.1
Riparian forest	Apan Sebedi	Sebedi 2	61	37	135.0	158.4	124.9
		Sebedi 3	91	43	203.9	248.5	215.1
	Apan C11	Apan C11 2	50	23	159.1	199.0	178.9
		Apan C11 3	53	30	115.7	149.9	139.3
Plot radius: 15 m							
Riparian forest	Apan C11	06 Apan C11	38	21	–	257.8	226.6
		07 Apan C11	36	26	–	122.4	101.1
	Apan Malat	01 Apan Malat	44	28	–	151.3	154.2
		02 Apan Malat	40	20	–	334.5	284.4
		03 Apan Malat	45	32	–	171.4	186.0
		04 Apan Malat	48	12	–	59.1	78.8
		05 Apan Malat	60	12	–	59.7	89.7
	Apan Sebedi	08 Apan Sebedi	35	29	–	271.3	268.5
		09 Apan Sebedi	52	33	–	201.3	210.8

Table 10.3 Number of genera, species and trees in each family recorded in 70 plots in the Anap Sustainable Development Unit

Family	Number of genera	Number of species	Number of trees
Achariaceae	4	17	179
Actinidiaceae	1	2	130
Anacardiaceae	10	27	140
Anisophylleaceae	1	2	8
Annonaceae	6	22	61
Apocynaceae	4	4	28
Aquifoliaceae	1	1	1
Araucariaceae	1	1	4
Arecaceae	2	3	39
Asteraceae	1	1	1
Bignoniaceae	1	1	3
Burseraceae	3	32	159
Calophyllaceae	1	16	34
Celastraceae	4	9	61
Chrysobalanaceae	3	3	4
Clusiaceae	5	24	91
Combretaceae	1	2	4
Cornaceae	2	5	7
Crypteroniaceae	1	2	11
Ctenolophonaceae	1	2	7
Dilleniaceae	1	6	9
Dipterocarpaceae	9	131	1989
Ebenaceae	2	28	115
Elaeocarpaceae	2	19	44
Escalloniaceae	1	3	3
Euphorbiaceae	20	56	757
Fabaceae	13	26	118
Fagaceae	3	36	132
Irvingiaceae	1	2	3
Ixonanthaceae	2	2	11
Lamiaceae	4	15	108
Lauraceae	12	49	164
Lecythidaceae	1	5	21
Loganiaceae	2	4	5
Lythraceae	1	1	2
Magnoliaceae	2	6	13
Malvaceae	11	30	151
Melastomataceae	2	5	49
Meliaceae	5	25	54
Memecylaceae	1	5	10
Moraceae	3	23	109

(continued)

Table 10.3 (continued)

Family	Number of genera	Number of species	Number of trees
Moringaceae	1	1	1
Myristicaceae	5	51	302
Myrsinaceae	1	4	8
Myrtaceae	3	48	335
Ochnaceae	1	1	1
Olacaceae	4	5	21
Oleaceae	1	4	15
Oxalidaceae	1	3	17
Pentaphylacaceae	3	5	14
Phyllanthaceae	6	56	154
Polygalaceae	1	16	94
Proteaceae	1	1	1
Rhizophoraceae	2	3	7
Rhamnaceae	1	1	1
Rosaceae	1	1	7
Rubiaceae	11	21	158
Rutaceae	2	3	29
Sabiaceae	1	1	4
Salicaceae	4	7	55
Sapindaceae	4	17	37
Sapotaceae	5	40	141
Simaroubaceae	1	1	2
Sonneratiaceae	1	1	4
Stemonuraceae	3	5	7
Symplocaceae	1	4	7
Tetrameristaceae	1	1	2
Thymelaeaceae	2	10	24
Ulmaceae	1	2	16
Unknown	1	1	78
Total	221	967	6381

this model, we estimated the distribution of the above-ground biomass in the ASDU (Fig. 10.7). The average of estimated the above-ground biomass in the AMFMU was 354.5 t ha^{-1}, while the mean and standard deviation of the average above-ground biomass derived by bootstrapping was 369.0 ± 176.3 t ha^{-1}.

The average of estimated above-ground biomass in coupes where the second harvest was conducted within the past 7 years (C03–C09) was not obviously lower than average of estimated above-ground biomass in coupes harvested only once before 2000 (C10–C24) (Fig. 10.7). The estimated above-ground biomass seems to correlate closely with altitude, with the estimated the above-ground biomass values being higher at high altitude areas especially near the southern border of the AMFMU.

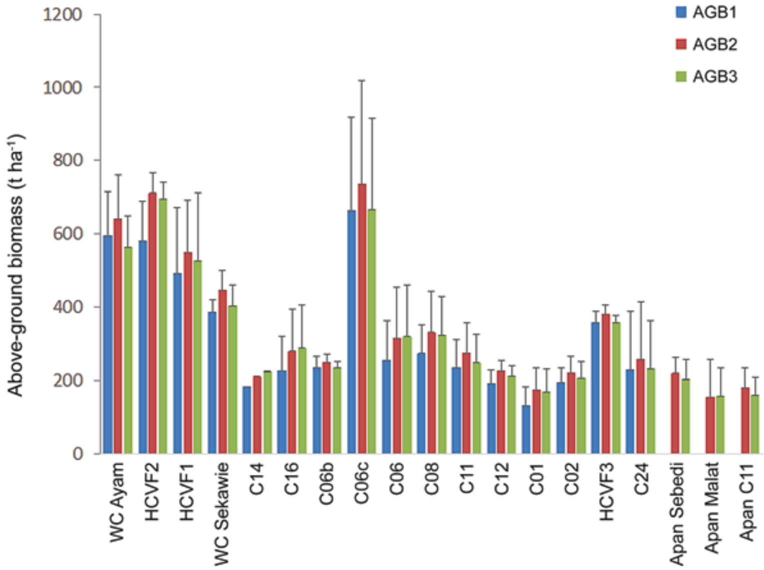


Fig. 10.5 Estimated above-ground biomass of the 19 study areas

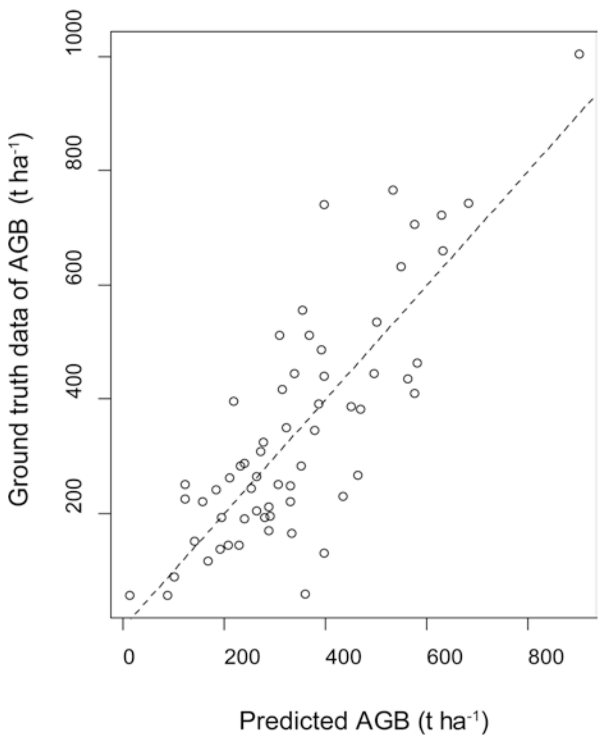


Fig. 10.6 Relationship between the above-ground biomass of 61 plots predicted by the regression model (using Landsat data and topography data) and the ground truth data of the above-ground biomass of the plots

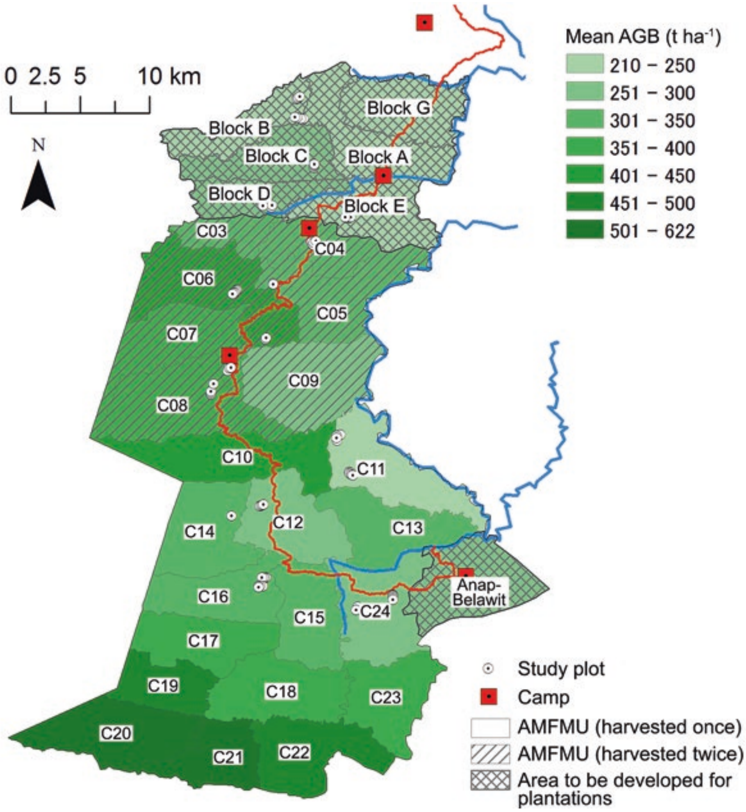


Fig. 10.7 Average of the estimated the above-ground biomass in each coupe in the Anap Sustainable Development Unit, 2009

10.3.4 Tree Species Diversity

The species rarefaction curve shows species diversity was not much different between the protected areas (HCVFs and WCs) and the normal logging areas (Fig. 10.8). The average number of genera in 400 randomly sampled trees in plots were 74–82 in HCVFs and WC while it was 73–82 in C16, C12 and C11.

The local generic diversities (i.e. α-diversity) in the ASDU were lower than that of previous study sites in same altitude range in Borneo (Fig. 10.9). Slik et al. (2009) showed the average number of genera in 400 randomly sampled trees is strongly correlated with the altitude of the study location. Among the 46 locations in Slik et al. (2009), 10 locations in their study were within altitude range of plots in six areas of this study (HCVF1, HCVF2, WC Sekawie, C16, C06 and C11); these plots were in the range of 146–356 m. The averaged number of genera among 400 randomly sampled trees at the six study areas in the ASDU (79.0 ± 3.8, mean ± standard

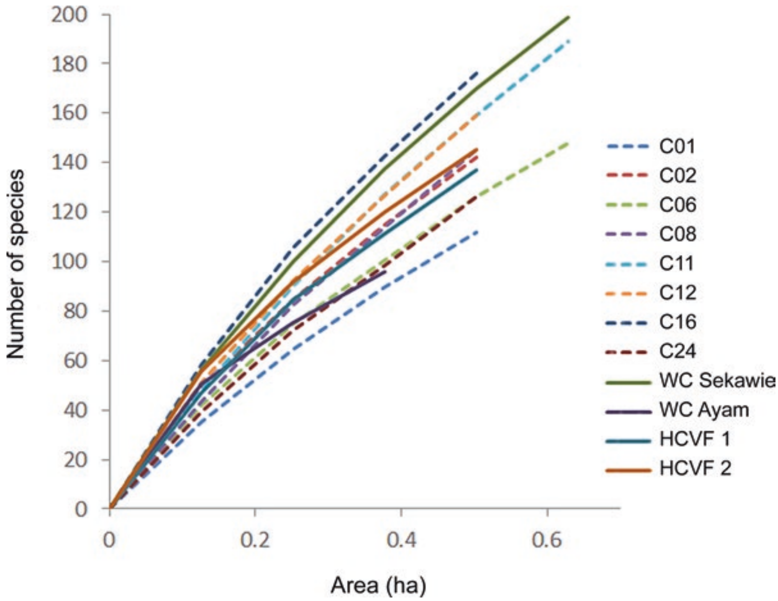


Fig. 10.8 Species rarefaction curves with the number of species against the number of plots for 12 study areas where more than three vegetation plots were established
Note: The number of species are the average number of species from the random selection of 400 trees 1000 times
Note: Solid lines are plots in protected areas (primary or old-growth forests) while dash lines are plots in normal logging concessions

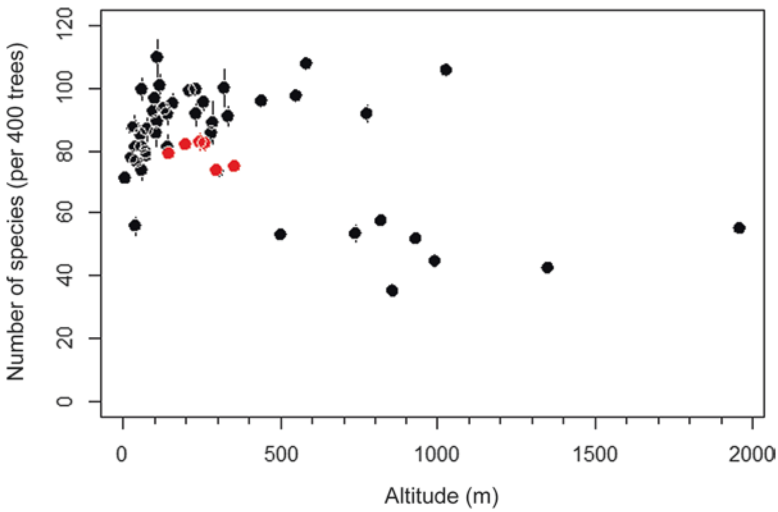


Fig. 10.9 Number of genera in 400 randomly selected trees in 46 locations in Slik et al. (2009) (black points) and six study areas in this research (red points)

deviation) in this study was significantly lower than those at the 10 locations in the previous study (91.9 ± 8.2) (Kruskal-Wallis test, $p < 0.05$).

10.4 Discussion

10.4.1 Above-Ground Biomass

We estimated the above-ground biomass in the AMFMU to be 354.5 t ha^{-1} on average. As it is generally about 50% of the above-ground biomass, the above-ground carbon stock was estimated as 177.2 t C ha^{-1} on average. Langner et al. (2012) also estimated above-ground carbon stocks of two logging concessions in Sabah: Deramakot and Tangkulap. Deramakot (which is FSC-certified and has been under sustainable forest management since 1995) has an estimated above-ground carbon stock of 167.9 t C ha^{-1} (143.7–195.7 t C ha^{-1}, 95% confidential interval). Tangkulap (which was logged using conventional methods until 2001) has an estimated above-ground carbon stock of 122.5 t C ha^{-1} (104.9–142.8 t C ha^{-1}). Therefore, we consider the above-ground biomass in the AMFMU to be at the same level as that of Deramakot.

Inside the AMFMU, the primary forests in HCVFs and WCs had high biomass stocks, indicated by an AGB2 value of 595.0 ± 157.1 t ha^{-1}. The above-ground biomass was even higher in forests harvested 30 years ago (HCVF1 and WC Sekawie), that is 493.1 ± 120.5 t ha^{-1}. Slik et al. (2013) compared the above-ground biomass of 120 sites in intact tropical forests in Southeast Asia, Africa and South America. Twenty-one of these 120 sites were the mixed dipterocarp forest in Borneo and the above-ground biomass value was 418 ± 112.9 t ha^{-1} (mean ± standard deviation). In comparison, the average above-ground biomass of primary forests in this study was higher than those of the 21 sites except for one study site in Lambir Hills National Park where the above-ground biomass was 678.6 t ha^{-1} in a 3.6 ha plot (Slik et al. 2013). Therefore, Anap-Muput has the potential to accumulate a very high biomass stock, even relative to other rainforests in Borneo.

In the normal timber harvesting area, the above-ground biomass was not well correlated with the duration since the last timber harvesting was performed. While AGB2 in C12 (which was recently harvested) was 227.8 ± 28.0 t ha^{-1}, the above-ground biomass values were similarly low in C16 (280.2 ± 115.6 t ha^{-1}) and C14 (221.2 t ha^{-1}) which were harvested 22–24 years ago. The coupe-wide average values also show that the above-ground biomass in coupes C11–C16 (where the forest was harvested only once about 20 years ago) was not much higher than those in coupes C03–C09 (where the forest had been harvested again in the past 7 years). As with C06c in coupe C06, many small patches of primary forest may remain in coupes at high altitudes as the steep terrain and challenging topography limit the area where bulldozers can enter during timber harvesting. It is considered that forests at lower altitudes with flatter terrain may have a high above-ground biomass before the first harvesting; however, most of the large trees may be logged and taken out during the first round of harvesting. The relative flatness of the forest floor also enables bulldozers to open large areas and destroy many small trees and seedlings, delaying the forest recovery after harvesting. On the other hand, the low biomass in the southern areas (including C16 and C14) may be because of poor soil fertility which would similarly delay the forest recovery after harvesting.

However, our estimation of the above-ground biomass by remote sensing could be an overestimation, especially at higher altitudes. The Landsat and topographic values of the vegetation plots in this study do not totally represent the variance inside the AMFMU (Fig. 10.10). While the altitude of our plots ranged from 64 to 525 m, that of the ASDU were between 13 and 963 m. While forest types generally change from hill mixed dipterocarp forest to upper mixed dipterocarp forest at an altitude of 700–800 m (Whitemore 1984), the relationship between the Landsat band values and biomass can vary between the vegetation types. Therefore, in order to improve the validity of the model and the above-ground biomass estimation in the AMFMU, it is necessary to establish more study plots at higher altitudes, especially at the southern ridge.

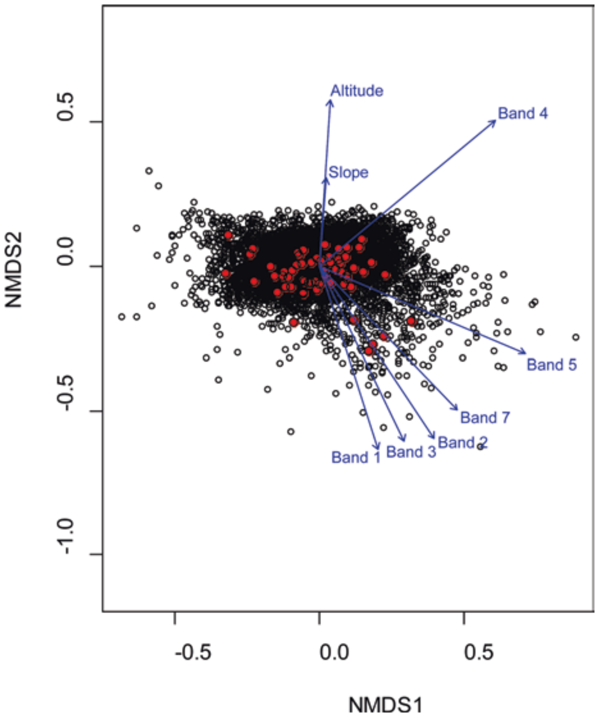


Fig. 10.10 Non-metric multidimensional scaling plot of variables (Landsat bands and topography) of 10,000 random points generated in the Anap-Muput Forest Management Unit (black points) and 62 study plots (red points)

10.4.2 Tree Diversity

We recorded a total of 967 species belonging to 69 families from 6381 trees with a dbh of greater than 10 cm in 70 plots of 8.33 ha in total. The foremost family found was Dipterocarpaceae, with both the greatest number of species as well as individual trees recorded. While 54 Dipterocarpaceae species were recorded in the AMFMU by Demies and Sang (2008), a greater number (131 species of Dipterocarpaceae) were recorded in this study. Given that Kathy MacKinnon et al. (1996) noted that there are at least 3000 trees species in Borneo (including 267 species of Dipterocarpaceae), approximately one third to half of the tree species in the region were found in the ASDU.

The species richness in logged areas was not obviously lower than that in primary forests (HCVFs and WCs), as Nicholas Berry et al. (2010) reported. Even areas that were harvested recently, for example C12 and C11, had as many species as the HCVFs and WCs. Thus, we consider the current logging system as not being too destructive in decreasing the species richness of the original primary rainforest.

The number of genera (α-diversity) found in the six study areas in the ASDU was slightly lower than previous study sites with the same altitude in Slik et al. (2009). Future studies are necessary to understand the causal factors. Nevertheless, as the 70 plots in this study were positioned to cover a large spatial range of the ASDU (106,820 ha), we recorded a high species richness in the concession due to the β-diversity. Primary forests in conservation areas have rich species diversity: 996 species were recorded among 32,962 trees with a dbh of greater than 10 cm in a 52 ha plot in Lambir Hills National Park, and 673 species were recorded among 28,997 trees with a dbh of greater than 10 cm in a 50 ha plot in Pasoh Forest Reserve in peninsular Malaysia (Condit et al. 2000). However, the areas of the national park and forest reserve in those studies were only 6952 ha and 2450 ha respectively, and are surrounded by large oil palm plantations.

10.5 Management Remarks

The above-ground biomass in the AMFMU is not linearly explainable by the number of years since the last logging as the decrease and recovery of the above-ground biomass appear to be spatially heterogenetic. Therefore, adaptive management with continuous monitoring of biomass could improve the sustainability of standing/carbon stock more efficiently by adjusting the current 25-year cutting cycle.

The primary forests in the HCVFs and WCs can be reference points of the original forest conditions and play an important role for potential improvements in the forest management of the ASDU. We recommend protecting more patches of primary forest inside all logging concessions in Sarawak.

In the field research we conducted, metal number tags were attached to all enumerated trees. Future measurement of the tagged trees can improve the estimations made in this study. While the annual accumulation rate in this study is presumed to be equal in all plots and refer to data of previous studies, repeat measurement could provide more appropriate values that are specific for different forest conditions and spatial locations in the ASDU. The annual accumulation rate also can be used to estimate an ASDU-specific annual allowable cutting volume for sustainable timber production.

While our estimation of the above-ground biomass in the ASDU is from 2009, sustainable forest management, including reduced-impact logging, started in the AMFMU in 2008. Therefore, the above-ground biomass status we estimated in this chapter is the result of past conventional logging. Future censuses and studies of the same study plots could be used to evaluate the performance of the current sustainable forest management methods in the AMFMU.

Acknowledgements We would like to thank the staff of Sarawak Forestry Corporation, Rantai Jawa, Tinjan Kuda and Shalih bin Rebi, who helped in conducting fieldwork and the identification of tree species. We also thank the managing director of Zedtee Sdn Bhd, Wong Ing Yung, and his staff, John Tasan and Wong Toh Meo, and the other staff in Camp Sekawie and Camp Ayam for their support during the fieldwork. We are grateful to our local assistants who helped with our fieldwork. We also thank Jason Hon from WWF-Malaysia who introduced us to the ASDU, helped to conduct this study and also edited the manuscript. We would also like to acknowledge Nobuo Imai, Andreas Langner, Atsushi Tanaka and Kanehiro Kitayama who helped in discussing the plot design, and Ayako Oide who helped with the remote sensing analysis. This study was financially supported by Grant-in-Aid for Scientific Research (22221010) from the Japan Society for the Promotion of Science and the Global Environment Research Funds (D-1006, 1-1403) of the Ministry of the Environment, Japan. This study was permitted by the Forest Department of Sarawak (NCCD.907.4.4 (Jld.7) -67).

References

Berry, Nicholas J., Oliver L. Phillips, Simon L. Lewis, Jane K. Hill, David P. Edwards, Noel B. Tawatao, Norhayati Ahmad, David Magintan, Chey V. Khen, M. Maryati, Robert C. Ong, and Keith C. Hamer. 2010. The high value of logged tropical forests: Lessons from northern Borneo. *Biodiversity Conservation* 19 (4): 985–997.

Blackman, Allen. 2013. Evaluating forest conservation policies in developing countries using remote sensing data: An introduction and practical guide. *Forest Policy and Economics* 34: 1–16.

Chave, Jérôme. 2008. Spatial variation in tree species composition across tropical forests: Pattern and process. In *Tropical forest community ecology*, ed. Walter P. Carson and Stefan A. Schnitzer, 11–30. Chichester: Wiley-Blackwell.

Chave, Jérôme, Christophe Andalo, Sandra Brown, Michael A. Cairns, Jeffrey Q. Chambers, Derek Eamus, Horst Fölster, François Fromard, Niro Higuchi, Tatuo Kira, Jean-Paul Lescure, Bruce Walker Nelson, H. Ogawa, Henri Puig, Bernard Riera, and Takuo Yamakura. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145 (1): 87–99.

Clark, Deborah A., Sandra Brown, David W. Kicklighter, Jeffrey Q. Chambers, John R. Thomlinson, Jian Ni, and Elisabeth A. Holland. 2001. Net primary production in tropical forests: An evaluation and synthesis of existing field data. *Ecological Applications* 11 (2): 371–384.

Condit, Richard, Peter S. Ashton, Patrick Baker, Sarayudh Bunyavejchewin, Savithri Gunatilleke, Nimal Gunatilleke, Stephen P. Hubbell, Robin B. Foster, Akira Itoh, James V. LaFrankie, Hua Seng Lee, Elizabeth Losos, N. Manokaran, Raman Sukumar, and Takuo Yamakura. 2000. Spatial patterns in the distribution of tropical tree species. *Science* 288 (5470): 1414–1418.

Demies, Malcom, and Julia Sang. 2008. *Structure and species composition of three dipterocarp genera in Anap Muput high conservation value forests*. Kuching: Sarawak Forestry Corporation.

Drake, Jason B., Robert G. Knox, Ralph O. Dubayah, David B. Clark, Richard Condit, J. Bryan Blair, and Michelle Hofton. 2003. Above-ground biomass estimation in closed canopy Neotropical forests using lidar remote sensing: Factors affecting the generality of relationships. *Global Ecology and Biogeography* 12 (2): 147–159.

Dubayah, Ralph O., S.L. Sheldon, David B. Clark, Michelle A. Hofton, J. Byran Blair, George C. Hurtt, and Robin L. Chazdon. 2010. Estimation of tropical forest height and biomass dynamics using lidar remote sensing at La Selva, Costa Rica. *Journal of Geophysical Research* 115: 1–17.

Ekstrand, Sam. 1996. Landsat TM-based forest damage assessment: Correction for topographic effects. *Photogrammetric Engineering and Remote Sensing* 62 (2): 151–162.

Esri. 2012. *ArcGIS desktop: Release 10.1*. Redlands: Environmental Systems Research Institute.

Exelis Visual Information Solutions. 2013. *ENVI version 5.1*. Boulder: Exelis Visual Information Solutions.

Food and Agriculture Organisation of the United Nations [FAO]. 1997. *Estimating biomass and biomass change of tropical forests: A primer*. Rome: Food and Agriculture Organisation of the United Nations, FAO Forestry Paper 134.

Foody, Giles M., Mark E. Cutler, Julia McMorrow, Dieter Pelz, Hamzah Tangki, Doreen S. Boyd, and Ian Douglas. 2001. Mapping the biomass of Bornean tropical rain forest from remotely sensed data. *Global Ecology and Biogeography* 10 (4): 379–387.

Griscom, Bronson, Peter Ellis, and Francis E. Putz. 2014. Carbon emissions performance of commercial logging in East Kalimantan, Indonesia. *Global Change Biology* 20 (3): 923–937.

Hexagon Geospatial. 2011. *ERDAS IMAGINE version 11.0.1*. Norcross: Hexagon Geospatial.

Hirata, Yasumasa, Gen Takao, Tamotsu Sato, and Jumpei Toriyama. 2012. *REDD-plus cookbook*. Kanagawa: REDD Research and Development Center, Forestry and Forest Products Research Institute Japan.

Hon, Jason. 2011. A new record for the Borneo bay cat in central Sarawak, Malaysian Borneo. *Cat News* Autumn (55): 4–6.

Hon, Jason, and Shozo Shibata. 2013. Temporal partitioning by animals visiting salt licks. *International Journal of Environmental Science and Development* 4 (1): 44–48.

Imai, Nobuo, Tatsuyuki Seino, Shin-ichiro Aiba, Masaaki Takyu, Jupiri Titin, and Kanehiro Kitayama. 2012. Effects of selective logging on tree species diversity and composition of Bornean tropical rain forests at different spatial scales. *Plant Ecology* 213 (9): 1413–1424.

Koizumi, Miyako. 2012. Developing a plant-survey method at Anap-Muput Forest Management Unit. *Equatorial Biomass Society* 3: 4–5.

Langner, Andreas, Hiromitsu Samejima, Robert C. Ong, Jupiri Titin, and Kanehiro Kitayama. 2012. Integration of carbon conservation into sustainable forest management using high resolution satellite imagery: A case study in Sabah, Malaysian Borneo. *International Journal of Applied Earth Observation and Geoinformation* 18: 305–312.

Lemmens, Roeland Hendrikus Maria Julien, Ishemat Soerianegara, and W.C. Wong. 1995. *Timber trees: Minor commercial timbers*. Leiden: Backhuys Publishers, Plant Resources of South-East Asia (PROSEA), No. 5 Part 2.

MacKinnon, Kathy, Gusti Hatta, Hakimah Halim, and Arthur Mangalik. 1996. *The ecology of Kalimantan, Indonesian Borneo*, Ecology of Indonesia series. Vol. 3. Singapore: Periplus Editions.

Manly, Bryan F.J. 2007. *Randomization, bootstrap and Monte Carlo methods in biology*. 3rd ed. London: Chapman & Hall/CRC.

Morel, Alexandra C., Sassan S. Saatchi, Yadvinder Malhi, Nicholas J. Berry, Lindsay Banin, David Burslem, Reuben Nilus, and Robert C. Ong. 2011. Estimating aboveground biomass in forest and oil palm plantation in Sabah, Malaysian Borneo using ALOS PALSAR data. *Forest Ecology and Management* 262 (9): 1786–1798.

Oey, Djoen Seng. 1951. *Perbandingan berat dari djenis*[2] *kaju Indonesia dan pengartian beratnja kaju untuk keperluan praktek*. Bogor: Balai Penjelidikan Kehutanan.

Okuda, Toshinori, Mariko Suzuki, Sinya Numata, Keiichiro Yoshida, Sen Nishimura, Naoki Adachi, Kaoru Niiyama, N. Manokaran, and Mazlan Hashim. 2004. Estimating of aboveground biomass in logged and primary lowland rainforests using 3-D photogrammeric analysis. *Forest Ecology and Management* 203 (1–3): 63–75.

Pinard, Michelle A., and Francis E. Putz. 1996. Retaining forest biomass by reducing logging damage. *Biotropica* 28 (3): 278–295.

Pinard, Michelle A., Francis E. Putz, and John Tay. 2000. Lessons learned from the implementation of reduced-impact logging in hilly terrain in Sabah, Malaysia. *International Forestry Review* 2 (1): 33–39.

Putz, Francis E., Pieter A. Zuidema, Timothy Synnott, Marielos Peña-Claros, Michelle A. Pinard, Douglas Sheil, Jerome K. Vanclay, Plinio Sist, Sylvie Gourlet-Fleury, Bronson Griscom, John Palmer, and Roderick Zagt. 2012. Sustaining conservation values in selectively logged tropical forests: The attained and the attainable. *Conservation Letters* 5 (4): 296–303.

R Development Core Team. 2013. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Ruekeith, Geryl Ogilvy. 2014. Longer tenure for timber licence. *Borneo Post*, August 21.

Samejima, Hiromitsu, and Jason Hon. 2014. Ground-dwelling mammals and birds recorded by camera traps in logged over forest in Anap Sustainable Development Unit, Sarawak, Malaysia. *Equatorial Biomass Society* 10: 12–18.

Saatchi, Sassan S., Miriam Marlier, Robin L. Chazdon, David B. Clark, and Ann E. Russell. 2011a. Impact of spatial variability of tropical forest structure on radar estimation of aboveground biomass. *Remote Sensing of Environment* 115 (11): 2836–2849.

Saatchi, Sassan S., Nancy L. Harris, Sandra Brown, Michael Lefsky, Edward T.A. Mitchard, William Salas, Brian R. Zutta, Wolfgang Buermann, Simon L. Lewis, Stephen Hagen, Silvia Petrova, Lee White, Miles Silman, and Alexandra Morel. 2011b. Benchmark map of forest carbon stocks in tropical regions across three continents. *Proceedings of the National Academy of Sciences of the United States of America* 108 (24): 9899–9904.

Slik, J.W. Ferry, Niels Raes, Shin-Ichiro Aiba, Francis Q. Brearley, Charles H. Cannon, Erik Meijaard, Hidetoshi Nagamasu, Reuben Nilus, Gary Paoli, Axel D. Poulsen, Douglas Sheil, Eizi Suzuki, Johan L.C.H. van Valkenburg, Campbell O. Webb, Peter Wilkie, and Stephan Wulffraat. 2009. Environmental correlates for tropical tree diversity and distribution patterns in Borneo. *Diversity and Distributions* 15 (3): 523–532.

Slik, J.W. Ferry, Gary Paoli, Krista McGuire, Ieda Amaral, Jorcely Barroso, Meredith Bastian, Lilian Blanc, Frans Bongers, Patrick Boundja, Connie Clark, Murray Collins, Gilles Dauby, Yi Ding, Jean-Louis Doucet, Eduardo Eler, Leandro Ferreira, Olle Forshed, Gabriella Fredriksson, Jean-Francois Gillet, David Harris, Miguel Leal, Yves Laumonier, Yadvinder Malhi, Asyraf Mansor, Emanuel Martin, Kazuki Miyamoto, Alejandro Araujo-Murakami, Hidetoshi Nagamasu, Reuben Nilus, Eddy Nurtjahya, Átila Oliveira, Onrizal Onrizal, Alexander Parada-Gutierrez, Andrea Permana, Lourens Poorter, John Poulsen, Hirma Ramirez-Angulo, Jan Reitsma, Francesco Rovero, Andes Rozak, Douglas Sheil, Javier Silva-Espejo, Marcos Silveira, Wilson Spironelo, Hans ter Steege, Tariq Stevart, Gilberto Enrique Navarro-Aguilar, Terry Sunderland, Eizi Suzuki, Jianwei Tang, Ida Theilade, Geertje van der Heijden, Johan van Valkenburg, Tran Van Do, Emilio Vilanova, Vincent Vos, Serge Wich, Hannsjoerg Wöll, Tsuyoshi Yoneda, Runguo Zang, Ming-Gang Zhang, and Nicole Zweifel. 2013. Large trees drive forest aboveground biomass variation in moist lowland forests across the tropics. *Global Ecology and Biogeography* 22 (12): 1261–1271.

Soerianegara, Ishemat, and Roeland Hendrikus Maria Julien Lemmens. 1993. *Timber trees: Major commercial timbers.* Leiden: Backhuys Publishers, Plant Resources of South-East Asia (PROSEA), No. 5 Part 1.

Sosef, Marcus Simon Maria, Lay Thong Hong, and S. Prawirohatmodjo. 1998. *Timber trees: Lesser-known timbers*. Leiden: Backhuys, Plant Resources of South-East Asia (PROSEA), No. 5 Part 3.

Tangkia, Hamzah, and Nick A. Chappell. 2008. Biomass variation across selectively logged forest within a 225-km^2 region of Borneo and its prediction by Landsat TM. *Forest Ecology and Management* 256 (11): 1960–1970.

US Geological Survey. 2015. *EarthExplorer*. http://earthexplorer.usgs.gov. Accessed 17 July 2018.

Whitemore, Timothy Charles. 1984. *Tropical rain forests of the Far East*. Oxford: Clarendon Press.

Zimmerman, Jess K., Jill Thompson, and Nicholas Brokaw. 2008. Large tropical forest dynamics plots: Testing explanations for the maintenance of species diversity. In *Tropical forest community ecology*, ed. Walter P. Carson and Stefan A. Schnitzer, 98–117. Chichester: Wiley-Blackwell.

Chapter 11
Influence of Herbicide Use in Oil Palm Plantations on Stream Water Chemistry in Sarawak

Naoko Tokuchi, Hiromitsu Samejima, Jason Hon, and Keitaro Fukushima

Abstract The drastic transformation in land use from natural forest to acacia and oil palm plantations in tropical regions is an issue of some controversy. The influence of land-use change on nutrient cycling is not fully understood. In this case, stream water chemistry is one of the most useful indexes of the nutrient status of an ecosystem. We investigated stream water chemistry in different land uses: lowland forests, acacia plantations and oil palm plantations. There were significant differences in the distribution and composition of stream water chemistry among the various land uses. Ion concentrations in stream water were the lowest in lowland forests, while the highest concentrations were found in oil palm plantations, especially Cl^- and K^+. This seems to originate from anthropogenic sources like herbicides and fertilisers. Our results suggest that land use and its management have a large influence not only on nutrient cycling but also on the sustainability of forest ecosystems.

Keywords Sarawak · Stream water chemistry · Herbicides · Fertilisers · Land use · Oil palm plantations

N. Tokuchi (✉)
Field Science Education and Research Center, Kyoto University, Kyoto, Japan
e-mail: tokuchi@kais.kyoto-u.ac.jp

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

J. Hon
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

K. Fukushima
Center for Ecological Research, Kyoto University, Kyoto, Japan
e-mail: fmktaro@ecology.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_11

11.1 Introduction

Land use has recently changed dramatically in Sarawak as primary forests have been rapidly converted to farms and oil palm and acacia plantations. These changes are having severe environmental effects on the air, soil and water in these areas. Stream water is very important in this region; many people live in longhouses beside rivers which are often their main source of water. However, there is little information about the influence of land-use changes on stream water in Sarawak. To examine the influence of these changes on stream water chemistry, we sampled the Kemena River (including the Jelalong, Pandan and Binyo rivers) and the Tatau River (including the Anap River) from 2010 to 2014 in areas with a range of land uses. In this chapter, we focus on the chemical characteristics of stream water associated with oil palm plantations, acacia plantations and natural forests under sustainable management.

11.2 Study Sites

The Kemena and the Tatau are two major rivers in Sarawak, Malaysia (Fig. 11.1). The Jelalong, Pandan and Binyo rivers are tributaries of the Kemena while the Anap River is a tributary of the Tatau. The topography of Sarawak is relatively flat. The research area covers more than 10,000 km^2, but the difference in elevation between the upper and lower parts of the research area is less than 50 m. As a result, there are many wetlands in the lower part of the watershed, particularly around the Binyo River.

Water samples were collected from streams in areas with three land-use types: lowland forests, oil palm plantations and acacia plantations. Areas of shifting cultivation were present in all watersheds but were not significant. The watershed and dominant land use were determined for each sampling point and a geographic information system (GIS) was used to define the dominant land use when the land-use type was not clear. A watershed was defined as being characterised by a particular land-use type when it covered 80% or more of the watershed. Land uses differed locally in the areas of central Sarawak where stream water samples were collected. There were many oil palm plantations around the Kemena, while acacia plantations were present in the Binyo area, and lowland forests remained in the Tatau region (Fig. 11.1; Hou et al. unpublished).

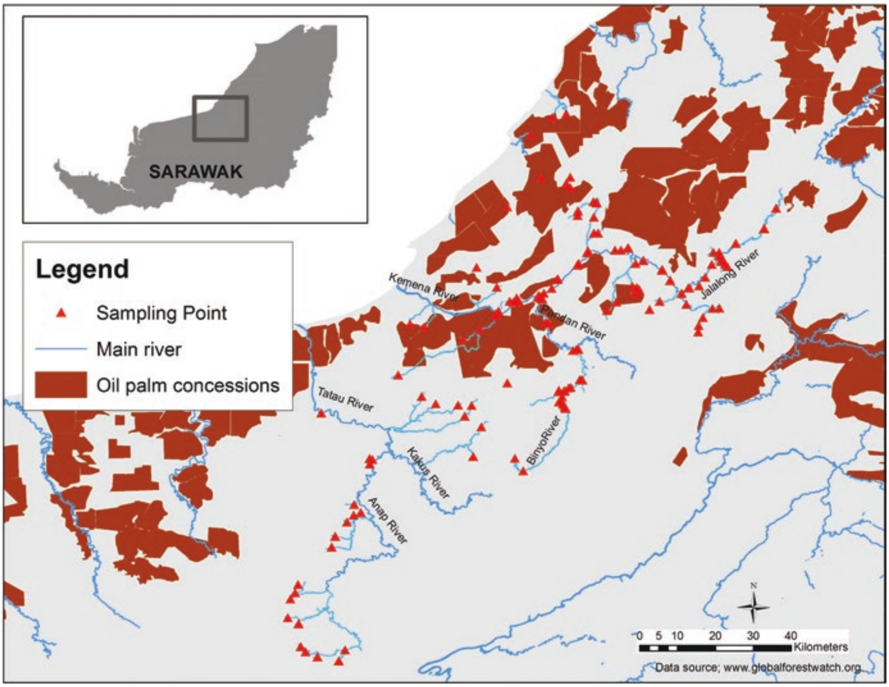


Fig. 11.1 Study site and oil palm concessions

11.3 Materials and Methods

Stream water was sampled in association with the different land uses. Sixty-one samples were collected including 18 near lowland forests, four near oil palm plantations and 17 near acacia plantations. All sampling sites are shown in Fig. 11.1. The pH and electric conductivity of the water were measured in situ. All water samples were taken to Japan, filtered in the laboratory of the Field Science Education and Research Centre, Kyoto University, and kept in a −4 °C refrigerator until analysis. Major anions and cations were analysed by ion chromatography using a Dionex system. These anions were chloride (Cl^-), nitrite (NO_2^-), nitrate (NO_3^-), sulphate (SO_4^{2-}) and phosphate (PO_4^{3-}), while the cations that were analysed were ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}). Concentration of NO_2^- and PO_4^{3-} were always below the detection limit.

11.4 Results and Discussion

11.4.1 Stream Water Chemistry and Land Use

There were clear differences in stream water chemistry among areas and varying land-use types. Because different land-use types were in close proximity to one another in some sampling areas, it was difficult to separate the effects of different land uses and location on stream water chemistry. Although location can greatly affect stream water chemistry through geology, there are no major or clear differences in geology of this region of central Sarawak. Therefore, we considered land use to be the primary factor influencing stream water chemistry in this study.

Concentrations of K^+, Cl^- and NO_3^- in stream water showed clear differences among the land-use types (Figs. 11.2, 11.3, and 11.4). All K^+, Cl^- and NO_3^- concentrations were significantly higher in sites associated with oil palm plantations than in those from lowlands or near acacia plantations (Miettinen et al. 2012). The NO_3^- concentrations were particularly low in water samples collected near lowland forests.

The chemical composition of the stream water differed significantly among the land-use types (Fig. 11.5). Both the total cation and total anion concentrations were highest in streams near oil palm plantations. The total anion concentration was the

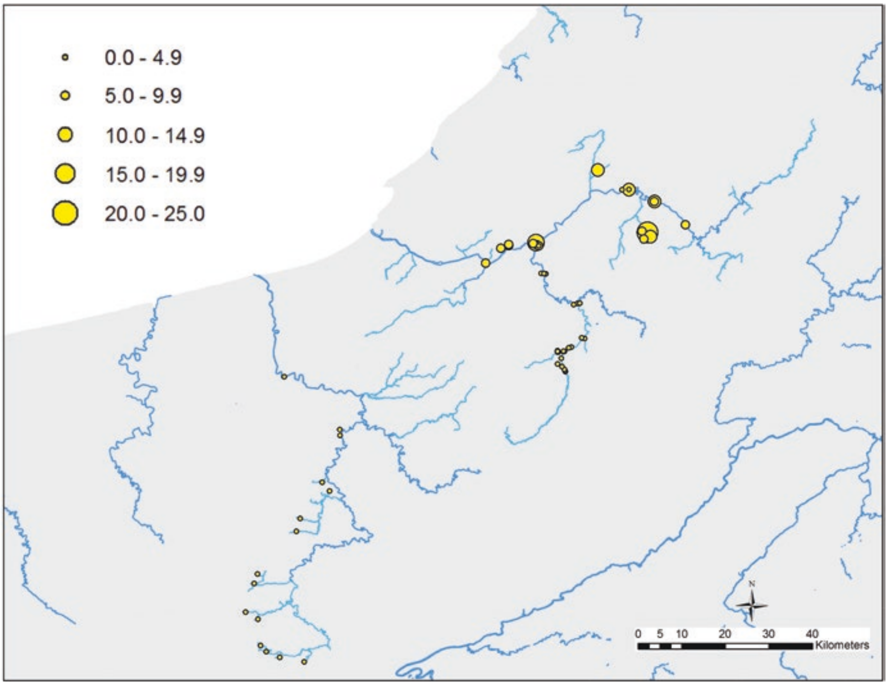


Fig. 11.2 Spatial distribution of NO_3^- (μeq L^{-1}) in stream water

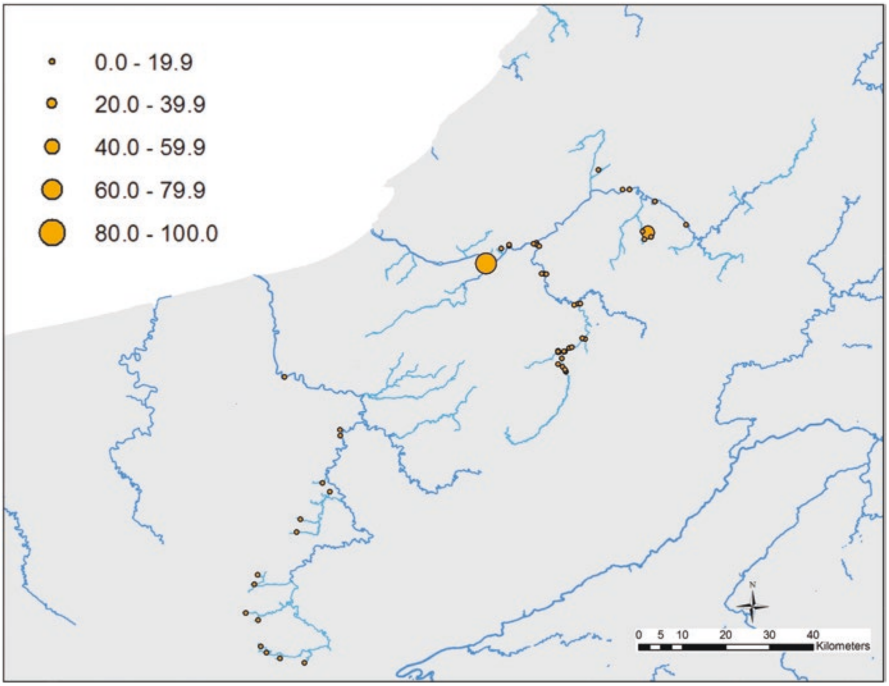


Fig. 11.3 Spatial distribution of Cl^- (μeq L^{-1}) in stream water

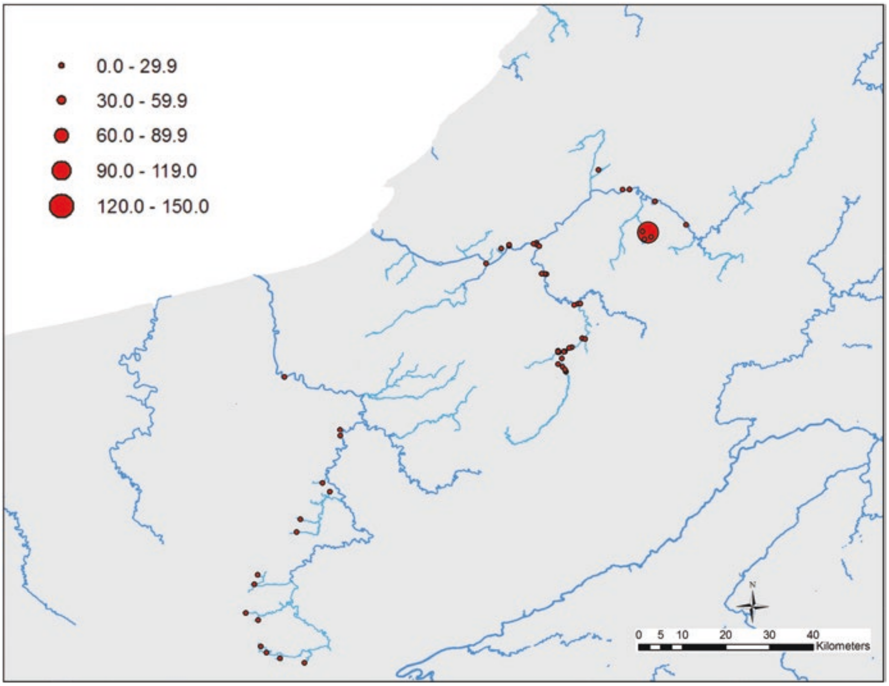


Fig. 11.4 Spatial distribution of K^+ (μeq L^{-1}) in stream water

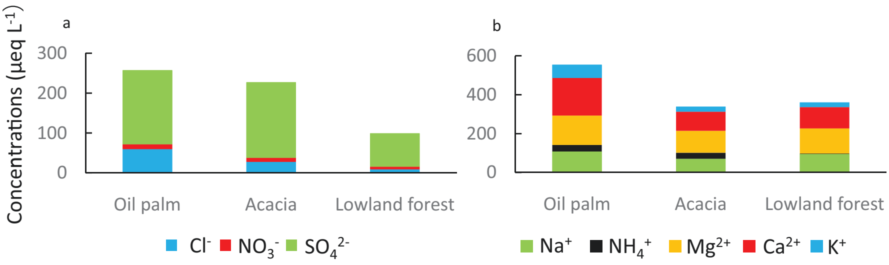


Fig. 11.5 Average chemical composition of (**a**) anions and (**b**) cations in stream water samples from lowland forests, acacia plantations and oil palm plantations

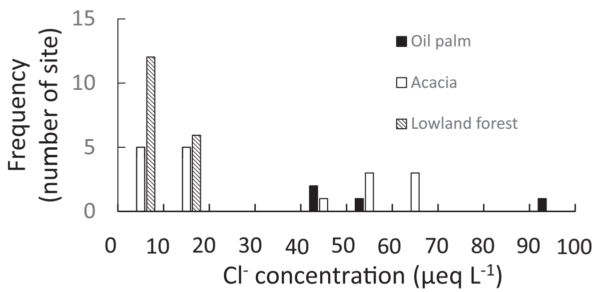


Fig. 11.6 Cl^- concentrations for three land-use types

lowest in the lowland forest (less than 100 μeq L^{-1}) and was 250 μeq L^{-1} near oil palm and acacia plantations. There was a clear difference in chemical composition, especially in Cl^-, K^+ and NH_4^+ among the land-use types.

Chloride concentrations in stream water differed significantly among land-use types (Figs. 11.3 and 11.6). Near acacia plantations and lowland forests, chloride concentrations were less than 70 μeq L^{-1}, but exceeded 50 μeq L^{-1} in samples near oil palm plantations, which indicates that chloride concentrations are typically high near oil palm plantations.

Oil palm plantations dominated land use in the Kemena area and most of the lowland forests were distributed in the Tatau area. Chloride generally originates from sea salt and saltwater rather than from soil materials, and it is therefore more likely that the differences in chloride concentrations in the stream samples here were a result of land use rather than geology.

Figure 11.7 shows several of the major herbicides used in the study area. Yumi Kato and Ryoji Soda (2012) showed that oil palm smallholders and nursery operators primarily use paraquat (Fig. 11.7c), a non-selective herbicide, to control weeds. The chemical formula for paraquat is $C_{12}H_{14}Cl_2N_2$, which shows that the main constituent is Cl^-. High chloride concentrations in streams near oil palm plantations thus may originate from this herbicide. The total ion concentrations of stream water in lowland forest areas where no herbicide is used were one sixtieth of those in areas with oil palm plantations.

Fig. 11.7 Major herbicides used in Sarawak: (**a**) Ally 20DF (metsulfuron methyl); (**b**) Powex (glyphosate isopropylamine); and (**c**) Paraquat 130 (paraquat dichloride) (Photograph: Y. Takeuchi 2014)

When anion concentrations increase, cations must also increase to maintain the ionic balance of a solution. However, there are insufficient cations in Sarawak's soils, which are classified as acrisols (FAO-UNESCO 1988) and are defined by their low cation exchange capacity (i.e. low cation content). However, K^+ concentrations in stream water were higher near oil palm plantations than near other land-use types (Fig. 11.4). Generally, soils of tropical areas are highly weathered and cations and phosphorus are often deficient in these soils. This results in little cations in the soil and leachates, which suggests that the possibility of cations in stream water near oil palm plantations does not originate from either the local geology or from natural sources. Fertilisers are also used in oil palm plantations and the major constituents in fertiliser are N, P and K. This indicates that N, P and K in stream water were likely derived from fertiliser. In oil palm plantations, the Cl^- content in paraquat increased total anion concentrations, which needs to be balanced by cations. Due to the lack of cations in tropical soil, this deficit is supplied instead by cations from fertiliser. We confirmed a strong correlation between Cl^- and K^+ concentrations ($r^2 = 0.999$, $p < 0.001$), thus indicating that the leaching of cations from fertiliser is linked to the presence of anions from herbicides.

Based on these results, the composition, timing of application and quantity of herbicides and fertilisers used are important factors affecting environmental water quality. Herbicides that contain high levels of Cl^- or other anions will influence stream water chemistry while herbicides used during periods of high rainfall can easily be washed into streams through runoff. The use of herbicides and fertilisers should be implemented carefully to ensure sustainable land use and to minimise any effects on the surrounding environment. Constant monitoring of water quality levels should also be performed in waterways in and around plantations. Among the techniques to reduce runoff and water pollution are the correct placement of fertilisers and herbicides at the sub-surface of soils instead of the surface, avoiding application of fertilisers and herbicides on waterlogged or flooded soils, as well as planting cover crops to prevent soil erosion.

11.5 Conclusion

Water samples from 2010 to 2014 were examined to determine the influence of different land uses on stream water chemistry. There was a significant difference in stream water chemistry among oil palm plantations, acacia plantations and lowland forests. Chloride was the dominant constituent in stream water associated with oil palm plantations and is thought to originate from herbicide. Chloride, accompanied by cations, is leached from soils into stream water. Some of the leached cations are derived from fertiliser and also from soil itself. The efficient and appropriate management of herbicide use is important to sustainable land use and preventing environmental water pollution.

References

Food and Agriculture Organisation of the United Nations-United Nations Educational, Scientific and Cultural Organisation [FAO-UNESCO]. 1988. *Revised legend of the FAO-UNESCO soil map of the world, world soil resources report 60*. Rome: Food and Agriculture Organisation of the United Nations.

Kato, Yumi, and Ryoji Soda. 2012. Emerging trends in oil palm smallholdings in Sarawak, Malaysia. *Geographical Studies* 7 (2): 26–35.

Miettinen, Jukka, Chenghua Shi, Wee Juan Tan, and Soo Chin Liew. 2012. 2010 land cover map of insular Southeast Asia in 250 m spatial resolution. *Remote Sensing Letters* 3 (1): 11–20.

Chapter 12
Spatial Variations in Dissolved and Particulate Organic Carbon in the Kemena and Tatau Rivers, Sarawak

Keitaro Fukushima, Naoko Tokuchi, Hiromitsu Samejima, Jason Hon, and Yuichi Kano

Abstract It is important to understand carbon (C) dynamics in terrestrial and coastal ecosystems in order to develop a strategy to control carbon dioxide effluxes. However, the factors determining concentrations of riverine carbon are still largely unknown, especially in Southeast Asia. We investigated the spatial distribution of dissolved and particulate organic carbon (DOC and POC, respectively) and suspended sediment (SS) concentrations in the Kemena and Tatau rivers of Sarawak, Malaysia, in 2011, 2012 and 2013. There are large variations in DOC and POC concentrations in both rivers and their spatial patterns also differ. DOC concentrations did not vary over the sampling years and mainly depended on the distribution of tropical peatland within the watershed. Excitation-emission matrix (EEM) fluorescence spectroscopy with parallel factor analysis showed that DOC supplied from peatland is distinctive though the fluorescence characteristics do not change with the creation of plantations. SS and POC concentrations were slightly higher in logged forests and plantations and significantly higher in main rivers than in intact forests. The results suggest that DOC concentrations are geographically controlled

K. Fukushima (✉)
Center for Ecological Research, Kyoto University, Kyoto, Japan
e-mail: fmktaro@ecology.kyoto-u.ac.jp

N. Tokuchi
Field Science Education and Research Center, Kyoto University, Kyoto, Japan
e-mail: tokuchi@kais.kyoto-u.ac.jp

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

J. Hon
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

Y. Kano
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan
e-mail: kano@species.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_12

by peatland distribution, while intensive plantation development and the resultant soil disturbance can cause an increase in terrestrial POC discharges to the ocean.

Keywords Sarawak · Dissolved organic carbon · Particulate organic carbon · Suspended sediment · Excitation-emission matrix fluorescence · Land-use change

12.1 Introduction

Carbon (C) cycling is a global concern because some gaseous forms of C (such as carbon dioxide and methane) contribute to global climate change. Effluxes of C must therefore be limited to the lowest possible level. The clearing and burning of trees and subsequent land-use changes in tropical rainforests contribute significantly to net C emissions from plant and soil systems to the atmosphere. In addition, these forest disturbances can also induce C loss to river systems because logging residues and soil organic matter are flushed out by episodic heavy rain that is common in this region (Ciais et al. 2013).

Rivers carry large quantities of C from the land to the ocean (Meybeck 1982; Schlünz and Schneider 2000). Though the flux is smaller than that of plant respiration, photosynthesis or of forest biomass removal by humans, it is nevertheless not negligible (Ciais et al. 2013). The major forms of riverine C are dissolved inorganic C, and dissolved and particulate organic C (DOC and POC, respectively) (Hossler and Bauer 2013; Meybeck 1982), which can be distinguished physically on the basis of size or particle diameter. DOC is hydrated and complex organic C; it includes humic substances produced by decomposing plant materials and protein-like substances derived from aquatic phytoplankton, algae and other such sources. Water containing a high concentration of DOC derived from humic-like substances is clear yellow to brown. POC includes colloidal aggregation of DOC, organic carbon absorbed in soil particles, phytoplankton-derived chlorophyll and fragmented plant or animal bodies. This fraction is almost equal to the C contained in suspended sediments (SS). Water with high SS or POC concentrations appears cloudy or has high turbidity.

DOC and POC play key biogeochemical roles within aquatic ecosystems. For instance, water colour and turbidity strongly regulate primary production by light attenuation, which is in turn closely related to aquatic biodiversity and food web structures in both rivers and oceans (Cloern 1987; Pusch et al. 1998; Fonte et al. 2011). Moreover, their concentrations and chemical properties can also affect nutrient and heavy metal transport and carbon dioxide (CO_2) emission by microbial respiration and photodegradation (Aiken et al. 2011; Meybeck 1982; Richey et al. 1990). In spite of the biogeochemical importance of riverine C in aquatic ecosystems, few observations are available for tropical regions in Southeast Asia. In recent years, tropical forests in Sarawak (which is located in the northwestern part of Borneo) have been intensively logged and rapidly clear-cut, with land converted to acacia and oil palm plantations. Additionally, there are also lowland peatlands in the area. Because peatlands store a large quantity of organic C in the soil, there has been significant concern that the recent widespread conversion of peatland areas to oil palm plantations may affect global C dynamics (Hooijer et al. 2010; Carlson et al. 2013). It is estimated that 11–14% of global peat C is found in the tropical peatlands of Southeast Asia; approximately 10% of the global peat C pool is in Malaysia (Page et al. 2011). Forest disturbances and land-use change may dramatically affect not only the CO_2 emissions from the land surface but also affect riverine C fluxes. However, due to a lack of riverine C data, these impacts and changes have not been examined.

In this study, we used excitation-emission matrix (EEM) fluorescence techniques. EEM fluorescence of dissolved organic matter (DOM) can be used to determine various DOC characteristics based on the resulting peak intensities and positions; it also provides information on sources of and transformations of DOM in aquatic systems (Hudson et al. 2007). Previous studies have reported that humic-like and protein-like fluorophores can be estimated separately using EEM fluorescence (e.g. Mostofa et al. 2013). Parallel factor analysis (PARAFAC), a recently developed statistical method, can take overlapping fluorescence spectra and objectively decompose the EEM into several independent fluorescence components. The PARAFAC model enables us to evaluate DOM characteristics of a diverse range of water samples based on more fluorescence components than was ever previously possible (Stedmon et al. 2003; Fellman et al. 2008; Yamashita et al. 2008; Mostofa et al. 2013).

We investigated the spatial distribution of DOC and SS concentrations in the Kemena and Tatau rivers of Sarawak during August and September of 2011, 2012 and 2013. We also measured the fluorescence intensity of DOM and estimated DOC characteristics via EEM-PARAFAC as well as the relationship between SS and POC concentrations. The main goal of this research was to assess spatial variations in riverine organic C and their relationship to land use as well as to reveal the factors determining riverine organic C concentrations in this region where multiple land uses can be found.

12.2 Material and Methods

12.2.1 Study Region Description

The Kemena and Tatau river basins are adjacent and located between 2°10′–3°30′ N and 112°38′–114°8′ E in northwestern Borneo (Fig. 12.1). Based on the 2008 land cover classification map by Andreas Langner et al. (2015) and the 2010 oil palm plantation map by SADIA et al. (2015), the major regional land uses were categorised into five classes as follows: acacia plantations (designated ACA), oil palm plantations (OIL), logged forests (LOG), natural or mature secondary forests (FOR) and tropical low-lying peatlands (PEAT) (Fig. 12.1b). We determined land-use

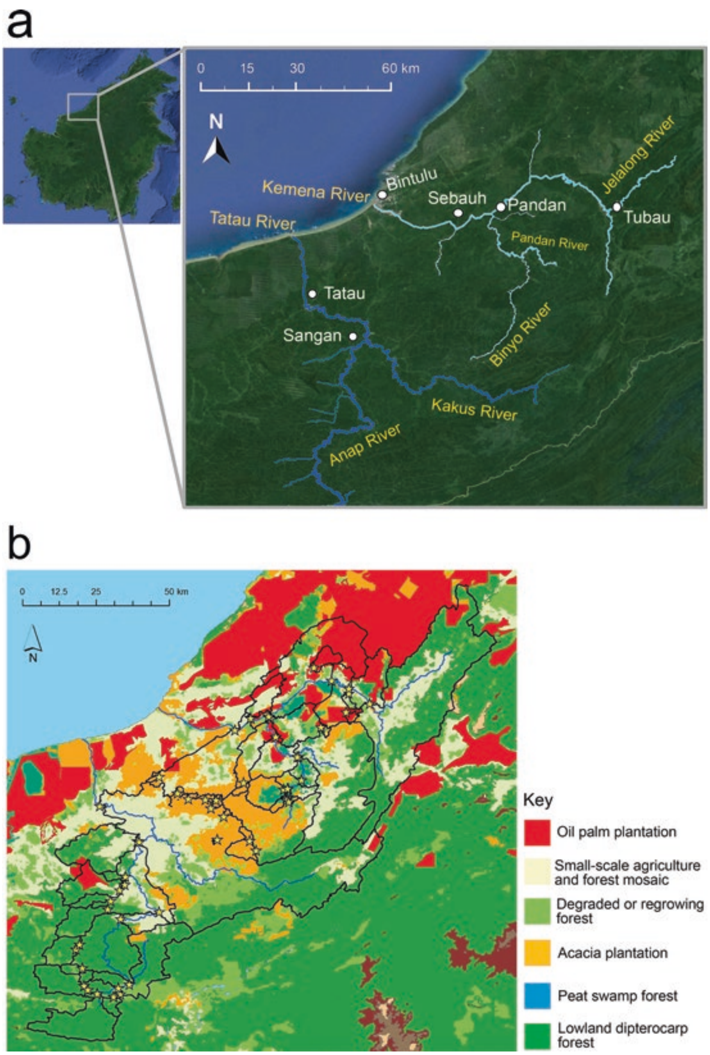


Fig. 12.1 Location of the study site with (**a**) the Kemena and Tatau basins on the northwestern part of Borneo, and (**b**) the land-use map of the area produced from Landsat data
Source: Google Earth, Image Landsat Data SIO. NOAA, US Navy, NGA, GEBCO, captured in 2011

classes within the watersheds of the river tributaries investigated based on the dominant land-use class. Additionally, we categorised main rivers (designated in figures as MAIN) separately from river tributaries; we defined points along the Tatau River and its main branches (Anap and Kakus rivers, Fig. 12.1a) and along the Kemena River and its main branches (the Jelalong, Pandan and Binyo rivers, Fig. 12.1a) as main rivers, then defining rivers that join them as tributaries.

12.2.2 Water Collection and Chemical Analysis

We collected water samples at 57, 48 and 39 locations along the two rivers during August and September in 2011, 2012 and 2013, respectively. Clean polyethylene terephthalate bottles were washed three times with river water before sample collection. The pH of water samples was measured at the sampling points using a handheld pH meter (model HM-20P, DKK-TOA).

Water samples were filtered with 25 mm glass microfibre filters (grade GF/F, Whatman), which were precombusted in a muffle furnace for 4 h at 450 °C and weighed. We used a polypropylene filter holder with silicone O-rings and then ran a known volume of river water through the filter using a 50 mL prewashed syringe within a day after collection. The filtrate was placed into precombusted amber glass bottles and stored in a refrigerator at 4 °C before analysis. We defined the C contained in filtrate as DOC and materials on the filter as SS. POC values were determined based on the total C content of SS.

Concentrations of DOC (mg C L^{-1}) from filtered river water samples were determined by high-temperature combustion using a total organic carbon analyser (model TOC-V, Shimadzu). In order to remove dissolved inorganic C in the form of carbonate, the water sample was acidified using 6 N HCl and purged with C-free air prior to measurement. Fluorescence EEMs of DOM were measured using a fluorescence spectrometer (model F-7000, Hitachi) with a xenon lamp. EEMs were created by measuring fluorescence intensity across excitation wavelengths ranging from 225–400 nm at 5 nm intervals and emission wavelengths ranging from 250–500 nm at 1 nm intervals. Water samples with more than 10 mg C L^{-1} of DOC were diluted by adding C-free ultrapure water (Milli-Q water, Milli-Q Integral) to avoid inner filter effects on the fluorescence readings. In order to correct the EEM for instrument bias, the fluorescence intensity of the water sample was transformed to Raman units (RU) by subtracting the fluorescence intensity of Milli-Q water; this was then normalised using the area under the Milli-Q water Raman peak at an excitation wavelength of 350 nm (Fellman et al. 2008).

PARAFAC was conducted using MATLAB software (version 8.0; MathWorks 2012), using the N-way toolbox (Stedmon et al. 2003). For PARAFAC modelling, we used excitation and emission wavelengths of a dataset of 144 EEMs at 260–400 nm and 250–500 nm, respectively.

The dry mass of total suspended sediments (SS, mg) was determined by changes in the filter dry mass before and after filtration. SS concentrations (mg L^{-1}) were then estimated by dividing the dry mass of SS by the filtering water volume. The dry mass of the glass filter was calculated after drying at 80 °C for 24 hours, followed by subsequent weighing. The total C content of SS (i.e. POC) was determined using an organic elemental analyser (model FLASH 2000, Thermo Fisher Scientific), coupled with a continuous-flow isotope ratio mass spectrometer (model DELTA V, Thermo Fisher Scientific). Since C contents in some SS samples were lower than the detection limits (*ca* 5 μg in C), we omitted these samples from the POC dataset.

12.2.3 Statistical Analysis

Pearson's correlation coefficients were used to examine correlations between measurements. We used the Kruskal-Wallis test followed by the Steel-Dwass post hoc test to compare measured parameters across land-use classes. Correlations and differences were assumed to be significant when the p value was less than 0.05. Data analysis was performed using the statistical software R (version 3.0.3; R Development Core Team 2013).

12.3 Results and Discussion

12.3.1 Spatial Variations in DOC and SS Concentrations

The range of DOC and SS concentrations across the three sampling years are as shown in Table 12.1.

There were large variations in DOC and SS concentrations in both rivers and the spatial patterns also differed between the two rivers (Figs. 12.2 and 12.3). An inter-year comparison (2011 versus 2012) of DOC and SS concentrations at selected sampling points showed that DOC correlated strongly and positively between years ($p < 0.01$) with a close to 1:1 line; however, there was no similar relationship for SS (Fig. 12.4). This result suggests that DOC concentrations are temporally stable and depend on geographical factors such as topography and land-use distribution, while episodic events like periods of heavy rainfall and soil disturbances along the river bank cause high variations in SS concentration.

We then analysed the average DOC and SS concentration values in river tributaries that drain five dominant land-use classes and in main rivers (Fig. 12.5). River waters that drain from peatland zones had the highest DOC concentrations (Fig. 12.5a). DOC was slightly higher in oil palm plantations than in acacia plantations and logged forests though these differences were not significant. Acacia and oil palm plantations had significantly higher concentrations of riverine DOC than natural forests. This indicates that DOC concentrations largely depend on the distribution of peatlands within the river basin and may be less affected by land-use change.

SS concentrations were highest in the main rivers (Fig. 12.5b). They were also significantly higher in river tributaries that drained acacia and oil palm plantations

Table 12.1 Dissolved organic carbon and suspended sediment concentrations across the three sampling years for the Kemena and Tatau rivers

	DOC concentration (mg C L^{-1})			SS concentration (mg L^{-1})		
River	2011	2012	2013	2011	2012	2013
Kemena River	1.87–35.6	2.33–46.4	0.85–10.6	0.41–109.6	2.16–660.7	1.21–48.0
Tatau River	0.93–8.97	1.46–9.00	1.29–4.97	1.05–161.4	0.88–71.5	1.89–50.6

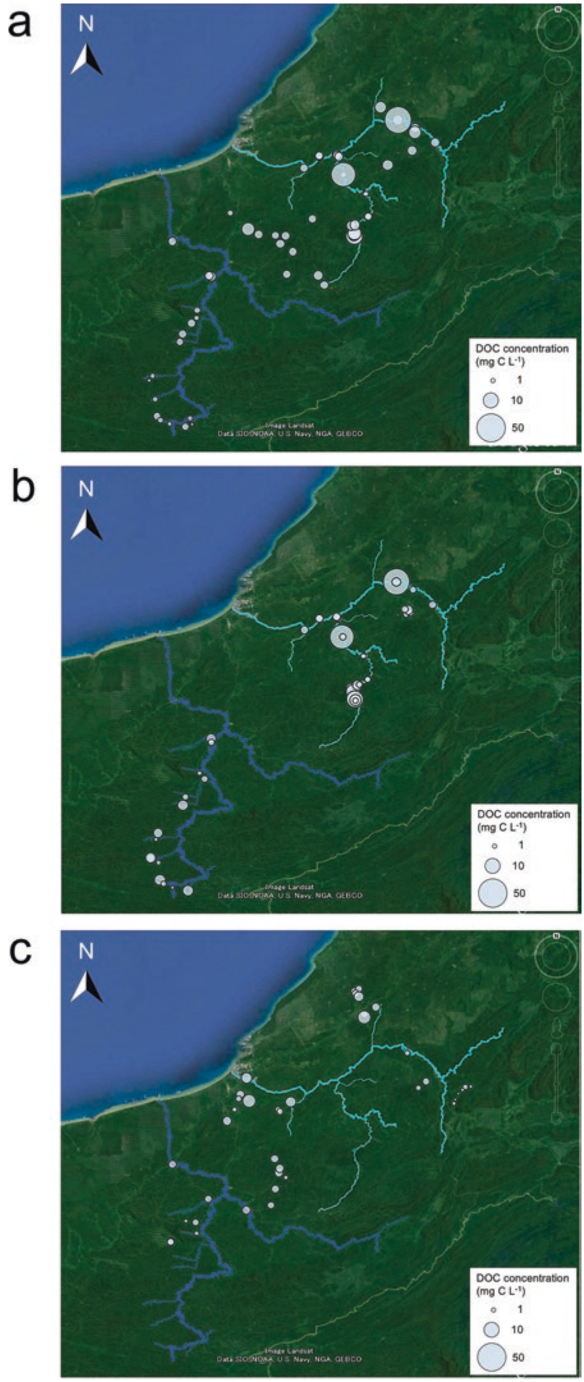


Fig. 12.2 Spatial distribution of dissolved organic carbon concentrations in (**a**) 2011; (**b**) 2012; and (**c**) 2013
Source: Google Earth, Image Landsat Data SIO. NOAA, US Navy, NGA, GEBCO, captured in **(a)** 2011; **(b)** 2012; and **(c)** 2013
Note: Bubble sizes are proportional to concentrations

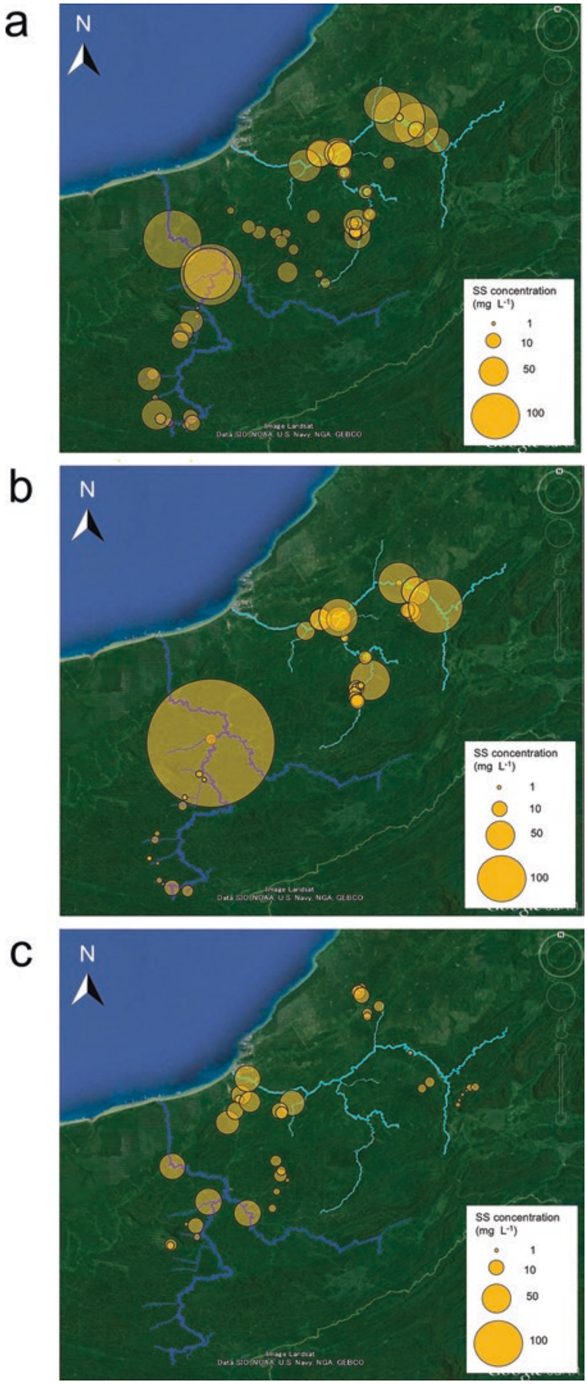


Fig. 12.3 Spatial distribution of suspended sediment concentrations in (**a**) 2011, (**b**) 2012, and (**c**) 2013
Source: Google Earth, Image Landsat Data SIO. NOAA, US Navy, NGA, GEBCO, captured in **(a)** 2011; **(b)** 2012; and **(c)** 2013
Note: Bubble sizes are proportional to concentrations

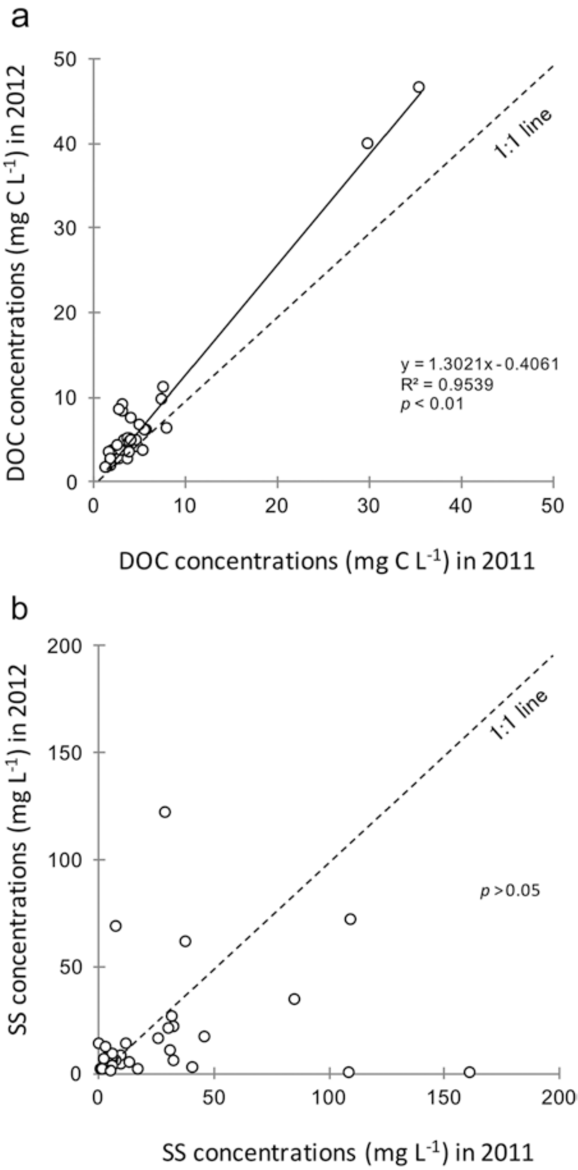


Fig. 12.4 Year-to-year comparison of (**a**) dissolved organic carbon and (**b**) suspended sediment concentrations

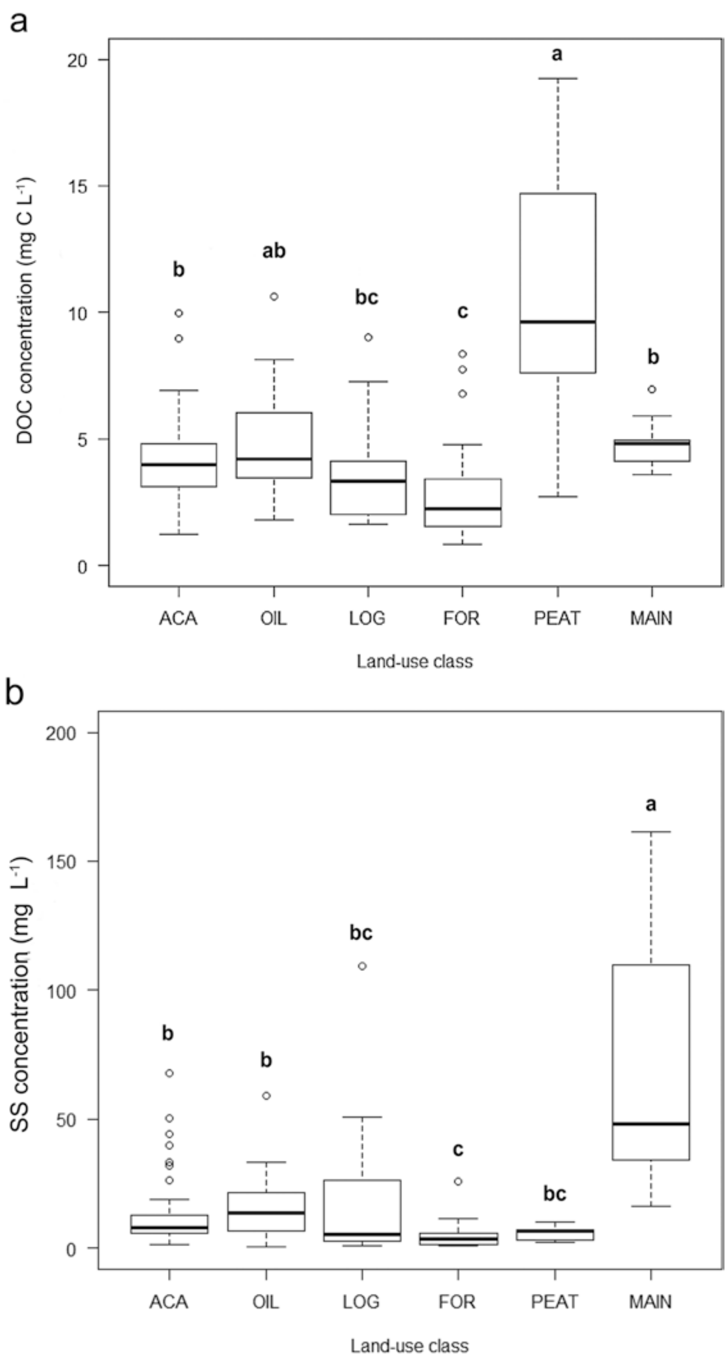


Fig. 12.5 Boxplot of (**a**) dissolved organic carbon and (**b**) suspended sediment concentrations for five land-use classes and main rivers
Note: Boxplots annotated with different letters (a, b, and c) indicate groups that are significantly different as determined using the Kruskal-Wallis and Steel-Dwass post hoc tests ($p < 0.05$)
Note: *ACA* acacia plantation, *OIL* oil palm plantation, *LOG* logged forest, *FOR* native and mature secondary forest, *PEAT* tropical lowland peatland, *MAIN* main river

than in those that drained natural forests. The concentration of riverine SS in logged forests was slightly higher than in natural forests but the difference was not significant. Land surface disturbances resulting from logging and the subsequent creation of acacia and oil palm plantations can increase surface soil loss from riparian areas and river banks, especially during heavy rainfall (Carlson et al. 2014). The major sources of SS in main rivers could possibly be from eroded river banks and uplifted sediments from river beds. Unfortunately, these sources of SS could not be accurately identified or confirmed from our dataset and additional research is therefore required.

12.3.2 Relationship Between SS and POC Concentrations

There was a linear relationship between SS and POC, indicating that organic C concentrations in SS were similar at all sampling points, except in forested small headwater catchment streams (Fig. 12.6). C content in SS ranged from 0.46–1.89% with two exceptions (5.28% and 14.5%) where C-rich organic matter (such as

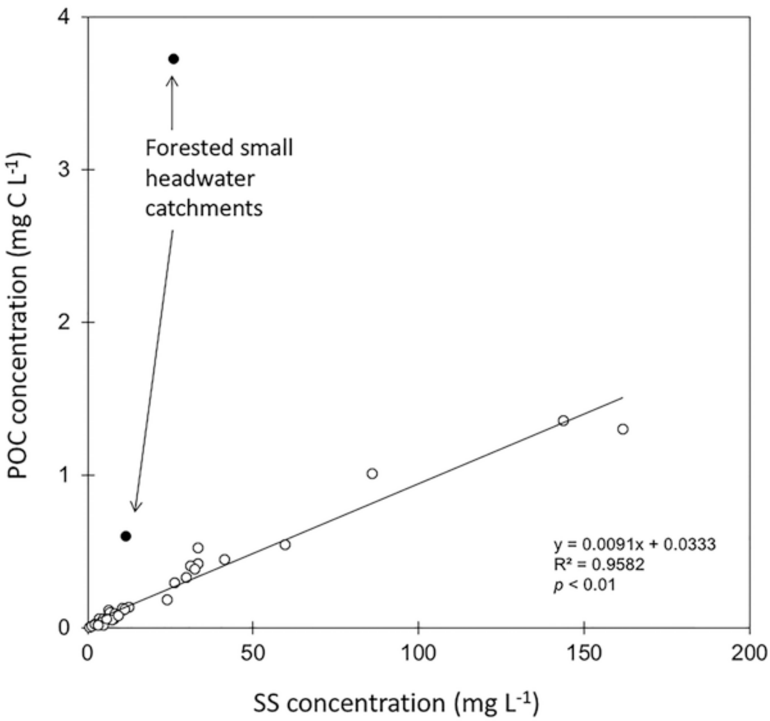


Fig. 12.6 Relationship between particulate organic carbon and suspended sediment concentrations across the range of measured samples

fragmented leaf litter or fresh foliage) provided a much greater and direct input of carbon. This result indicates that spatial variations in POC concentrations were almost similar to those of SS in this study. This further suggests that a possible source of POC is soil organic matter transported by surface soil loss and/or bank erosion, together with phytoplankton-derived organic matter. Further research is necessary to determine the sources of carbon in riverine POC by measuring other qualitative indices, such as the stable C isotope ratios of SS.

12.3.3 Fluorescence Characteristics of DOM

Four fluorescence components were identified by PARAFAC modelling. Excitation (Ex.) and emission (Em.) pairs of the main peak positions are shown in Table 12.2. Components were separated into one terrestrial fulvic acid-like component (component 1), two terrestrial humic acid-like components (components 2 and 3) and one tryptophan-like component (component 4). Assignment of fluorescence components was determined according to Paula Coble (1996), Khan M.G. Mostofa et al. (2013) and Tsutomu Ohno and Rasmus Bro (2006). The fulvic acid-like component 1 was dominant in river water DOM for all land-use classes. This component was also found in the Judan River, which is located about 90 km west of the Tatau River (Maie et al. 2014). All components correlated significantly with DOC concentrations (Fig. 12.7).

In order to evaluate DOC characteristics of each land-use class, we calculated the relative contribution of the four components from the rivers draining the five land-use classes and from main rivers (Fig. 12.8). The results highlight the contrasting fluorescence characteristics of DOC in river tributaries that drained from peatlands and those that drained from natural or secondary forests. The larger contribution of terrestrial humic acids (component 2) found in peatlands indicates that the source of this component may in part be decomposed organic material, with peatlands accumulating a large amount of old plant matter and leaf litter in the soil (Gandois et al. 2013). Moreover, the contribution of tryptophan-like substances (component 4) was less in peatlands than in forests. In some of the river waters that drained from peatland, the pH value was less than 4.5 (Fig. 12.9); at this pH level, the intensity of tryptophan-like fluorescence can be decreased by as much as 15% (Reynolds 2003).

Table 12.2 Results of EEM-PARAFAC and possible assignment of the components

Component	Excitation maximum (nm)	Emission maximum (nm)	Tentative source assignment
1	<260	468	Terrestrial fulvic acids
2	365	478	Terrestrial humic acids
3	<260, 330	417	Terrestrial humic acids; autochthonous fulvic acids
4	275	382	Tryptophan-like autochthonous

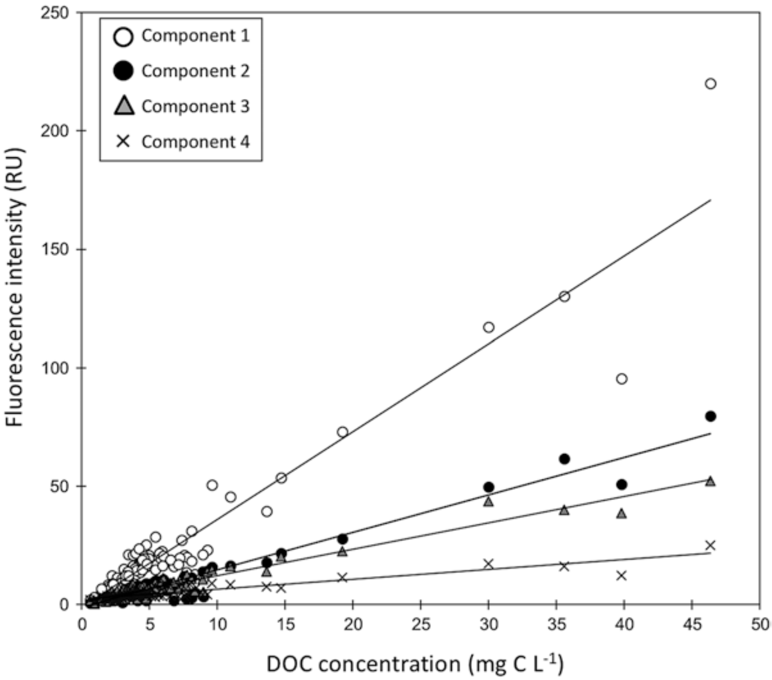


Fig. 12.7 Relationship between relative fluorescence intensity (determined by PARAFAC modelling) and dissolved organic carbon concentrations

However, even allowing for quenching of this fluorescence under acidic conditions, sufficiently low contributions of tryptophan-like substances—which are relatively more decomposable than fulvic- and humic-acid-like materials (Fellman et al. 2008) and are derived from algae, phytoplankton and/or soil microbes—indicate that more complex and recalcitrant DOC can be supplied from peatlands than from natural or mature secondary forests. In addition, no clear effects of anthropogenic land uses (including of acacia and oil palm plantations) on DOM characteristics were observed. This result suggests that the specific fluorescence component may not become prominent and different types of DOM having different fluorescence characteristics identified by PARAFAC may not emerge due to intensive plantation creation.

12.4 Concluding Remarks

This study reveals that DOC concentrations and DOM fluorescence characteristics are geographically controlled by the distribution of peatland and are likely largely unaffected by human activities. On the other hand, SS concentrations (and POC by extension) varied both temporally and spatially. This is possibly due to other factors,

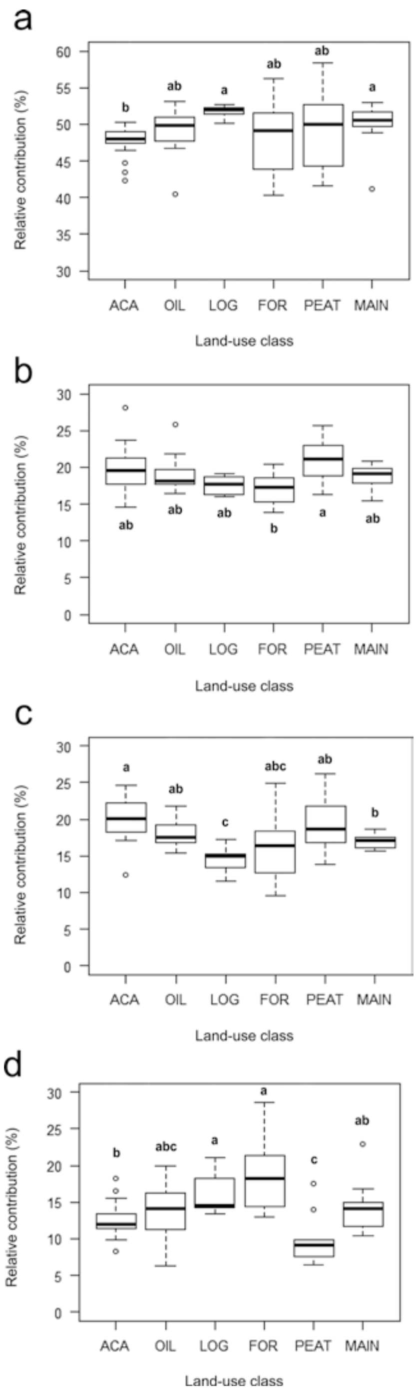


Fig. 12.8 Boxplot of the relative contribution of fluorescence intensity of (**a**) component 1; (**b**) component 2; (**c**) component 3; and (**d**) component 4 to the sum of all four intensities for five land-use classes and main rivers

Note: Boxplots annotated with different letters (**a**, **b**, and **c**) indicate groups that are significantly different as determined using the Kruskal-Wallis and Steel-Dwass post hoc tests ($p < 0.05$)

Note: *ACA* acacia plantation, *OIL* oil palm plantation, *LOG* logged forest, *FOR* native and mature secondary forest, *PEAT* tropical lowland peatland, *MAIN* main river

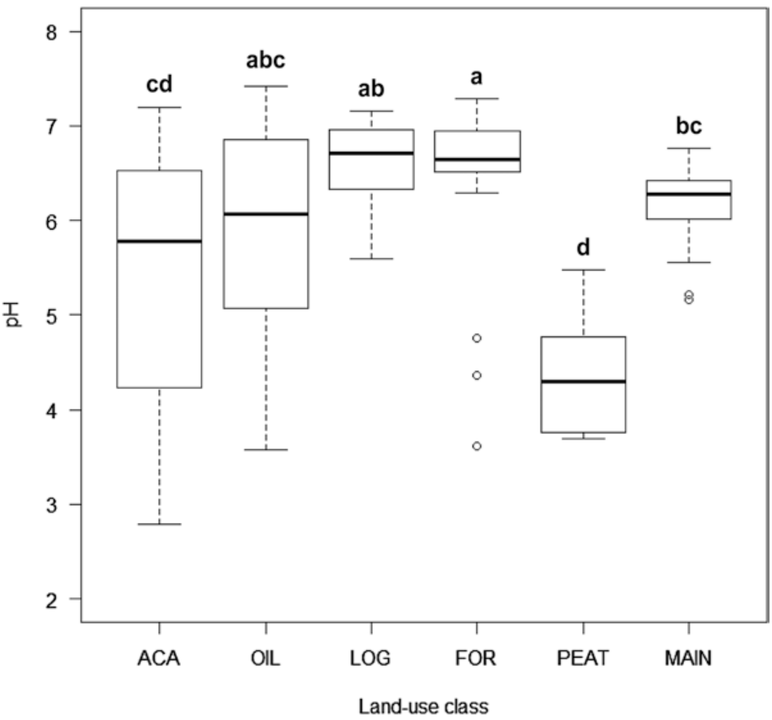


Fig. 12.9 Boxplot of pH values for the five land-use classes and main rivers
Note: Boxplots annotated with different letters (**a**, **b**, **c**, **d**) indicate groups that are significantly different as determined using the Kruskal-Wallis and Steel-Dwass post hoc tests ($p < 0.05$)
Note: *ACA*: acacia plantation; *OIL*: oil palm plantation; *LOG*: logged forest; *FOR*: native and mature secondary forest; *PEAT*: tropical lowland peatland; *MAIN*: main river

such as river bank erosion driven by hydrological events and/or surface soil disturbances caused by land-use change. The intensive creation of acacia and oil palm plantations and resultant surface soil disturbances can cause an increase in terrestrial SS and POC discharges to the ocean due to soil loss and bank erosion. Conservation of riparian forest can mitigate the influences of intensive plantation creation on riverine C effluxes as POC forms, resulting not only in conservation of aquatic fauna but also in the prevention of increased C emissions in aquatic systems. Further monitoring of SS concentrations should be carried out to ensure that the riverine systems can still support the natural aquatic fauna of the region.

Acknowledgements We wish to acknowledge Wong Ing Yung, John Tasan and Tie Siew Teck of Zedtee Sdn Bhd, Joanes Unggang and Belden Gilman Neilson of Grand Perfect Sdn Bhd, Abdul Aziz Bin Zainal Abidin, Keresa Plantations Sdn Bhd, Logie Sema and many other local people for their assistance with our field survey and sample collection. We also thank Dr Naoko Matsuo and Wataru Hidaka for their assistance with the chemical analysis performed.

References

Aiken, George R., Heileen Hsu-Kim, and Joseph N. Ryan. 2011. Influence of dissolved organic matter on the environmental fate of metals, nanoparticles, and colloids. *Environmental Science & Technology* 45 (8): 3196–3201.

Carlson, Kimberly M., Lisa M. Curran, Gregory P. Asner, Alice McDonald Pittman, Simon N. Trigg, and J. Marion Adeney. 2013. Carbon emissions from forest conversion by Kalimantan oil palm plantations. *Nature Climate Change* 3: 283–287.

Carlson, Kimberly M., Lisa M. Curran, Alexandra G. Ponette-González, Dessy Ratnasari, Neli Lisnawati Ruspita, Yadi Purwanto, Kate A. Brauman, and Peter A. Raymond. 2014. Influence of watershed-climate interactions on stream temperature, sediment yield, and metabolism along a land use intensity gradient in Indonesian Borneo. *Journal of Geophysical Research – Biogeosciences* 119 (6): 1110–1128.

Ciais, Philippe, Christopher Sabine, Govindasamy Bala, Laurent Bopp, Victor Brovkin, Josep Canadell, Abha Chhabra, Ruth DeFries, James Galloway, Martin Heimann, Christopher Jones, Corrine Le Quéré, Ranga B. Myneni, Shilong Piao, and Peter Thornton. 2013. Carbon and other biogeochemical cycles. In *Climate change 2013: The physical science basis. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*, ed. Thomas F. Stocker, Dahe Qin, Gian-Kasper Plattner, Melinda Tignor, Simon K. Allen, Judith Boschung, Alexander Nauels, Yu Xia, Vincent Bex, and Pauline M. Midgley, 465–570. Cambridge: Cambridge University Press.

Cloern, James E. 1987. Turbidity as a control on phytoplankton biomass and productivity in estuaries. *Continental Shelf Research* 7 (11–12): 1367–1381.

Coble, Paula G. 1996. Characterisation of marine and terrestrial DOM in seawater using excitation-emission matrix spectroscopy. *Marine Chemistry* 51 (4): 325–346.

Fellman, Jason B., David V. D'Amore, Eran Hood, and Richard D. Boone. 2008. Fluorescence characteristics and biodegradability of dissolved organic matter in forest and wetland soils from coastal temperate watersheds in Southeast Alaska. *Biogeochemistry* 88 (2): 169–184.

Fonte, Ellen S., Luciana S. Carneiro, Adriano Caliman, Reinaldo L. Bozelli, Francisco De A. Esteves, and Vinicius F. Farjalla. 2011. Effects of resources and food web structure on bacterioplankton production in a tropical humic lagoon. *Journal of Plankton Research* 33 (10): 1596–1605.

Gandois, Laure, Alexander R. Cobb, Chieng Hei Ing, Linda Lim Biaw Leng, Kamariah Abu Salim, and Charles F. Harvey. 2013. Impact of deforestation on solid and dissolved organic matter characteristics of tropical peat forests: implications for carbon release. *Biogeochemistry* 114 (1–3): 183–199.

Hossler, Katie, and James E. Bauer. 2013. Amounts, isotopic character, and ages of organic and inorganic carbon exported from rivers to ocean margins: 1. Estimates of terrestrial losses and inputs to the Middle Atlantic Bight. *Global Biogeochemical Cycles* 27: 1–16.

Hooijer, Aljosja, Susan Page, J.G. Canadell, Marcel Silvius, Jaap Kwadijk, H. Wösten, and Jyrki Jauhiainen. 2010. Current and future CO_2 emissions from drained peatlands in Southeast Asia. *Biogeosciences* 7: 1505–1514.

Hudson, Naomi, Andy Baker, and Darren Michael Reynolds. 2007. Fluorescence analysis of dissolved organic matter in natural, waste and polluted waters—A review. *River Research and Applications* 23 (6): 631–649.

Langner, Andreas, Frédéric Achard, Christelle Vancutsem, Jean-Francois Pekel, Dario Simonetti, Giacomo Grassi, Kanehiro Kitayama, and Mikiyasu Nakayama. 2015. Assessment of above-ground biomass of Borneo forests through a new data-fusion approach combining two pan-tropical biomass maps. *Land* 4 (3): 656–669.

Maie, Nagamitsu, Satoshi Sekiguchi, Akira Watanabe, Kiyoshi Tsutsuki, Youhei Yamashita, Lulie Melling, Kaelin M. Cawley, Eikichi Shima, and Rudolf Jaffé. 2014. Dissolved organic matter dynamics in the oligo/meso-haline zone of wetland-influenced coastal rivers. *Journal of Sea Research* 91: 58–69.

MathWorks. 2012. *MATLAB: The language of technical computing*. Natick: The MathWorks Inc.

Meybeck, Michel. 1982. Carbon, nitrogen, and phosphorus transport by world rivers. *American Journal of Science* 282: 401–450.

Mostofa, Khan M.G., Cong-Qiang Liu, Takahito Yoshioka, Davide Vione, Yunlin Zhang, and Hiroshi Sakugawa. 2013. Fluorescent dissolved organic matter in natural waters. In *Photobiogeochemistry of organic matter*, ed. Khan M.G. Mostofa, Takahito Yoshioka, Abdul Mottaleb, and Davide Vione, 429–560. Berlin: Springer.

Ohno, Tsutomu, and Rasmus Bro. 2006. Dissolved organic matter characterisation using multiway spectral decomposition of fluorescence landscapes. *Soil Science Society of America Journal* 70 (6): 2028–2037.

Page, Susan E., John O. Rieley, and Christopher J. Banks. 2011. Global and regional importance of the tropical peatland carbon pool. *Global Change Biology* 17 (2): 798–818.

Pusch, Martin, Douglas M. Fiebig, Ingrid Brettar, Heinrich Eisenmann, Bonnie K. Ellis, Louis A. Kaplan, Maurice A. Lock, Markus W. Naegeli, and Walter Traunspurger. 1998. The role of micro-organisms in the ecological connectivity of running waters. *Freshwater Biology* 40 (3): 453–495.

R Development Core Team. 2013. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Reynolds, Darren Michael. 2003. Rapid and direct determination of tryptophan in water using synchronous fluorescence spectroscopy. *Water Research* 37 (13): 3055–3060.

Richey, Jeffrey E., John I. Hedges, Allan H. Devol, Paul D. Quay, Reynaldo Victoria, Luiz Martinelli, and Bruce R. Forsberg. 1990. Biogeochemistry of carbon in the Amazon River. *Limnology and Oceanography* 35 (2): 352–371.

SADIA, Aidenvironment, and Earthsight Investigations. 2015. Sarawak oil palm concessions. Global Forest Watch. http://data.globalforestwatch.org/datasets/ff96c17423404ac6951ad77c-8cf3f743_7. Accessed 19 July 2018.

Stedmon, Colin A., Stiig Markager, and Rasmus Bro. 2003. Tracing dissolved organic matter in aquatic environments using a new approach to fluorescence spectroscopy. *Marine Chemistry* 82 (3–4): 239–254.

Schlünz, Birger, and Ralph R. Schneider. 2000. Transport of terrestrial organic carbon to the oceans by rivers: Re-estimating flux- and burial rates. *International Journal of Earth Sciences* 88 (4): 599–606.

Yamashita, Youhei, Rudolf Jaffé, Nagamitsu Maie, and Eiichiro Tanoue. 2008. Assessing the dynamics of dissolved organic matter (DOM) in coastal environments by excitation emission matrix fluorescence and parallel factor analysis (EEM-PARAFAC). *Limnology and Oceanography* 53 (5): 1900–1908.

Chapter 13
Stream Fish Biodiversity and the Effects of Plantations in the Bintulu Region, Sarawak

Yuichi Kano, Jason Hon, Mohd Khairulazman Sulaiman, Mitsuhiro Aizu, Koji Noshita, and Hiromitsu Samejima

Abstract The biodiversity of stream-dwelling fish and the effects of oil palm and acacia plantations on this biodiversity were evaluated by field research conducted in the Bintulu region of central Sarawak, Malaysia. A quantitative survey was conducted at 61 locations by electrofishing. These 61 locations included 16 sites in oil palm plantations, five sites in acacia plantations, four sites in local community-protected forests (called *pulau* or *pulau galau* by local communities) and 36 sites in natural forests. The protected forests had the highest species richness (average ± standard deviation: 9.3 ± 2.6) followed by natural forests (7.4 ± 3.1). The species richness of oil palm (3.3 ± 1.9) and acacia (4.0 ± 1.9) plantations was approximately half that of protected and secondary forests. Cluster analysis suggests that the fish fauna was largely divided into two main groups: the plantation group and the forest group. Statistical analysis by a generalised linear model also

Y. Kano (✉)
Institute of Decision Science for a Sustainable Society, Kyushu University, Fukuoka, Japan
e-mail: kano@species.jp

J. Hon
WWF-Malaysia, Sarawak Programme, Kuching, Sarawak, Malaysia
e-mail: hjason@wwf.org.my

Mohd Khairulazman Sulaiman
Sarawak Conservation Programme, WWF-Malaysia, Selangor, Malaysia

M. Aizu
Research Institute of Environment for Sustainability, Faculty of Engineering, Kyushu University, Fukuoka, Japan

K. Noshita
Graduate School of Agricultural and Life Sciences, University of Tokyo, Tokyo, Japan
e-mail: noshita@morphometrics.jp

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_13

suggests that plantations have a negative impact on fish diversity as species richness, the number of individuals and Shannon's diversity index were all negatively affected by both oil palm and acacia plantations. The models included topographical parameters, such as slope and altitude, but the effect of plantations was much stronger than the effects of these parameters, indicating that there was no spurious relationship between plantations and fish communities. In this chapter, we evaluate the negative effect of plantations on fish biodiversity. The mechanisms by which plantations affect fish biodiversity need to be investigated in the future.

Keywords Sarawak · Biodiversity · Freshwater fish · Land use · Plantations · Species richness

13.1 Introduction

Globally, freshwater fish are among the most endangered organisms. On average the abundance of populations monitored in freshwater systems has declined by 81% between 1970 and 2012 (Ormerod et al. 2010; Strayer and Dudgeon 2010; WWF 2016). The effects of human activities in watersheds can accumulate in fish habitats, such as rivers and lakes, through water pollution (de Almeida and de Oliveira Ribeiro 2016), silt discharge (Erman and Ligon 1988) and damming (Ziv et al. 2012; Kano et al. 2016). In addition, alien fishes sometimes negatively affect native fish populations (Leprieur et al. 2008). Overfishing is also a threat to freshwater fishes (Allan et al. 2005).

The types of land use and land cover often affect the distribution and abundance of local fish communities (Strayer et al. 2003; Weijters et al. 2008). Plantations in tropical regions are often considered to be a significant environmental issue because of their considerable impacts on local ecosystems (Evans 1992; Malmer 1996). In particular, the expansion of oil palm plantations is perceived to be a significant threat to tropical biodiversity (Fitzherbert et al. 2008; Koh and Wilcove 2009; Turner et al. 2011).

Borneo is the third largest island in the world and is famous for its high biodiversity and endemism. Information about the taxonomy and distribution of Bornean freshwater fishes has occasionally been reported (Roberts 1989; Inger and Chin 2002; Parenti and Lim 2005; Tan 2006; Atack 2006; Tan and Lim 2007; Kottelat 2013). These reports indicate the endemism of Bornean fish and suggest the past biological continuity of Sundaland during the last ice age. Relatively little information is available about the ichthyofauna of the Bintulu region in central Sarawak (Parenti and Lim 2005) in comparison with other areas of Borneo, such as Sabah (Inger and Chin 1990; Lim and Wong 1994; Martin-Smith 1998), eastern Sarawak (Iwata et al. 2003; Atack 2006), West Kalimantan (Roberts 1989), East Kalimantan (Christensen 1992) and Brunei (Choy and Chin 1994; Parenti and Meisner 2003). Studies of Bornean fish have mainly focused on the description of endemic species, records of new species and taxonomical data. Ecological information about Bornean freshwater fish is still quite sparse and relatively little is known about the impact of plantations on freshwater fishes.

In this chapter, we complement existing information about Bornean freshwater fishes around the Bintulu region in order to further the understanding of Asian freshwater fish distributions and to aid their conservation. The main purpose of this research was to evaluate the effect of plantations on freshwater fish biodiversity.

13.2 Methods

13.2.1 Fish Collection

We collected fishes from 61 locations around the Bintulu area (Fig. 13.1) from August 2013 to June 2014. The sites included 16 locations in oil palm plantations, five locations in acacia plantations, four locations in locally protected forests (called *pulau* or *pulau galau* by local people) and 36 locations in natural forests. An example of the typical landscapes and environmental conditions for these different sampling locations can be seen in Fig. 13.2. Fishes were collected by electrofishing for approximately 20 minutes, which allowed us to collect almost all of the species present at each site for quantitative analysis. The images of the individual fish were taken after applying anaesthetic according to the procedure used by Yuichi Kano and Jun Nakajima (2014). Fishes were identified according to various sources, including Roberts (1989), Kottelat and Lim (1995), Lim (1995), Inger and Chin (2002), Atack (2006), Tan (2006), Tan and Lim (2007), Kottelat and Tan (2011),

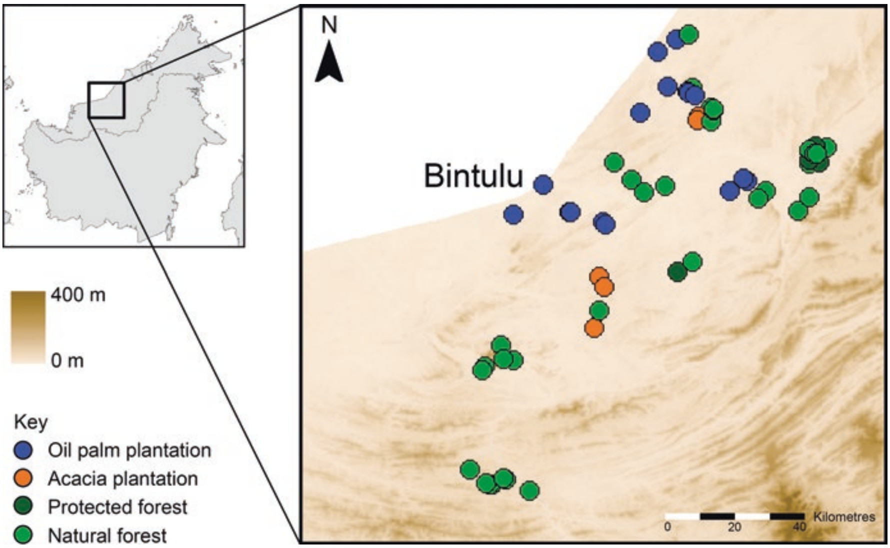


Fig. 13.1 Study area with sampling locations in plantations and forests

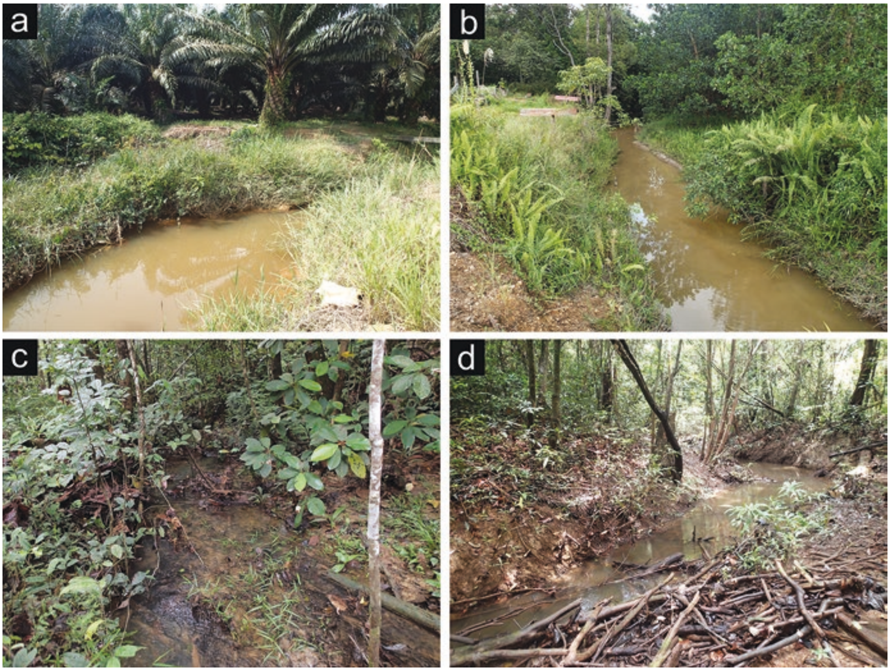


Fig. 13.2 Typical landscapes and environmental conditions for different sampling locations: (**a**) oil palm plantations; (**b**) acacia plantations; (**c**) protected forests; and (**d**) natural forests. (Photographs: Yuichi Kano 2013)

Kottelat (2013), Ng and Kottelat (2013) and Ng and Kottelat (2016). Voucher specimens were deposited in the Molecular Aquatic Laboratory, Universiti Malaysia Sarawak (UNIMAS).

13.2.2 Data Analysis

In this research, the impact of different land uses on fish assemblages in the Bintulu area were analysed using analysis of variance (ANOVA) with multiple comparisons among groups, cluster analysis and generalised linear models (GLM) analysis. A p value of less than 0.05 was considered statistically significant. The analysis was conducted using the statistical software R (version 2.15; R Development Core Team 2013).

ANOVA was conducted using the 'aov' (analysis of variance) command in R and the species richness at each site was compared between four land-use types: oil palm plantation, acacia plantation, protected forest and natural forest. Multiple comparisons were conducted using the Holm method and the 'pairwise.t.test' (pairwise t test) function in R.

A cluster analysis was conducted using absence (0) and presence (1) data for each species at each sampling location. The analysis was conducted using the 'pvclust' (hierarchical clustering with *p* values) function in R with Euclidean distance, Ward's method and a 10,000 bootstrap.

GLMs were used to analyse three dependent variables—species richness, number of individuals and Shannon's diversity index—to relate with the environmental variables: land use, land slope, altitude, watershed area and distance from the sea. The land use was classified into two dummy variables—'plantation' for oil palm and acacia plantations: 1, and 'forest' for protected and natural forests: 0—because the number of sampling sites from protected forest and acacia plantation sites was insufficient for examining the discrimination between all four land-use types. Using the geographic information systems (GIS) software ArcGIS (version 10.1; ESRI 2012), the data for altitude, watershed area, distance from the sea and land slope were determined from a digital elevation model with a mesh of 100 m. Species richness was analysed using the 'glm' (generalised linear model, GLM) function in R with Poisson distribution. For the number of individuals, GLM analysis was conducted using the 'glm.nb' (negative binomial GLM) function in R with negative binomial distribution. Shannon's diversity index was analysed using the 'glm' (generalised linear model, GLM) function in R with Gaussian distribution. In each analysis, Akaike information criterion (AIC; Akaike 1974) was used for model selection and the model with the lowest AIC was defined as the best model.

GLM analysis was also conducted at the species level to determine which species are more sensitive to plantations. For the 18 species that were caught at more than six locations, the relationship between the number of individuals of each species and the five environmental variables described above was analysed using GLMs. The analyses were generally conducted using the 'glm' function in R with Poisson distribution. However, several species (*Rasbora* sp. [cf. *atranus*], *Nemacheilus spiniferus* and *Channa lucius*) were never recorded in any of the plantation sampling sites, causing a statistical 'separation' issue; therefore, the 'brglm' (bias reduction in binomial-response GLM) function was used to reduce the resulting bias. Moreover, for *Rasbora hosii*, we used the 'glm.nb' (negative binomial GLM) function with negative binomial distribution because of overdispersion. Finally, the model with the lowest AIC was selected as the best model.

13.3 Results

13.3.1 Fish Collection and Species List

We collected a total of 82 fish species that comprised eight orders, 25 families and 55 genera (Table 13.1), while four species could not be clearly identified: *Osteochilus* sp. (cf. *enneaporos*), *Rasbora* sp. (cf. *atranus*), *Clarias* sp. (cf. *batrachus*) and *Pseudomystus* sp. In total, 36 species were collected from the oil palm and acacia

Table 13.1 Number of sampling locations and the number of individuals of each fish species found in forest and plantation environments

ID number	Species	Plantations (21 locations)		Forests (40 locations)	
		Number of locations	Number of individuals	Number of locations	Number of individuals
	Order: Cypriniformes				
	Family: Cyprinidae				
1	*Barbodes kuchingensis*	2	3	4	4
2	*Barbodes banksi*	4	16	14	37
3	*Barbonymus schwanenfeldii*	1	1	7	12
4	*Cyclocheilichthys apogon*	2	12	10	24
5	*Desmopuntius johorensis*	2	5	5	24
6	*Esomus metallicus*[a]	0	0	1	18
7	*Garra borneensis*	0	0	1	1
8	*Hampala bimaculata*	0	0	7	9
9	*Hampala macrolepidota*	1	2	6	8
10	*Labiobarbus leptocheilus*	0	0	1	1
11	*Leptobarbus hosii*	0	0	3	7
12	*Lobocheilos bo*	0	0	2	5
13	*Nematabramis steindachnerii*	2	9	10	86
14	*Osteochilus* sp. (cf. *enneaporos*)	0	0	3	5
15	*Osteochilus microcephalus*	3	8	17	49
16	*Osteochilus vittatus*	0	0	5	9
17	*Oxygaster anomalura*	2	4	1	2
18	*Rasbora* sp. (cf. *atranus*)	0	0	8	31
19	*Rasbora cephalotaenia*	2	6	2	6
20	*Rasbora dusonensis*	2	5	11	47
21	*Rasbora einthovenii*	0	0	3	9
22	*Rasbora ennealepis*	2	13	7	20
23	*Rasbora hosii*	9	40	24	182
24	*Rasbora kottelati*	0	0	1	1
25	*Rasbora tornieri*	0	0	2	4
26	*Rasbora trilineata*	0	0	3	13
27	*Tor douronensis*	0	0	4	20
28	*Trigonopoma pauciperforatum*	0	0	1	10

(continued)

Table 13.1 (continued)

ID number	Species	Plantations (21 locations)		Forests (40 locations)	
		Number of locations	Number of individuals	Number of locations	Number of individuals
	Family: Cobitidae				
29	*Pangio semicincta*	0	0	3	6
30	*Pangio shelfordii*	0	0	1	1
	Family: Barbuccidae				
31	*Barbucca diabolica*	0	0	1	1
	Family: Balitoridae				
32	*Homaloptera orthogoniata*	0	0	5	6
33	*Homalopteroides stephensoni*	1	1	3	11
34	*Homalopteroides tweediei*	1	1	8	17
	Family: Gastromyzontidae				
35	*Gastromyzon megalepis*	0	0	1	1
36	*Gastromyzon viriosus*	0	0	2	2
37	*Neogastromyzon chini*	0	0	1	2
	Family: Nemacheilidae				
38	*Nemacheilus spiniferus*	0	0	12	33
	Order: Siluriformes				
	Family: Sisoridae				
39	*Glyptothorax major*	0	0	2	2
40	*Glyptothorax exodon*	0	0	4	5
	Family: Siluridae				
41	*Kryptopterus cryptopterus*	0	0	1	27
42	*Kryptopterus limpok*	0	0	1	6
43	*Pterocryptis furnessi*	1	1	2	9
44	*Silurichthys marmoratus*	0	0	1	1
	Family: Clariidae				
45	*Clarias* sp. (cf. *batrachus*)	1	1	2	2
46	*Clarias leiacanthus*	1	1	2	2
47	*Clarias nieuhofii*	0	0	1	1
48	*Clarias planiceps*	0	0	2	7
	Family: Pangasiidae				
49	*Pseudolais micronemus*	0	0	1	1
	Family: Bagridae				
50	*Hemibagrus capitulum*	0	0	1	1
51	*Hemibagrus fortis*	0	0	5	5

(continued)

Table 13.1 (continued)

ID number	Species	Plantations (21 locations)		Forests (40 locations)	
		Number of locations	Number of individuals	Number of locations	Number of individuals
52	*Hemibagrus hoevenii*	0	0	1	3
53	*Leiocassis hosii*	0	0	1	1
54	*Pseudomystus* sp.[b]	0	0	1	8
	Order: Atheriniformes				
	Family: Phallostethidae				
55	*Phenacostethus smithi*	0	0	2	2
	Order: Beloniformes				
	Family: Zenarchopteridae				
56	*Dermogenys colletei*[c]	5	10	1	3
57	*Hemirhamphodon kuekenthali*	2	8	20	54
	Order: Syngnathiformes				
	Family: Syngnathidae				
58	*Doryichthys martensii*	1	1	0	0
	Order: Synbranchiformes				
	Family: Synbranchidae				
59	*Monopterus javanensis*	2	2	2	2
	Family: Mastacembelidae				
60	*Macrognathus circumcinctus*	0	0	1	1
61	*Macrognathus maculatus*	0	0	1	1
62	*Mastacembelus unicolor*	0	0	1	1
	Order: Perciformes				
	Family: Nandidae				
63	*Nandus nebulosus*	0	0	2	2
64	*Pristolepis fasciata*	1	1	2	2
	Family: Cichlidae				
65	*Oreochromis niloticus*[a]	2	3	0	0
	Family: Eleotrididae				
66	*Eleotris melanosoma*	0	0	2	3
67	*Oxyeleotris marmorata*	1	4	0	0

(continued)

Table 13.1 (continued)

ID number	Species	Plantations (21 locations) Number of locations	Number of individuals	Forests (40 locations) Number of locations	Number of individuals
68	*Oxyeleotris urophthalmus*	0	0	3	12
69	*Butis amboinensis*	1	1	0	0
	Family: Gobiidae				
70	*Eugnathogobius siamensis*	1	3	1	2
71	*Pseudogobiopsis oligactis*	1	4	5	7
72	*Stenogobius ingeri*	1	1	0	0
	Family: Anabantidae				
73	*Anabas testudineus*	1	1	2	4
	Family: Osphronemidae				
74	*Betta akarensis*	2	16	10	31
75	*Luciocephalus pulcher*	0	0	1	1
76	*Osphronemus goramy*	1	1	1	1
77	*Trichopodus pectoralis*	1	4	0	0
78	*Trichopodus trichopterus*	2	2	2	8
	Family: Channidae				
79	*Channa baramensis*	1	2	1	2
80	*Channa lucius*	0	0	9	13
81	*Channa striata*	8	13	6	29
	Order: Tetraodontiformes				
	Family: Tetraodontidae				
82	*Carinotetraodon lorteti*	0	0	1	1

[a]Alien species
[b]Might be an undescribed species
[c]May include D. brunei

plantations, while 79 species were collected from protected and natural forests (see Appendix 13.1 for the images of each species and the online database of freshwater fishes of mainland Southeast Asia available at http://ffish.asia/BintuluFish for any updated identification of species in this chapter) (Kano et al. 2013a).

Figure 13.3 shows the average species richness for each land-use type. Protected forests had the highest species richness (average ± standard deviation: 9.3 ± 2.6; min.–max.: 7–13), followed by natural forests (7.4 ± 3.1; 2–16). The species richness of oil palm plantations (3.3 ± 1.9; 1–8) and acacia plantations (4.0 ± 1.9; 0–8) was almost half that of protected and natural forests.

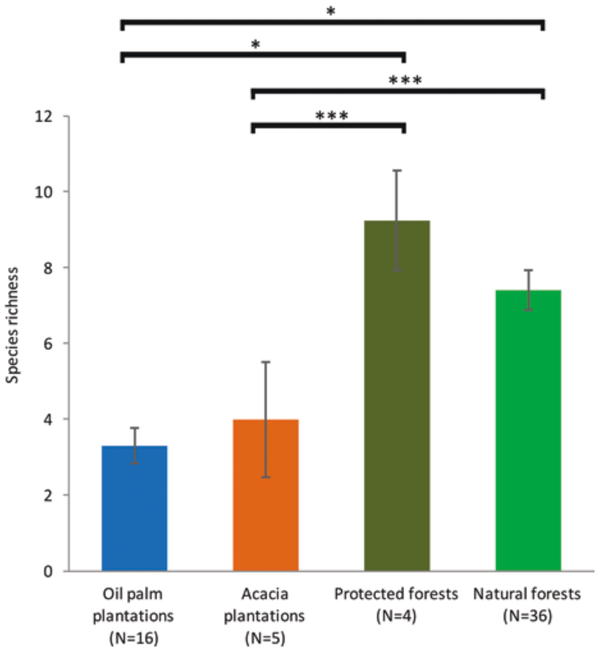


Fig. 13.3 Average species richness of stream fish in oil palm plantations, acacia plantations, protected forests and natural forests
Note: Error bars indicate standard errors while black bars and asterisks show significant differences between a pair of land uses by a multiple comparison conducted using the Holm method
Note: $*p < 0.05$, $***p < 0.001$

ANOVA results indicated that species richness was significantly different among land-use types. ($p < 0.0001$). Multiple comparison analysis indicated that there were differences between oil palm plantations and protected forests. ($p < 0.05$), oil palm plantations and natural forests. ($p < 0.05$), acacia plantations and protected forests. ($p < 0.001$), and acacia plantations and natural forests. ($p < 0.001$). We found no difference in species richness between protected and natural forests or between oil palm plantations and acacia plantations (Fig. 13.3).

13.3.2 Fish Fauna and Cluster Analysis

Figure 13.4 shows the results of cluster analysis. The cluster was largely divided into two groups: the left group contained 13 plantations (oil palm: 11; acacia: two) and seven forests (protected: one; natural: six), whereas the right group contained eight plantations (oil palm: five; acacia: three) and 33 forests (protected: three; natural: 30).

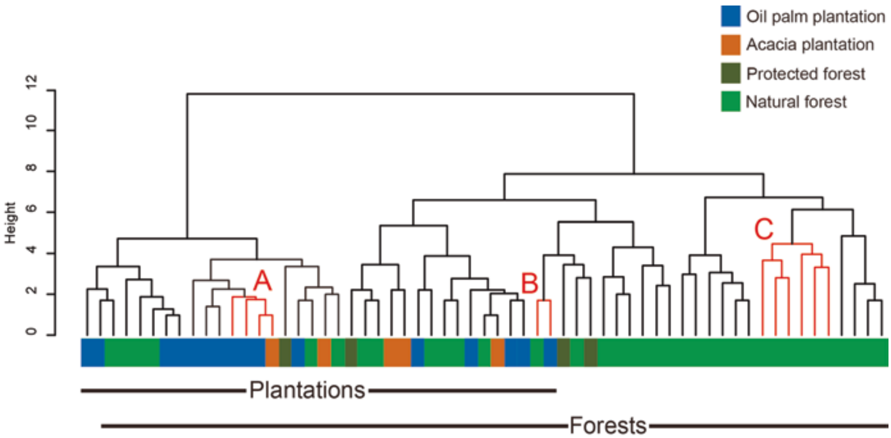


Fig. 13.4 Cluster analysis based on the absence and presence of fish species at sites classified by land-use type
Note: The red subclusters (*A*, *B* and *C*) were supported by an AU *p* value of greater than 0.95

Of several subclusters, subclusters A, B and C (red clusters in Fig. 13.4) were supported by high approximately unbiased (AU) *p* values, suggesting that the subclusters were stable. Sites in subcluster A had low species richness (average: 1.3) and tended to contain only *Oreochromis niloticus* or *Pristolepis fasciata*. Sites in subcluster B had high species richness (average: 8.5) and were distinguished from sites in other clusters by the presence of *Desmopuntius johorensis* and *Oxygaster anomalura*. Sites in subcluster C also had high species richness (average: 8.5) and representative species included *Barbonymus schwanenfeldii*, *Hampala macrolepidota*, *Osteochilus microcephalus*, *Leptobarbus hosii* and *Phenacostethus smithi*.

13.3.3 Environment and Fish Fauna

Species richness was generally correlated with land use (Table 13.2). The top 10 models all included a significant negative value from the effect of plantations. The effect of distance from the sea had a positive value on species richness and was associated with significant *p* values in eight of the top 10 models. Slope had a significant negative effect on species richness in six of the top 10 models. Watershed area and altitude were not included in the best model and the coefficients associated with these variables generally had non-significant *p* values.

The number of individuals at each site showed a similar trend to that of species richness (Table 13.3). The presence of a plantation had a significant negative effect towards the number of individuals in all of the top 10 models. Slope also had a negative effect on the number of individuals in seven models, although the coefficient associated with slope was not statistically significant in the fifth best model. Distance

Table 13.2 The best 10 generalised linear models (using Poisson distribution) as determined by AIC value for species richness and coefficients of each model

Ranking	AIC	Land use (plantation:1; forest:0)	Watershed area (km^2/1000)	Distance from the sea (km/100)	Altitude (km)	Slope (degree/10)
1	288.5	−0.61***		0.39***		−0.40*
2	289.0	−0.63***		0.28*	2.67ns	−0.53*
3	289.6	−0.60***	0.35 ns	0.38***		−0.44*
4	290.4	−0.62***	0.29 ns	0.28*	2.43ns	−0.55*
5	290.9	−0.58***		0.34***		
6	291.0	−0.75***			5.43***	−0.61**
7	292.3	−0.74***	0.31 ns		5.17**	−0.63**
8	292.7	−0.57***	0.17 ns	0.33**		
9	292.9	−0.58***		0.35**	−0.06ns	
10	294.6	−0.57***	0.18 ns	0.35**	−0.30ns	

ns not significant
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 13.3 The best 10 generalised linear models (using negative binomial distribution) as determined by AIC value for the number of individuals and coefficients of each model

Ranking	AIC	Land use (plantation:1; forest:0)	Watershed area (km^2/1000)	Distance from the sea (km/100)	Altitude (km)	Slope (degree/10)
1	467.5	−0.79***		0.43*		−0.72*
2	469.2	−0.80***	−0.32ns	0.44*		−0.70*
3	469.3	−0.81***		0.38ns	1.67ns	−0.82*
4	469.7	−0.96***			5.83ns	−1.02*
5	470.1	−1.02***				−0.62ns
6	470.1	−0.73**		0.36ns		
7	471.0	−0.72**		0.51*	−3.84ns	
8	471.1	−0.82***	−0.32ns	0.38ns	1.71ns	−0.81*
9	471.3	−0.93***				
10	471.6	−0.97***	−0.29ns		5.93ns	−1.01*

ns not significant
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

from the sea had a positive effect on the number of individuals, as it was included in six models and was significant in three models. Watershed area and altitude were included in some models, but did not have significant *p* values.

In all models, plantations were negatively associated with Shannon's diversity index (Table 13.4). Altitude was included in the best model, but the *p* value for this variable is not significant. Watershed, distance from the sea and slope were only sporadically included in models and did not have any significant *p* values.

Table 13.4 The best 10 generalised linear models (using Gaussian distribution) as determined by AIC value for Shannon's diversity index and coefficients of each model

Ranking	AIC	Land use (plantation:1; forest:0)	Watershed area (km^2/1000)	Distance from the sea (km/100)	Altitude (km)	Slope (degree/10)
1	84.6	−0.64***			3.54ns	
2	85.4	−0.58***		0.23ns		
3	85.8	−0.65***			4.69*	−0.24ns
4	86.0	−0.62***	0.37ns		3.12ns	
5	86.2	−0.59***		0.11ns	2.56ns	
6	86.2	−0.72***				
7	86.5	−0.57***	0.44ns	0.20ns		
8	86.6	−0.68***	0.58ns			
9	87.1	−0.64***	0.39ns		4.31ns	−0.25ns
10	87.4	−0.58***		0.23ns		−0.01ns

ns not significant
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

13.3.4 Distribution Model for Each Species

The results for each species are listed in Table 13.5. The presence of a plantation was selected as a negative factor for eight species and the coefficient was statistically significant for two species. Watershed affected 10 species, both negatively and positively. Distance from the sea positively affected 10 species, but negatively affected *Rasbora dusonensis*. Altitude had negative and positive effects on three and four species respectively; all with statistically significant *p* values. Slope negatively affected six species but positively affected *Betta akarensis*.

13.4 Discussion

In this survey, we ascertained the distribution of 82 freshwater fish species in streams in the Bintulu region. In the only other comparable study, Tan Heok Hui and Kevin K.P. Lim (2007) reported 47 species from the Binyo–Penyilam and Bukit Sarang areas, which were included in our sampling range. Most of the species reported by Tan and Lim (2007) were also included in our sampling. However, several species that inhabit relatively large streams or rivers, such as *Wallago leerii* and *Bagroides melapterus*, were not found during the present study because our sampling was restricted to small streams. Tan and Lim found no alien species in their survey areas. In contrast, we found two alien fishes in our relatively large sampling area. These were *Oreochromis niloticus* (Nile tilapia), which was found only in the plantation streams near Bintulu town, and *Esomus metallicus* (Arbsuwan et al. 2012), which was found in a small stream in the upper reaches of the Tatau basin. Both species were found only sporadically which supports Tan and Lim's (2007) impression that the habitats in the study area are relatively undisturbed by human activity that tends to increase alien species.

Table 13.5 The best GLMS (using Poisson distribution and where AIC was lowest) for species that were caught in more than six locations

Species	Land use (plantation:1; forest:0)	Watershed area (km^2/1000)	Distance from the sea (km/100)	Altitude (km)	Slope (degree/10)
Barbodes banksi		−3.026**	0.46ns		−1.47ns
Barbonymus schwanenfeldii		0.349**	1.23**		
Cyclocheilichthys apogon			0.81**		−1.29ns
Desmopuntius johorensis			1.03**		−7.36**
Hampala bimaculata				34.2***	
Hampala macrolepidota		0.377**			
Nematabramis steindachnerii	−0.72ns	−7.350*	0.97***	11.9***	−0.91*
Osteochilus microcephalus			2.35***	−53.0***	
Rasbora sp. (cf. *atranus*)[a]	−1.90ns			18.7 ns	
Rasbora dusonensis	−1.56**	−0.658	−0.59ns	22.7***	−1.05*
Rasbora ennealepis					−0.13
Rasbora hosii[b]		−0.527	1.94***	−18.7*	
Homalopteroides tweediei	−1.64 ns		0.81*		
Nemacheilus spiniferus[a]	−2.94 ns				
Hemirhamphodon kuekenthali	−1.33***	−0.156			
Betta akarensis		−0.541*	0.40 ns		0.83*
Channa lucius[a]	−1.79 ns	−0.493 ns	1.82 ns		
Channa striata	−0.46 ns	−4.570 ns		−58.6***	

ns not significant
$***p < 0.001$, $**p < 0.01$, $*p < 0.05$
[a]The 'brglm' (bias reduction GLM) function was conducted because of statistical 'separation' issue noted in Sect. 13.2.2
[b]The 'glm.nb' (negative binomial GLM) was conducted because of overdispersion noted in Sect. 13.2.2

The negative effect of plantations on fish communities was obvious. Species richness, the simplest indicator of biodiversity, in oil palm and acacia plantations was almost half that in protected and natural forests (Fig. 13.3). Species composition also differed between plantation and forest habitats (Fig. 13.4). Although it is not clear why the distance from the sea was positively associated with species richness and the number of individuals (Tables 13.2 and 13.3), it is possible that distance from the sea is correlated with distance from cities where both fishing pressure and water pollution are likely high. Habitats in deep forests, which are far from the sea and densely populated cities, are thus likely to have relatively higher freshwater fish biodiversity.

In the cluster analysis (Fig. 13.4), three subclusters were supported as statistically significant groups. Subcluster A represents the typical unhealthy conditions caused by plantations where fishes were almost absent except *Oreochromis niloticus* (alien) and/or *Pristolepis fasciata*, which are a pollution-tolerant hardy species (Garcia-Santos et al. 2006) and well adapted to wide range of water qualities and habitat types (Taki 1978), respectively. Subcluster B includes sites that could be characterised as peat swamps. For example, *Desmopuntius johorensis* and *Oxygaster anomalura* are reported to inhabit peat swamps of Southeast Asia (Khairul et al. 2009; Fahmi-Ahmad et al. 2015; Hussein et al. 2016). Subcluster C represents healthy environments with relatively general species such as *Hampala macrolepidota* and *Osteochilus microcephalus*. Although these three subclusters were statistically supported, the cluster as a whole was unstable. This may be due to the presence of rare species. Of the 82 species collected, 41 species were found only at one or two locations (Table 13.1). The inclusion of such rare species in the cluster analysis resulted in statistical noise and made the clusters unstable.

There could be many reasons for the observed negative effect of plantations on fish biodiversity. One might be that the plantations were typically found in relatively flat lowland areas near the sea (Fig. 13.1). Therefore, the plantations themselves may not have affected the fish. Instead, the environmental features of plantation areas may have been the negative factors affecting fish biodiversity, that is, there may have been a spurious correlation between plantations and fish biodiversity. However, our analysis included four environmental features (altitude, watershed area, distance from the sea and land slope) as factors. The results of this analysis (Tables 13.2, 13.3 and 13.4) showed that even when these environmental factors were considered, the negative effect of plantations was included in all of the top 10 models for species richness, number of individual sand Shannon's diversity index.

In this study, we did not identify the particular aspects of plantations that directly affect fish communities. Several factors associated with plantations could contribute to their negative impact on fish communities. One such factor is sediment influx. Several studies have reported sediment influx from plantations (Gharibreza et al. 2013; Carlson et al. 2014), which potentially flattens the physical complexity of stream habitats by filling the spaces among small pebbles and rocks, and degrades the riffle-pool structure of streams by making the streambeds sandy (Gorman and Karr 1978; Wood and Armitage 1997). Kano et al. (2013b) reported that freshwater fishes in a stream of peninsular Malaysia are generally adapted to meso- or microhabitats, such as riffle-pool units. For example, small catfishes (*Glyptothorax* spp.) are reported to prefer the rocky riffle habitats of streams. Such riffle-dependent fishes would be unable to inhabit sediment-fluxed sandy streams.

The absence of riparian forest may be another reason for the negative association between plantations and fish biodiversity. For example, at least one *Rasbora* species, *Rasbora elegans*, prefers shadowy habitats with insects falling from the canopy of the riparian forest (Kano et al. 2013b). The number of such insectivores is likely to be low in streams surrounded by plantations without riparian forests. The absence of riparian forest also increases the water temperature because sunlight directly irradiates streams that are not shaded by forest canopies (Richardson et al. 2007). Increasing water temperature may affect species composition, as heated water might negatively affect the physiology of certain fishes and positively affect the physiology of others, such as

Oreochromis niloticus (Grammer et al. 2012). Increased water temperature also results in a decrease in dissolved oxygen which would negatively affect most fishes.

Water pollution from plantations could also be a problem for fish communities. The degradation of water quality due to fertiliser application and soil disturbance has been reported in the plantations of the Bintulu region (Tokuchi et al., Chap. 11; Fukushima et al., Chap. 12). Chemical pollution by pesticides (Aktar et al. 2009) and turbid water by sedimentation influx can also disturb local fish populations and lead to physiological damage (Cohen et al. 1993). High turbidity also reduces the fishes' ability to forage for food causing them to decline (Wenger et al. 2012; Lunt and Smee 2015).

The negative effect of plantations on individual species (Table 13.5) was not as clear as their effect on comprehensive biodiversity indices (Tables 13.2, 13.3, and 13.4). A significant negative impact of plantations was detected for only two species, *Rasbora dusonensis* and *Hemirhamphodon kuekenthali*. It is possible that rare species are more sensitive to plantations than common species. Out of 82 species, 64 species were not analysed because of insufficient data. We suspect that these rare species had already decreased in number before the development of plantations due to the impacts of other human activities (for example, overfishing, pollution, logging and acid precipitation). If sensitive species are easily impacted upon by plantations, we would only be able to detect the effects of plantations by using comprehensive indicators such as species richness.

According to our study, plantations generally have a negative impact on fish biodiversity. Nevertheless, we must also consider that plantations may not always decrease fish biodiversity if mitigation measures were taken to reduce the impact. We found species richness at one plantation site (eight species) to be comparable to that at forest sites. Moreover, several fish communities found in plantations belonged to the forest cluster (Fig. 13.4). The mechanisms underlying the effects of plantations on fish biodiversity need to be investigated. Understanding these mechanisms would help us to implement constructive and practical conservation measures for freshwater fish biodiversity and improve the welfare of local communities.

Acknowledgements We deeply appreciate the kind assistance we received from Abdul Aziz, Bibian Diway, Noboru Ishikawa, Ryoji Soda, Joanes Unggang, Wong Ing Yung, Sarawak Forestry Corporation and the inhabitants of Rumah Aying, Rumah Mawang and Rumah Irai. We also thank Dr Ruhana Hassan for allowing us to deposit the samples in her laboratory at UNIMAS. This work was supported by the Environment Research and Technology Development Fund (S9) from the Ministry of the Environment, Japan, by the Global COE Program (centre of excellence for Asian conservation ecology as a basis of human–nature mutualism), MEXT, Japan, and by the Program for Leading Graduate Schools (graduate education and research training program in decision science for a sustainable society), Japan Society for the Promotion of Science.

Appendix 13.1: Images of Freshwater Fish Species

ID numbers correspond to those in Table 13.1. The authors are grateful for any suggestions of identification or potential misidentifications (contact: Yuichi Kano, kano@species.jp). The updated identification list is available at http://ffish.asia/BintuluFish.

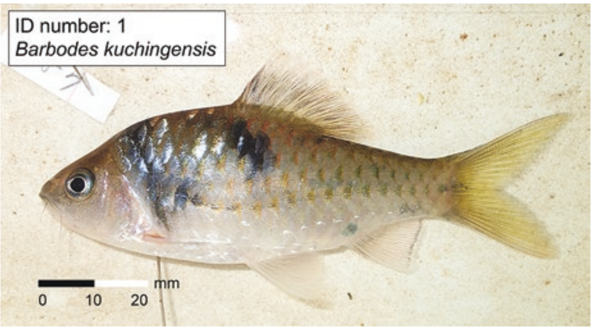


Fig. 13.5 *Barbodes kuchingensis* with ID number 1 in this study. (Photograph: Yuichi Kano 2013)

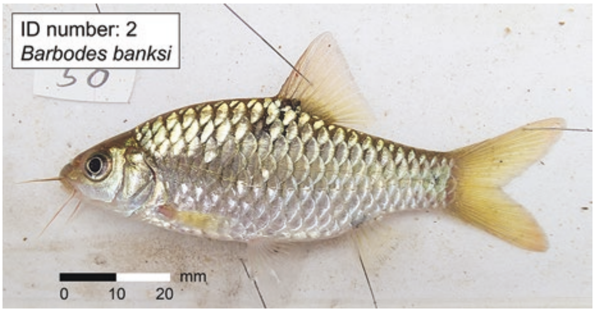


Fig. 13.6 *Barbodes banksi* with ID number 2 in this study. (Photograph: Yuichi Kano 2013)

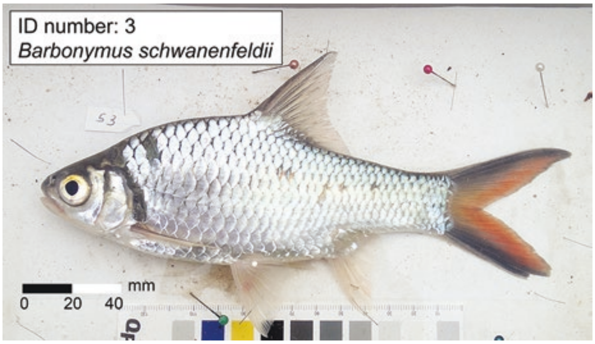


Fig. 13.7 *Barbonymus schwanenfeldii* with ID number 3 in this study. (Photograph: Yuichi Kano 2013)

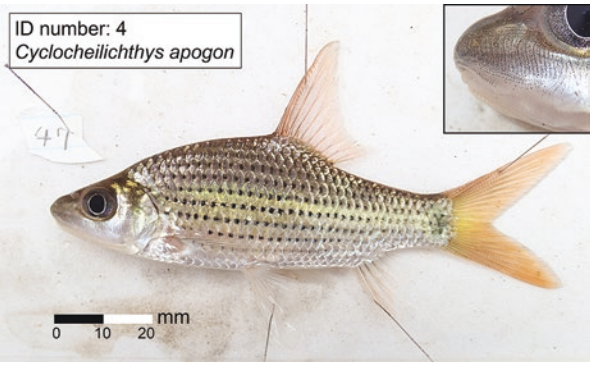


Fig. 13.8 *Cyclocheilichthys apogon* with ID number 4 in this study. (Photograph: Yuichi Kano 2013)

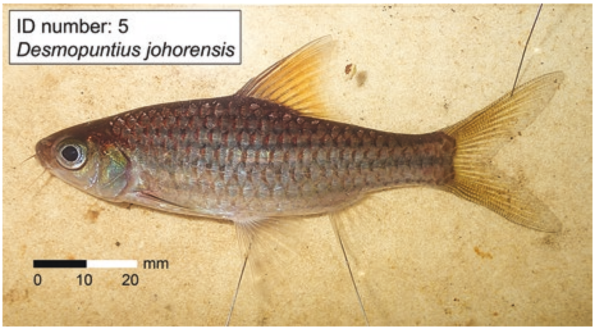


Fig. 13.9 *Desmopuntius johorensis* with ID number 5 in this study. (Photograph: Yuichi Kano 2013)

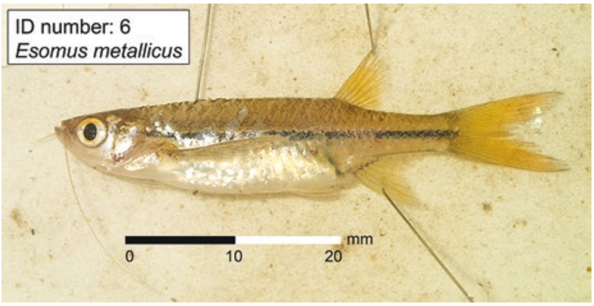


Fig. 13.10 *Esomus metallicus* with ID number 6 in this study. (Photograph: Yuichi Kano 2013)

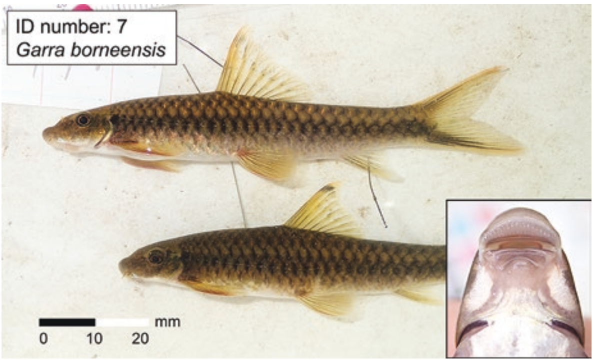


Fig. 13.11 *Garra borneensis* with ID number 7 in this study. (Photograph: Yuichi Kano 2013)

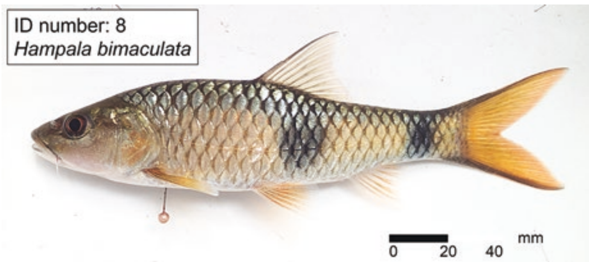


Fig. 13.12 *Hampala bimaculata* with ID number 8 in this study. (Photograph: Yuichi Kano 2013)

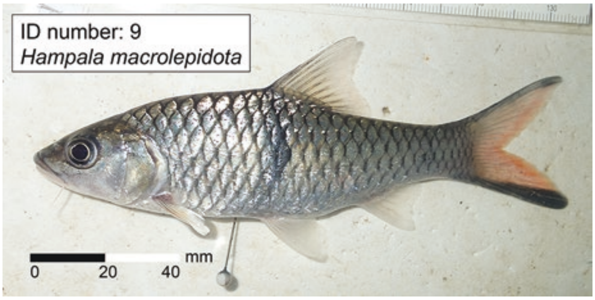


Fig. 13.13 *Hampala macrolepidota* with ID number 9 in this study. (Photograph: Yuichi Kano 2013)

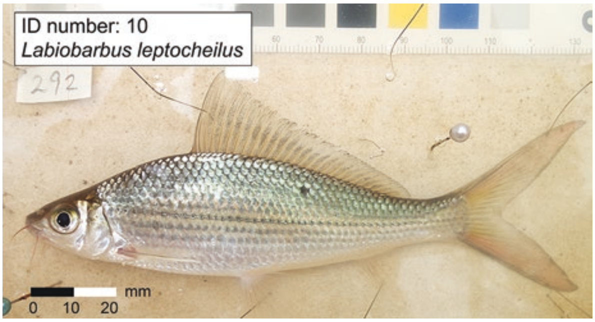


Fig. 13.14 *Labiobarbus leptocheilus* with ID number 10 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.15 *Leptobarbus hosii* with ID number 11 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.16 *Lobocheilos bo* with ID number 12 in this study. (Photograph: Yuichi Kano 2013)

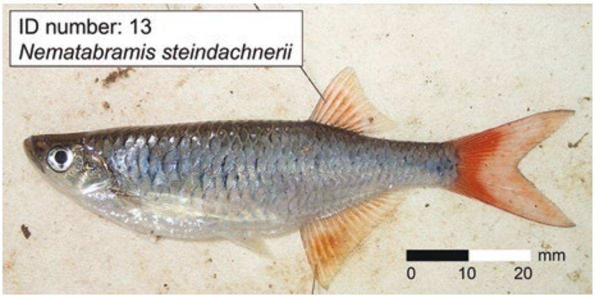


Fig. 13.17 *Nematabramis steindachnerii* with ID number 13 in this study. (Photograph: Yuichi Kano 2014)

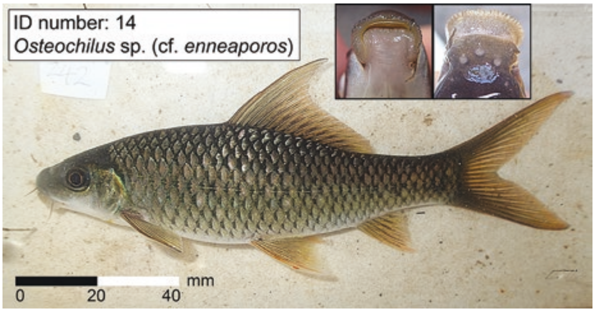


Fig. 13.18 *Osteochilus* sp. (cf. *enneaporos*) with ID number 14 in this study. (Photograph: Yuichi Kano 2013)

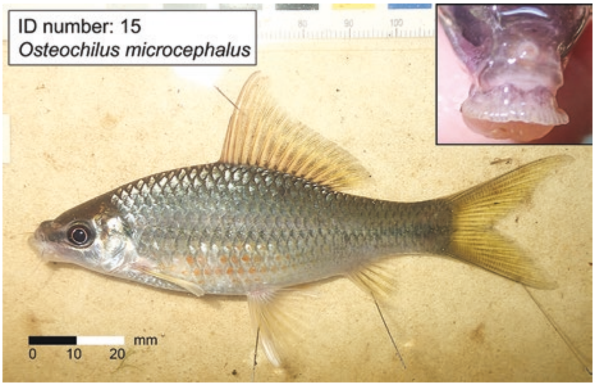


Fig. 13.19 *Osteochilus microcephalus* with ID number 15 in this study. (Photograph: Yuichi Kano 2014)

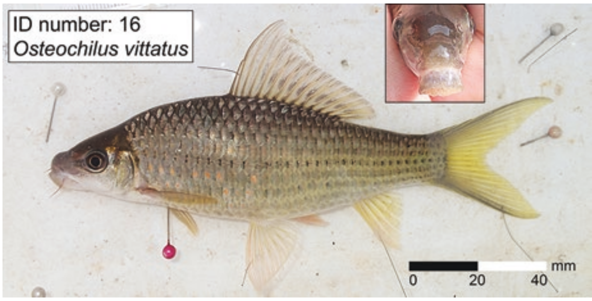


Fig. 13.20 *Osteochilus vittatus* with ID number 16 in this study. (Photograph: Yuichi Kano 2013)

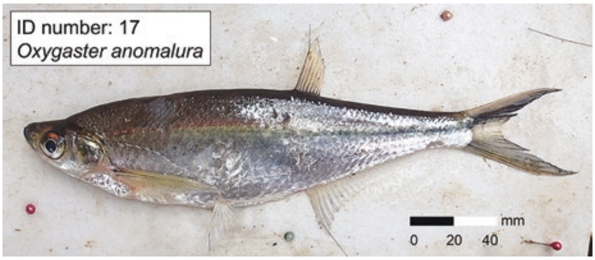


Fig. 13.21 *Oxygaster anomalura* with ID number 17 in this study. (Photograph: Yuichi Kano 2013)

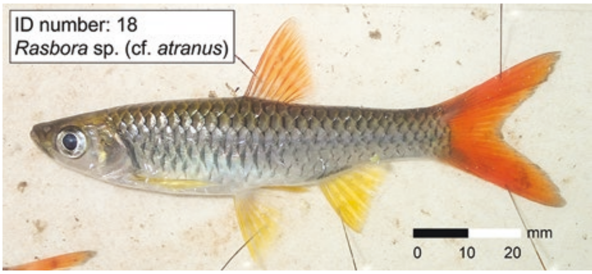


Fig. 13.22 *Rasbora* sp. (cf. *atranus*) with ID number 18 in this study. (Photograph: Yuichi Kano 2014)

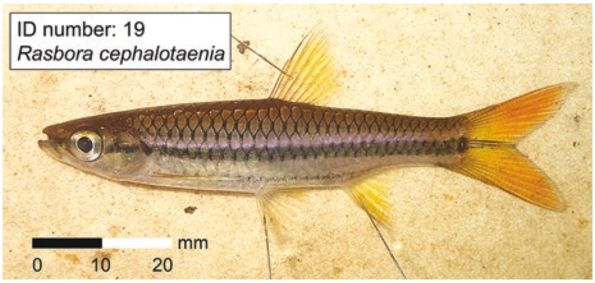


Fig. 13.23 *Rasbora cephalotaenia* with ID number 19 in this study. (Photograph: Yuichi Kano 2014)

Fig. 13.24 *Rasbora dusonensis* with ID number 20 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.25 *Rasbora einthovenii* with ID number 21 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.26 *Rasbora ennealepis* with ID number 22 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.27 *Rasbora hosii* with ID number 23 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.28 *Rasbora kottelati* with ID number 24 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.29 *Rasbora tornieri* with ID number 25 in this study. (Photograph: Yuichi Kano 2014)

Fig. 13.30 *Rasbora trilineata* with ID number 26 in this study. (Photograph: Yuichi Kano 2013)

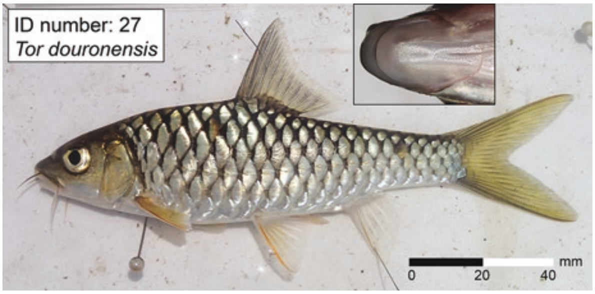


Fig. 13.31 *Tor douronensis* with ID number 27 in this study. (Photograph: Yuichi Kano 2013)

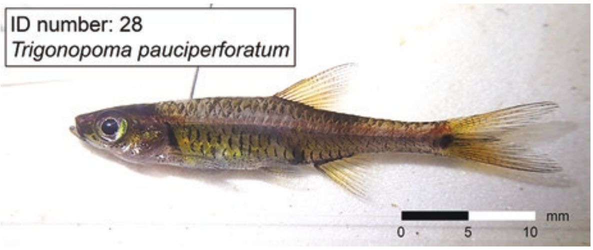


Fig. 13.32 *Trigonopoma pauciperforatum* with ID number 28 in this study. (Photograph: Yuichi Kano 2013)

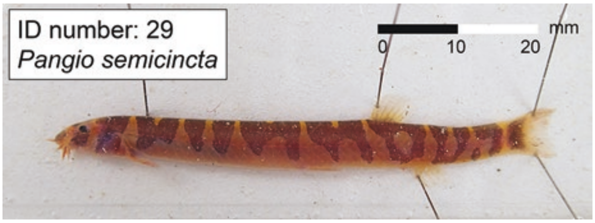


Fig. 13.33 *Pangio semicincta* with ID number 29 in this study. (Photograph: Yuichi Kano 2013)

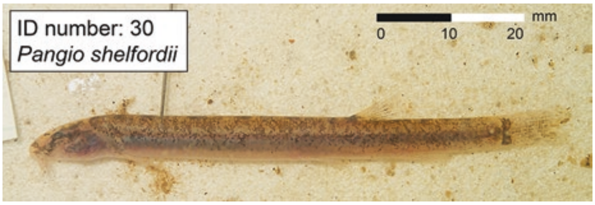


Fig. 13.34 *Pangio shelfordii* with ID number 30 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.35 *Barbucca diabolica* with ID number 31 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.36 *Homaloptera orthogoniata* with ID number 32 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.37 *Homalopteroides stephensoni* with ID number 33 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.38 *Homalopteroides tweediei* with ID number 34 in this study. (Photograph: Yuichi Kano 2013)

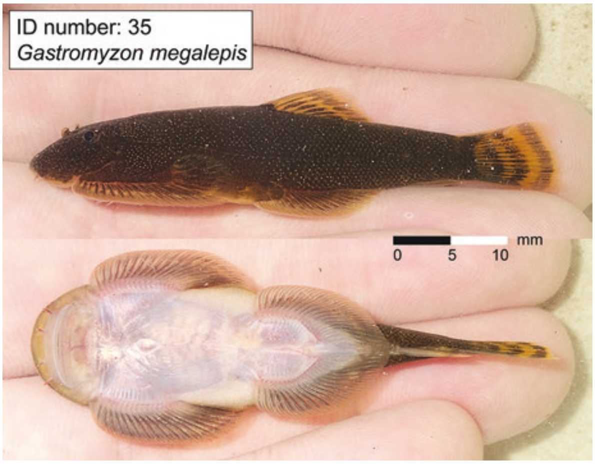


Fig. 13.39 *Gastromyzon megalepis* with ID number 35 in this study. (Photograph: Yuichi Kano 2013)

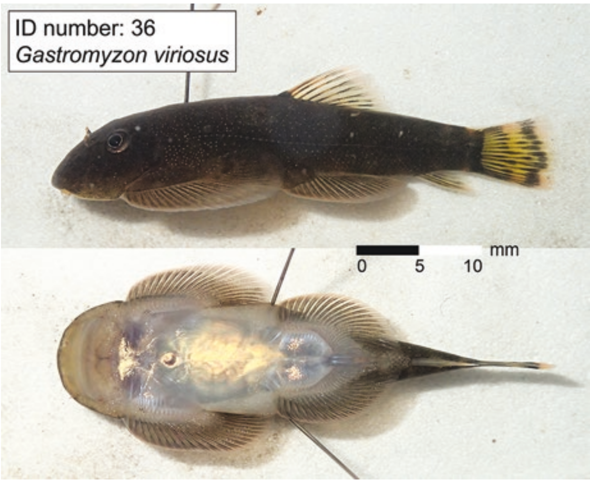


Fig. 13.40 *Gastromyzon viriosus* with ID number 36 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.41 *Neogastromyzon chini* with ID number 37 in this study. (Photograph: Yuichi Kano 2013)

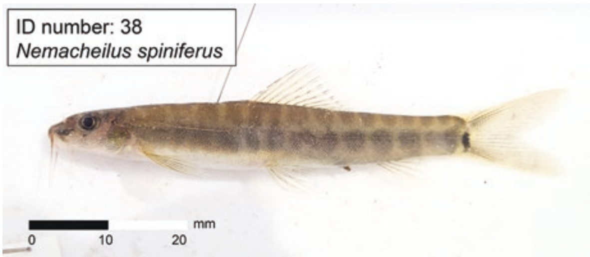


Fig. 13.42 *Nemacheilus spiniferus* with ID number 38 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.43 *Glyptothorax major* with ID number 39 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.44 *Glyptothorax exodon* with ID number 40 in this study. (Photograph: Yuichi Kano 2013)

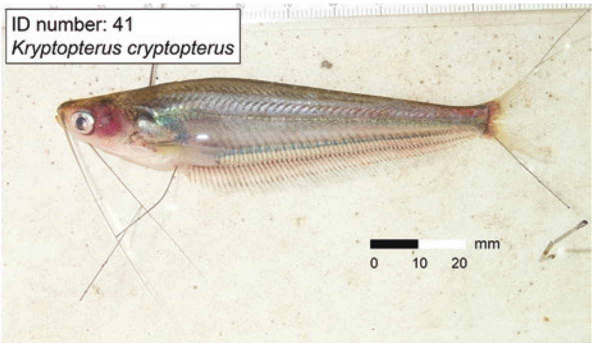


Fig. 13.45 *Kryptopterus cryptopterus* with ID number 41 in this study. (Photograph: Yuichi Kano 2013)

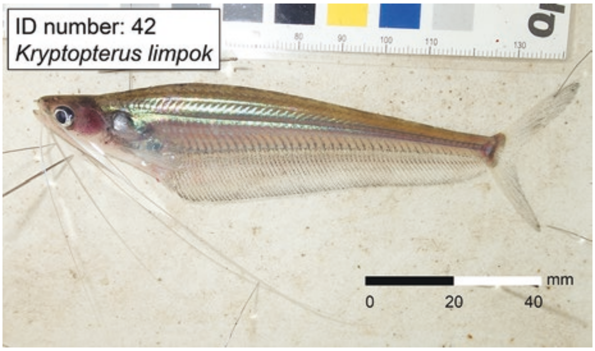


Fig. 13.46 *Kryptopterus limpok* with ID number 42 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.47 *Pterocryptis furnessi* with ID number 43 in this study. (Photograph: Yuichi Kano 2014)

Fig. 13.48 *Silurichthys marmoratus* with ID number 44 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.49 *Clarias* sp. (cf. *batrachus*) with ID number 45 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.50 *Clarias leiacanthus* with ID number 46 in this study. (Photograph: Yuichi Kano 2014)

Fig. 13.51 *Clarias nieuhofii* with ID number 47 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.52 *Clarias planiceps* with ID number 48 in this study. (Photograph: Yuichi Kano 2013)

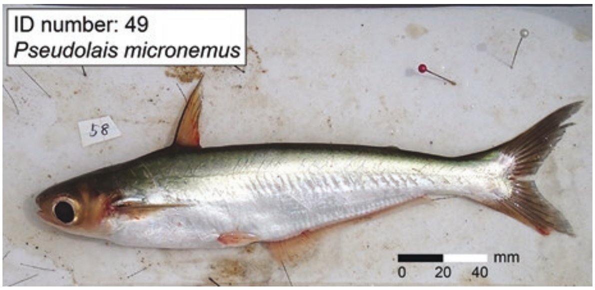


Fig. 13.53 *Pseudolais micronemus* with ID number 49 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.54 *Hemibagrus capitulum* with ID number 50 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.55 *Hemibagrus fortis* with ID number 51 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.56 *Hemibagrus hoevenii* with ID number 52 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.57 *Leiocassis hosii* with ID number 53 in this study. (Photograph: Yuichi Kano 2013)

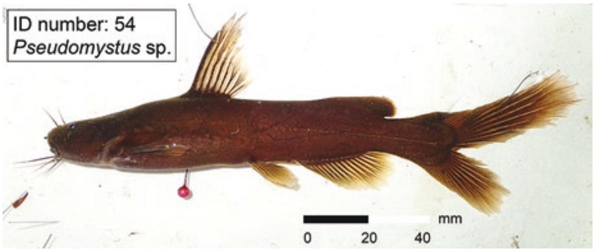


Fig. 13.58 *Pseudomystus* sp. with ID number 54 in this study. (Photograph: Yuichi Kano 2013)

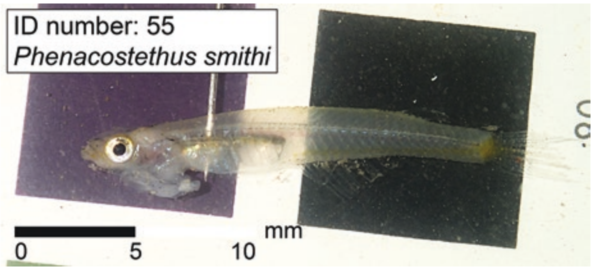


Fig. 13.59 *Phenacostethus smithi* with ID 55 number in this study. (Photograph: Yuichi Kano 2014)

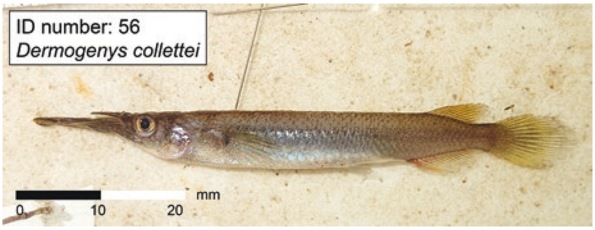


Fig. 13.60 *Dermogenys collettei* with ID number 56 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.61 *Hemirhamphodon kuekenthali* with ID number 57 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.62 *Doryichthys martensii* with ID number 58 in this study. (Photograph: Yuichi Kano 2013)

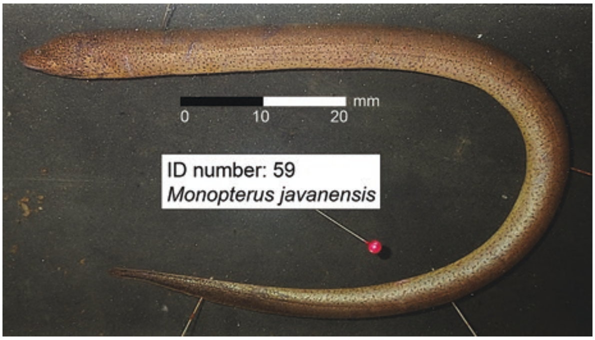


Fig. 13.63 *Monopterus javanensis* with ID number 59 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.64 *Macrognathus circumcinctus* with ID number 60 in this study. (Photograph: Yuichi Kano 2013)

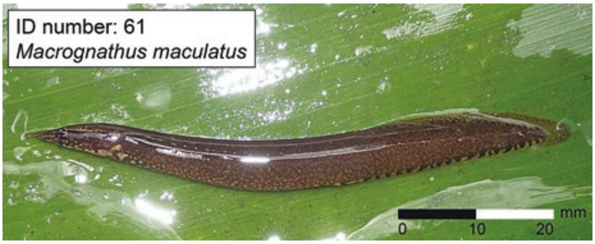


Fig. 13.65 *Macrognathus maculatus* with ID number 61 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.66 *Mastacembelus unicolor* with ID number 62 in this study. (Photograph: Yuichi Kano 2013)

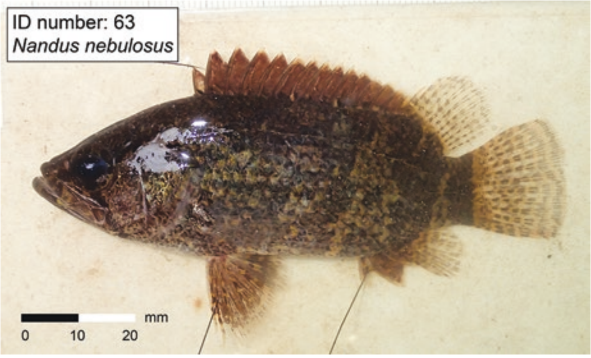


Fig. 13.67 *Nandus nebulosus* with ID number 63 in this study. (Photograph: Yuichi Kano 2014)

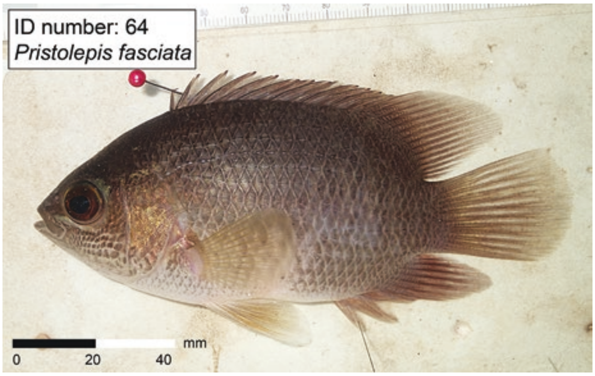


Fig. 13.68 *Pristolepis fasciata* with ID number 64 in this study. (Photograph: Yuichi Kano 2013)

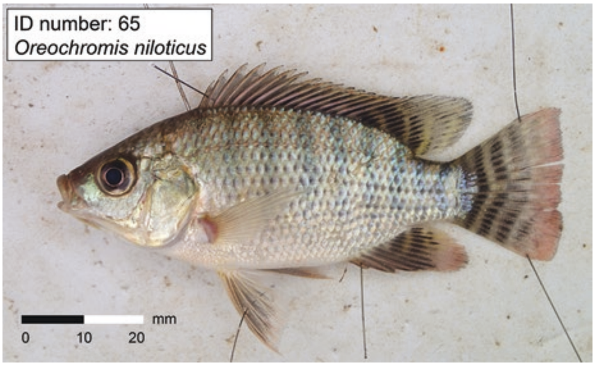


Fig. 13.69 *Oreochromis niloticus* with ID number 65 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.70 *Eleotris melanosoma* with ID number 66 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.71 *Oxyeleotris marmorata* with ID number 67 in this study. (Photograph: Yuichi Kano 2013)

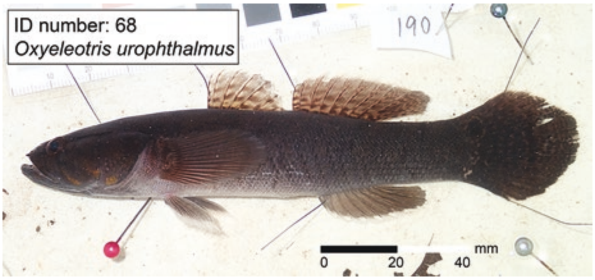


Fig. 13.72 *Oxyeleotris urophthalmus* with ID number 68 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.73 *Butis amboinensis* with ID number 69 in this study. (Photograph: Yuichi Kano 2013)

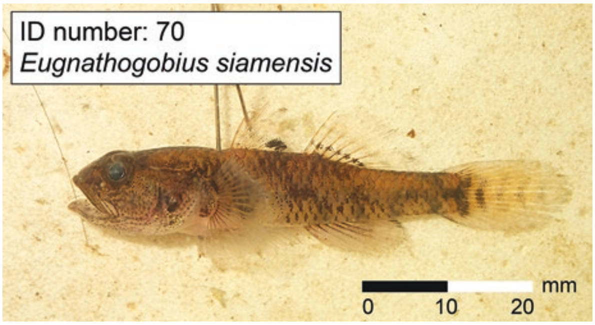


Fig. 13.74 *Eugnathogobius siamensis* with ID number 70 in this study. (Photograph: Yuichi Kano 2013)

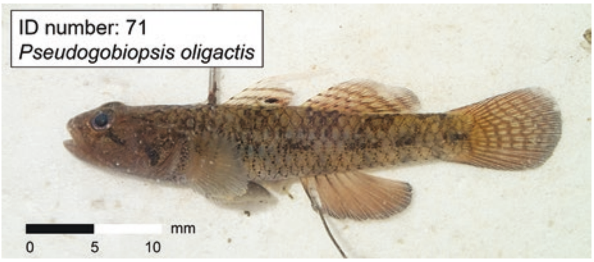


Fig. 13.75 *Pseudogobiopsis oligactis* with ID number 71 in this study. (Photograph: Yuichi Kano 2013)

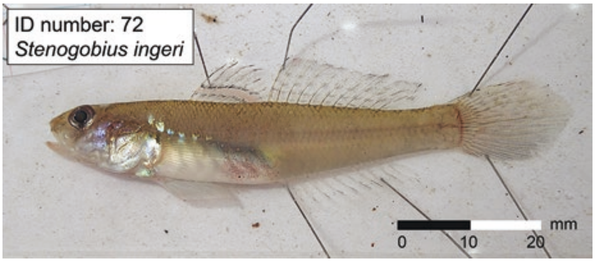


Fig. 13.76 *Stenogobius ingeri* with ID number 72 in this study. (Photograph: Yuichi Kano 2013)

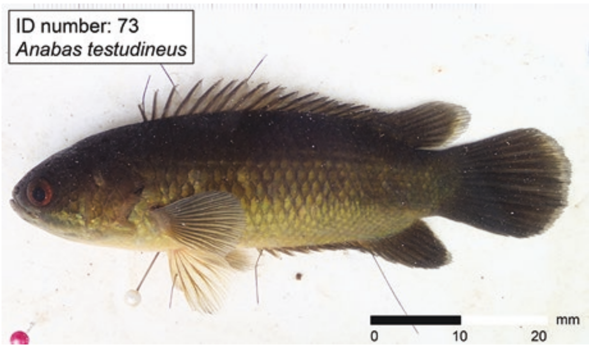


Fig. 13.77 *Anabas testudineus* with ID number 73 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.78 *Betta akarensis* with ID number 74 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.79 *Luciocephalus pulcher* with ID number 75 in this study. (Photograph: Yuichi Kano 2013)

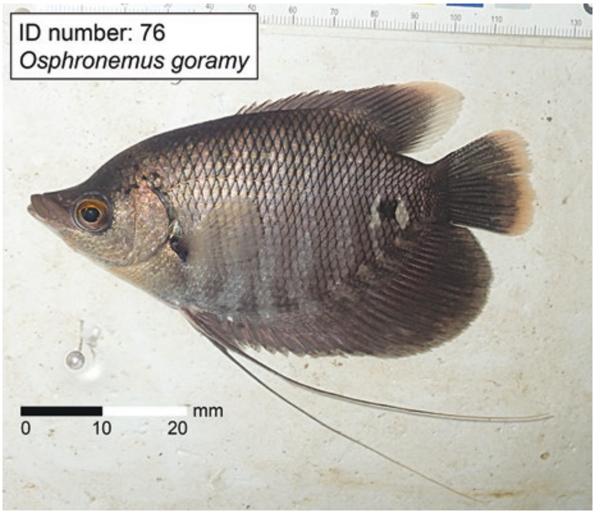


Fig. 13.80 *Osphronemus goramy* with ID number 76 in this study. (Photograph: Yuichi Kano 2013)

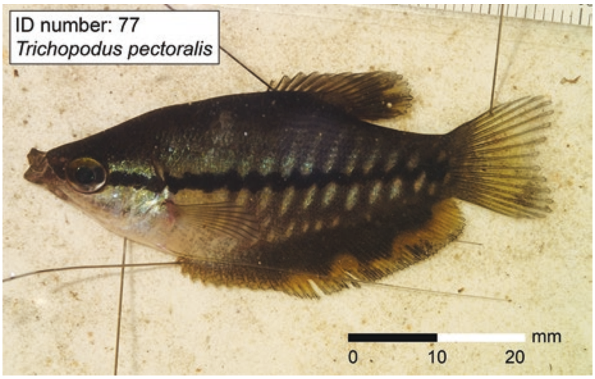


Fig. 13.81 *Trichopodus pectoralis* with ID number 77 in this study. (Photograph: Yuichi Kano 2013)

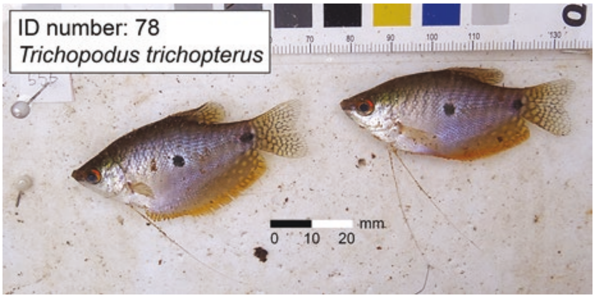


Fig. 13.82 *Trichopodus trichopterus* with ID number 78 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.83 *Channa baramensis* with ID number 79 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.84 *Channa lucius* with ID number 80 in this study. (Photograph: Yuichi Kano 2013)

Fig. 13.85 *Channa striata* with ID number 81 in this study. (Photograph: Yuichi Kano 2013)

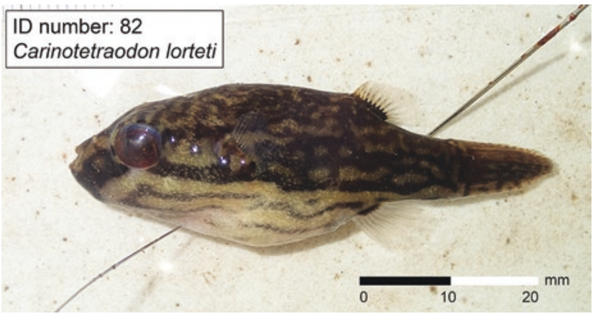


Fig. 13.86 *Carinotetraodon lorteti* with ID number 82 in this study. (Photograph: Yuichi Kano 2013)

References

Akaike, Hirotugu. 1974. A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 19 (6): 716–723.

Aktar, M. Wasim, Dwaipayan Sengupta, and Ashim Chowdhury. 2009. Impact of pesticides use in agriculture: Their benefits and hazards. *Interdisciplinary Toxicology* 2 (1): 1–12.

Allan, J. David, Robin Abell, Zeb Hogan, Carmen Revenga, Brad W. Taylor, Robin L. Welcomme, and Kirk Winemiller. 2005. Overfishing of inland waters. *BioScience* 55 (12): 1041–1051.

Arbsuwan, Sakda, Prachya Musikasinthorn, Melfa Marini, and Husnah Samhudi. 2012. First record of the cyprinid fish, *Esomus metallicus* (Actinopterygii: Cyprinidae) from Sumatra. *Natural History Bulletin of the Siam Society* 58 (1–2): 59–65.

Atack, Katherine. 2006. *A field guide to the fishes of Kuching rivers: Sarawak, Malaysian Borneo*. Kota Kinabalu: Natural History Publications.

Carlson, Kimberly M., Lisa M. Curran, Alexandra G. Ponette-González, Dessy Ratnasari, Neli Lisnawati Ruspita, Yadi Purwanto, Kate A. Brauman, and Peter A. Raymond. 2014. Influence of watershed-climate interactions on stream temperature, sediment yield, and metabolism along a land use intensity gradient in Indonesian Borneo. *Journal of Geophysical Research – Biogeosciences* 119 (6): 1110–1128.

Choy, Satish C., and P.K. Chin. 1994. Fresh-water fishes from the headwaters of the Belalong-Temburong river system, Brunei Darussalam, Borneo. *The Raffles Bulletin of Zoology* 42 (4): 757–774.

Christensen, Mikkel S. 1992. Investigations on the ecology and fish fauna of the Mahakam River in East Kalimantan (Borneo), Indonesia. *International Review of Hydrobiology* 77 (4): 593–608.

Cohen, Andrew S., Roger Bills, Christine Z. Cocquyt, and A.G. Caljon. 1993. The impact of sediment pollution on biodiversity in Lake Tanganyika. *Conservation Biology* 7 (3): 667–677.

de Almeida, Eduardo Alves, and Ciro Alberto de Oliveira Ribeiro, eds. 2016. *Pollution and fish health in tropical ecosystems*. Boca Raton: CRC Press.

Erman, Don C., and Franklin K. Ligon. 1988. Effects of discharge fluctuation and the addition of fine sediment on stream fish and macroinvertebrates below a water-filtration facility. *Environmental Management* 12 (1): 85–97.

Evans, Julian. 1992. *Plantation forestry in the tropics: Tree planting for industrial, social, environmental, and agroforestry purposes*. Oxford: Clarendon Press.

Fahmi-Ahmad, Muhammad, Syed A. Rizal, and Amirrudin B. Ahmad. 2015. Ichthyofaunal diversity of Tasek Bera Ramsar site, Pahang, Peninsular Malaysia. *Journal of Wildlife and Parks* 30: 27–43.

Fitzherbert, Emily B., Matthew J. Struebig, Alexandra More, Finn Danielsen, Carsten A. Brüh, Paul F. Donald, and Ben Phalan. 2008. How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution* 23 (10): 538–545.

Garcia-Santos, Sofia, António Fontaínhas-Fernandes, and Jonathan Mark Wilson. 2006. Cadmium tolerance in the Nile tilapia (*Oreochromis niloticus*) following acute exposure: Assessment of some ionoregulatory parameters. *Environmental Toxicology* 21 (1): 33–46.

Gharibreza, Mohammadreza, John Kuna Raj, Ismail Yusoff, Muhammad Aqeel Ashraf, Zainudin Othman, and Wan Zakaria Wan Muhamad Tahir. 2013. Effects of agricultural projects on nutrient levels in Lake Bera (Tasek Bera), Peninsular Malaysia. *Agriculture, Ecosystems and Environment* 165: 19–27.

Gorman, Owen T., and James R. Karr. 1978. Habitat structure and stream fish communities. *Ecology* 59 (3): 507–515.

Grammer, Gretchen L., William T. Slack, Mark S. Peterson, and Mark A. Dugo. 2012. Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) establishment in temperate Mississippi, USA: Multi-year survival confirmed by otolith ages. *Aquatic Invasions* 7 (3): 367–376.

Hussein, Aliu Sule, Ahmad Ismail, and Mohammad Noor Amal Azmai. 2016. A review of the ichthyofauna of Malaysian peat swamp forest. *Pertanika Journal of Tropical Agricultural Science* 39 (4): 421–458.

Inger, Robert F., and Phui Kong Chin. 1990. *The fresh-water fishes of North Borneo*. Kota Kinabalu: Sabah Zoological Society.

———. 2002. *The fresh-water fishes of North Borneo; with a supplementary chapter by Chin Phui Kong*. Kota Kinabalu: Natural History Publications.

Iwata, Tomoya, Shigeru Nakano, and Mikio Inoue. 2003. Impacts of past riparian deforestation on stream communities in a tropical rain forest in Borneo. *Ecological Applications* 13 (2): 461–473.

Kano, Yuichi, and Jun Nakajima. 2014. Ko-chugata tansuigyo ni okeru hisasshouteki katsu kan-i na gyotaisatsueihou [Non-killing simple photography techniques of small–middle freshwater fishes in the field]. *Gyoruigaku Zasshi* [Japanese Journal of Ichthyologyl] 61: 23–125.

Kano, Yuichi, Mohad Shalahuddin Adnan, Chaiwut Grudpan, Jarungjit Grudpan, Wichan Magtoon, Prachya Musikasinthorn, Yoshihiro Natori, Stefan Ottomanski, Bounthob Praxaysonbath, Koneouma Phongsa, Achariya Rangsiruji, Koichi Shibukawa, Yukihiro Shimatani, Nam So, Apinun Suvarnaraksha, Phanara Thach, Phuong Nguyen Thanh, Dac Dinh Tran, Kenzo Utsugi, and Tomomi Yamashita. 2013a. An online database on freshwater fish diversity and distribution in Mainland Southeast Asia. *Ichthyological Research* 60 (3): 293–295.

Kano, Yuichi, Yusuke Miyazaki, Yuta Tomiyama, Chika Mitsuyuki, Shin Nishida, and Zulkafli A. Rashid. 2013b. Linking mesohabitat selection and ecological traits of a fish assemblage in a small tropical stream (Tinggi River, Pahang Basin) of the Malay Peninsula. *Zoological Science* 30 (3): 178–184.

Kano, Yuichi, David Dudgeon, So Nam, Hiromitsu Samejima, Katsutoshi Watanabe, Chaiwut Grudpan, Jarungjit Grudpan, Wichan Magtoon, Prachya Musikasinthorn, Phuong Thanh Nguyen, Bounthob Praxaysonbath, Tomoyuki Sato, Koichi Shibukawa, Yukihiro Shimatani, Apinun Suvarnaraksha, Wataru Tanaka, Phanara Thach, Dac Dinh Tran, Tomomi Yamashita, and Kenzo Utsugi. 2016. Impacts of dams and global warming on fish biodiversity in the Indo-Burma hotspot. *PLoS One* 11 (8): e0160151.

Khairul, Adha, A. Rahim, Siti Khalijah Daud, Siti Shapor Siraj, Aziz Arshad, Yuzine Esa, and Eza Rena Ibrahim. 2009. Freshwater fish diversity and composition in Batang Kerang Floodplain, Balai Ringin, Sarawak. *Pertanika Journal of Tropical Agricultural Science* 32: 7–16.

Koh, Lian Pin, and David S. Wilcove. 2009. Oil palm: Disinformation enables deforestation. *Trends in Ecology & Evolution* 24 (2): 67–68.

Kottelat, Maurice. 2013. The fishes of the inland waters of Southeast Asia: A catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *The Raffles Bulletin of Zoology* 2013 (Suppl 27): 1–663.

Kottelat, Maurice, and Tan Heok Hui. 2011. *Rasbora atranus*, a new species of fish from central Borneo (Teleostei: Cyprinidae). *Ichthyological Exploration of Freshwaters* 22 (3): 215–220.

Kottelat, Maurice, and Kevin K.P. Lim. 1995. Freshwater fishes of Sarawak and Brunei Darussalam: A preliminary annotated check-list. *Sarawak Museum Journal* 48: 227–256.

Leprieur, Fabien, Olivier Beauchard, Simon Blanchet, Thierry Oberdorff, and Sébastien Brosse. 2008. Fish invasions in the world's river systems: When natural processes are blurred by human activities. *PLoS Biology* 6 (12): e322.

Lim, Kevin K.P. 1995. *Rasbora kottelati*, a new species of cyprinid fish from north-western Borneo. *The Raffles Bulletin of Zoology* 43 (1): 65–74.

Lim, Kevin K.P., and A. Wong. 1994. Fishes of the Kinabatangan basin, Sandakan district, Sabah, East Malaysia. *Sabah Museum Journal* 1: 39–71.

Lunt, Jessica, and Delbert L. Smee. 2015. Turbidity interferes with foraging success of visual but not chemosensory predators. *Peer J* 3: e1212.

Malmer, A. 1996. Hydrological effects and nutrient losses of forest plantation establishment on tropical rainforest land in Sabah, Malaysia. *Journal of Hydrology* 174 (1/2): 129–148.

Martin-Smith, Keith M. 1998. Relationships between fishes and habitat in rainforest streams in Sabah, Malaysia. *Journal of Fish Biology* 52 (3): 458–482.

Ng, Heok Hee, and Maurice Kottelat. 2013. Revision of the Asian catfish genus *Hemibagrus* Bleeker, 1862 (Teleostei: Siluriformes: Bagridae). *The Raffles Bulletin of Zoology* 61 (1): 205–291.

———. 2016. The Glyptothorax of Sundaland: A revisionary study (Teleostei: Sisoridae). *Zootaxa* 4188 (1): 1–92.

Ormerod, Steve J., Michael Dobson, Alan G. Hildrew, and C.R. Townsend. 2010. Multiple stressors in freshwater ecosystems. *Freshwater Biology* 55 (S1): 1–4.

Parenti, Lynne R., and Kevin K.P. Lim. 2005. Fishes of the Rajang basin, Sarawak, Malaysia. *The Raffles Bulletin of Zoology* 2005 (Suppl 13): 175–208.

Parenti, Lynne R., and Amy L. Downing Meisner. 2003. Fishes of the Belait River. *Brunei Museum Journal* 10: 17–54.

R Development Core Team. 2013. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Richardson, David M., Patricia M. Holmes, Karen J. Esler, Susan M. Galatowitsch, Juliet C. Stromberg, Steven P. Kirkman, Petr Pyšek, and Richard J. Hobbs. 2007. Riparian vegetation: Degradation, alien plant invasions, and restoration prospects. *Diversity and Distributions* 13 (1): 126–139.

Roberts, Tyson R. 1989. *The freshwater fishes of western Borneo (Kalimantan Barat, Indonesia)*, Memoirs of the California Academy of Sciences Series, no. 14. San Francisco: California Academy of Sciences.

Strayer, David L., and David Dudgeon. 2010. Freshwater biodiversity conservation: Recent progress and future challenges. *Journal of the North American Benthological Society* 29 (1): 344–358.

Strayer, David L., R. Edward Beighley, Lisa C. Thompson, Shane Brooks, Christer Nilsson, Gilles Pinay, and Robert J. Naiman. 2003. Effects of land cover on stream ecosystems: Roles of empirical models and scaling issues. *Ecosystems* 6 (5): 407–423.

Taki, Yasuhiko. 1978. An analytical study of the fish fauna of the Mekong basin as a biological production system in nature. *Research Institute of Evolutionary Biology Tokyo Special Publication* 1: 1–77.

Tan, Heok Hui. 2006. *The Borneo suckers: Revision of the torrent loaches of Borneo (Balitoridae: Gastromyzon, Neogastromyzon)*. Kota Kinabalu: Natural History Publications.

Tan, Heok Hui, and Kevin K.P. Lim. 2007. The freshwater fishes of Binyo-Penyilam and Bukit Sarang conservation areas, Bintulu Division, Sarawak. In *Proceedings of the regional conference of biodiversity conservation in tropical planted forests in Southeast Asia*, ed. Robert B. Stuebing, Joanes Unggang, Jodi Ferner, Jacinta Richard Seling, Belden Giman, John Ferner, and Kee Kum Ping, 79–82. Kuching: Forest Department, Sarawak Forestry Corporation and Grand Perfect.

Turner, Edgar C., Jake L. Snaddon, Robert M. Ewers, Tom M. Fayle, and William A. Foster. 2011. The impact of oil palm expansion on environmental change: Putting conservation research in context. In *Environmental impact of biofuels*, ed. Marco Aurélio dos Santos Bernardes, 19–40. Rijeka: InTechOpen.

Weijters, Maaike J., Jan H. Janse, Rob Alkemade, and Jos T.A. Verhoeven. 2008. Quantifying the effect of catchment land use and water nutrient concentrations on freshwater river and stream biodiversity. *Aquatic Conservation* 19 (1): 104–112.

Wenger, Amelia S., Jacob L. Johansen, and Geoffrey P. Jones. 2012. Increasing suspended sediment reduces foraging, growth and condition of a planktivorous damselfish. *Journal of Experimental Marine Biology and Ecology* 428: 43–48.

Wood, Paul J., and Patrick D. Armitage. 1997. Biological effects of fine sediment in the lotic environment. *Environmental Management* 21 (2): 203–217.

WWF. 2016. *Living planet report 2016: Risk and resilience in a new era*. Gland: WWF International.

Ziv, Guy, Eric Baran, So Nam, Ignacio Rodríguez-Iturbe, and Simon A. Levin. 2012. Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences of the United States of America* 109 (15): 5609–5614.

Part III
Plantations as Social Complexes and Infrastructure

Chapter 14
The Effects of Landscape and Livelihood Transitions on Hunting in Sarawak

Yumi Kato and Hiromitsu Samejima

Abstract Over the last few decades, the landscape of Borneo has drastically changed from primary forests to a mosaic of secondary forests and crop plantations, and more recently to the monocultures of single crop plantations. At the same time, livelihoods have become more linked to urban economies. To evaluate the effects of these changes on hunting activity, 1050 households in 34 villages in the Kemena and Tatau basins in Bintulu, central Sarawak, were studied. Using regression analysis, the importance of landscape type, the proportion of inhabited *bilik* and livelihood activities were analysed as factors affecting hunting activity. Results show that both environmental and social transitions are important factors that influence hunting activities. This research contributes to the understanding of current human–animal relations in view of the increasing expansion of oil palm and tree plantations in insular Southeast Asia.

Keywords Sarawak · Hunting · Plantations · Mosaic landscape · Game animals

14.1 Introduction

The indigenous communities of Southeast Asia, especially Borneo, have had close relationships with wild animals such as the bearded pig and sambar deer (Bennett et al. 2000). These peoples not only consume wild meat in their daily lives but have also accumulated vast knowledge about the animals (Needham 1964; Seitz 2008; Okuno 2012; Kato and Samejima 2013). In Sarawak, most indigenous groups have also relied on swidden cultivation and other agricultural activities for decades, resulting in a variety of vegetation around villages (Ichikawa 2013; Hon and Samejima, Chap. 3). The area surrounding villages that people use in their daily

Y. Kato (✉)
Center for Arts and Sciences, Fukui Prefectural University, Eiheiji, Japan

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_14

lives is called *menua* in the Iban language. Current *menua* include smallholdings of oil palm plantations in addition to conventional paddy fields, fallow forests, natural forests, orchards, vegetable gardens and rubber plantations. Previous research has documented how these man-made landscapes affect the habitats of various animal species (Meijaard et al. 2005; Momose 2006; Samejima and Hon, Chap. 8) and how people have hunted in these habitats (Kato 2014).

Land use in Southeast Asia has been changing rapidly over the past few decades. Natural forests have been degraded by commercial logging since the 1970s and have recently been converted into vast plantations of acacia and oil palm (Cramb 1990, 2007; Sasaki 1999; Potter 2008; McCarthy and Cramb 2009; Cramb and Sujang 2013). Landscapes around rural villages are rapidly turning into monocrop plantations with some villages now totally surrounded by plantations.

These land-use changes affect animal populations and local hunting activities (Duff et al. 1984; Bennett and Gumal 2001; Wadley and Colfer 2004; McShea et al. 2009; Hon and Shibata 2013). Shoko Sakai et al. (2014) reported differences in the number of hunted animals in several areas in Sarawak.[1] However, it is still unclear how and to what extent wildlife is adapting to new habitats, what animal species are being hunted and what factors are influencing changes in local hunting behaviours.

Landscape conversion is not the only factor changing the relationship between people and animals in Borneo. In contemporary longhouse communities in Sarawak, not as many people depend on paddy cultivation as they did previously (Kato and Soda 2012; Kato 2014). Off-farm jobs outside villages and the cultivation of commercial crops have become increasingly important economic activities. Many people have left their villages in rural areas to live in towns where they can obtain a more stable livelihood (Parnwell and King 1998; Soda 2001; Bala 2007; Ichikawa 2011; Soda and Kato, Chap. 17). Even those who continue to live in villages participate in new agricultural activities, especially oil palm cultivation, and may no longer have time to hunt. It can be assumed therefore that the number of people living and hunting in village areas of Sarawak has correspondingly decreased in comparison to previous decades. It is possible that these recent transitions have resulted in a substantial change in hunting activity, regardless of the stability of wild animal populations.

This chapter investigates the relationship between landscape variation (especially that caused by plantation expansions and changes in livelihood activities) and hunting activities in Bintulu Division. The objectives of the chapter are as follows: (1) to identify the current variation of livelihood activities of local communities in the region; (2) to identify the major game animals and hunting methods; (3) to examine the changes in livelihood activities and game animal populations over recent decades; and (4) to examine environmental and social factors affecting the number of hunted bearded pigs (*Sus barbatus*), which is the most important game animal in Borneo (Caldecott 1988). Interviews were con-

[1] 'Hunted animals' here refers to animals which were successfully captured by hunters.

ducted in 34 villages surrounded by various landscape types ranging from natural forests to plantations.

This research has four unique characteristics. First, the study area includes multiple landscapes in an entire river basin and therefore considers the variation of landscapes, hunting and livelihood activities of the whole river system. Second, in contrast to previous studies conducted in natural forests, this research focuses on new landscapes, including plantations. It is obvious that natural forests are decreasing and the expansion of monocrop plantations has accelerated rapidly in many regions in the world, especially in Malaysia. Various landscapes, including oil palm and acacia plantations, fallow forests, natural primary forests and mixed vegetation areas were therefore studied. This research contributes to understandings of the dynamics of human–animal relations within these transitional landscapes, which are increasingly found throughout tropical countries in Asia, Africa and South America. Third, the research considers both the ecological and social consequences of transitional landscapes. Quantitative analysis using statistical data was combined with qualitative narratives collected through interviews to clarify what factors are affecting hunting activities. Fourth, we investigated whether hunting and livelihood activities differed among each ethnic group by conducting interviews among the Iban, Bekatan, Punan Bah, Kayan, Penan and Tatau. As described in Kato et al., Chap. 5, villages in this region have a multiethnic composition.

14.2 Study Area and Methods

14.2.1 Scope of Study

This study was conducted in the Kemena and Tatau basins in Bintulu Division, Sarawak (Figs. 14.1 and 14.2). Two to 10 villages in each of the major landscape types in this region were selected. These landscape types comprise natural forests, secondary forests after shifting agriculture (fallow forests), acacia plantations and oil palm plantations. Interviews were conducted with 1050 households in 34 villages. The major ethnic groups in the villages were the Iban (23 villages), Penan (three villages, of which two villages are mixed with Iban), Punan Bah (three villages), Bekatan (two villages), Kayan (two villages) and Tatau (one village which is mixed with Iban). Interviews were conducted in August 2011 and in March, July and August 2012.

Structured interviews were conducted with the village chief and village residents using a questionnaire. Villages in the study area were made up of longhouses which are called *rumah*. Separate units within the longhouse are called *bilik*, usually occupied by one household. Interview questions covered the major vegetation types surrounding the village, the total number of *bilik* in the village, the number of inhabited *bilik*, major livelihood activities, hunting methods and the number of animals hunted in the village in the past year. An inhabited *bilik* was defined as one in which a

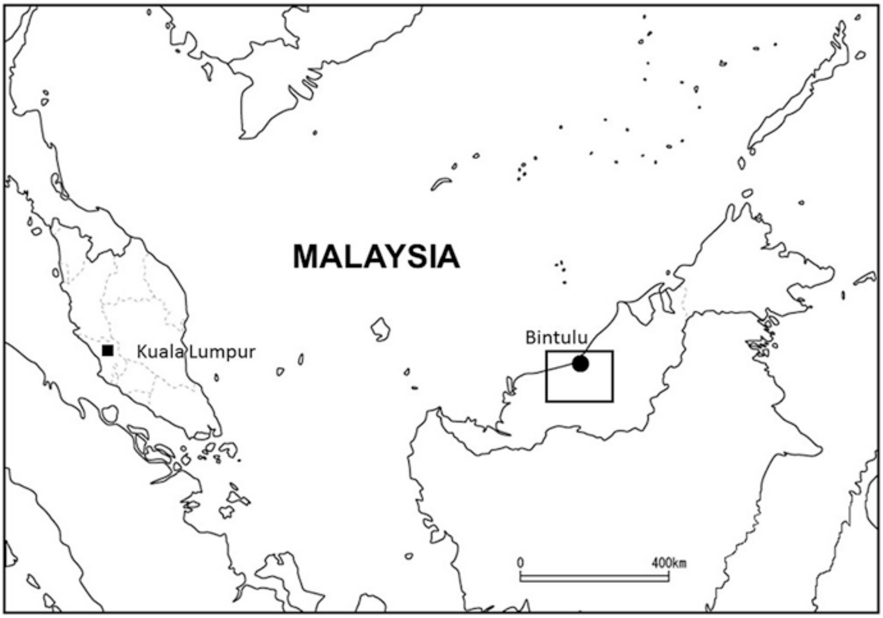


Fig. 14.1 Location of the study area
Source: Author's field research

household member or members stay once a month or more. An uninhabited *bilik* was defined as one in which household member(s) return to the village less frequently than once per month. Livelihood activities included paddy, oil palm, rubber and pepper cultivation, and off-farm jobs outside the village, such as at logging or plantation companies or in town. Other livelihood activities considered important to the villages were also studied in detail.

Interviews about hunting included questions about the number of animals hunted in the past month and in the past year, with a focus on popular game species including the bearded pig (*Sus barbatus*) (Fig. 14.3), the sambar deer (*Rusa unicolor*) (Fig. 14.4), the barking deer (*Muntiacus muntjac* and *Muntiacus atherodes*) (Fig. 14.5), the mouse deer (*Tragulus napu borneanus* and *Tragulus kanchil*) (Fig. 14.6) and monkeys. Hunting methods and locations, times and tools employed as well as population differences of the major game species between the 1980s and the time of the interview were also investigated in addition to agricultural damage caused by animals. Illustrations of animals from *A field guide to the mammals of Borneo* (Payne and Francis 1985) were used in the interviews.

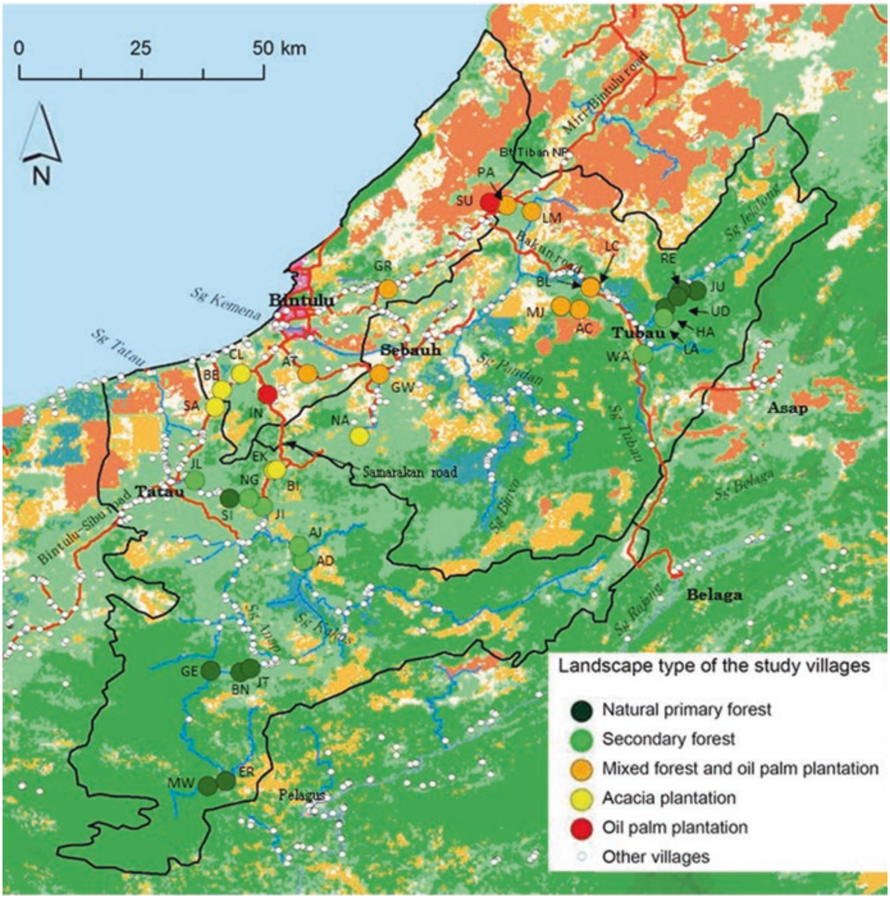


Fig. 14.2 Locations of the study villages with various landscape types surrounding each village
Source: Author's field research

14.2.1.1 Landscape Types

All interviewed villages were categorised into five groups according to the landscape type surrounding the village. The landscape type was determined according to the dominant vegetation in a 3–5-km radius around the village. This distance was chosen because it is the usual hunting range of villagers. Vegetation surrounding villages was identified by: (1) a Landsat image taken in 2009; (2) on-site observations; and (3) information provided by the villagers. The names of the study villages

Fig. 14.3 Bearded pig (*Sus barbatus*). (Photograph: Hiromitsu Samejima 2012)

Fig. 14.4 Sambar deer (*Rusa unicolor*). (Photograph: Hiromitsu Samejima 2011)

Fig. 14.5 Barking deer (*Muntiacus muntjac* and *Muntiacus atherodes*). (Photograph: Hiromitsu Samejima 2011)

Fig. 14.6 Mouse deer (*Tragulus napu borneanus* and *Tragulus kanchil*). (Photograph: Hiromitsu Samejima 2011)

and landscape types that surround them are summarised in Table 14.1. A 'natural primary forest' was defined as a primary or a selectively logged forest. Secondary forests, which are fallow forests regrown after swidden cultivation, were not included the category of natural primary forest. The five landscape types are:

Table 14.1 Study villages and the surrounding landscape types

Surrounding landscape type	Village name	Major ethnic group	Number of *bilik*
Natural primary forest	SI	Iban	12
	HA	Punan Bah	20
	UD	Penan, Iban	27
	RE	Penan	14
	JU	Penan, Iban	21
	JT	Bekatan	32
	BN	Bekatan	20
	GE	Iban	23
	ER	Iban	12
	MW	Iban	20
Secondary forest	JL	Tatau, Iban	17
	NG	Iban	43
	JI	Iban	57
	AJ	Punan Bah	58
	AD	Punan Bah	116
	WA	Kayan	75
	LA	Kayan	23
Mixed forest and oil palm plantation	AT	Iban	11
	PA	Iban	20
	LM	Iban	65
	MJ	Iban	26
	AC	Iban	19
	GW	Iban	17
	GR	Iban	43
	BL	Iban	17
	LC	Iban	17
Acacia plantation	CL	Iban	19
	BE	Iban	30
	SA	Iban	33
	NA	Iban	20
	EK	Iban	12
	BI	Iban	25
Oil palm plantation	SU	Iban	35
	IN	Iban	16

Note: The number of *bilik* for each longhouse was based on fieldwork and interviews conducted in 2012
Source: Author's field research

1. *Natural primary forest areas: 10 villages*
   These villages are in an area mostly covered with natural primary forest (see Fig. 14.7). This category mainly includes villages in the upper Anap River and upper Jelalong River. Although located downstream of the Tatau River, SI village is also classified in this group because the surrounding terrain is precipitous and selective logging concessions remain.
2. *Secondary forest areas: seven villages*
   These villages are in an area mostly covered with secondary forests that have regrown after swidden cultivation (see Fig. 14.8). These are also known as fallow forests. Villages along the Tatau River and downstream of the Kakus River and the Tubau River both fall into this group.
3. *Mixed forest and oil palm plantation areas: nine villages*
   These villages are in areas where secondary forests and natural forests are mixed with oil palm plantation areas (see Fig. 14.9). Plantation areas include both plantations and smallholdings. Villages along the Miri–Bintulu, Bakun and Sebauh roads belong to this category. Although a village along the Miri–Bintulu road is surrounded by oil palm plantations, it was placed in this category because hunting often takes place in boundary area between Bukit Tiban National Park and an oil palm plantation.

Fig. 14.7 Village in an area mostly covered with natural forest. (Photograph: Yumi Kato 2011)

Fig. 14.8 Secondary forest area or fallow forest after swidden cultivation. (Photograph: Yumi Kato 2012)

Fig. 14.9 Area with mixed forest and oil palm plantations. (Photograph: Yumi Kato 2012)

Fig. 14.10 Acacia plantation. (Photograph: Hiromitsu Samejima 2013)

4. *Acacia plantation areas: six villages*
   These villages are in areas that are covered with acacia plantations (see Fig. 14.10). Villages along the Tatau–Bintulu road and the Samarakan road belong in this category.
5. *Oil palm plantation areas: two villages*
   These villages are in areas predominantly covered by oil palm plantations (see Fig. 14.11). Villages along the Miri–Bintulu road and the Samarakan road that adjoin oil palm plantations were grouped into this category.

14.2.2 Statistical Analysis

To understand the factors influencing the number of bearded pigs hunted annually, a multiple regression model was developed and we conducted a model selection using Akaike information criterion (AIC). From the data collected, five variables were selected:

A. Number of bearded pigs hunted in the past year
B. Surrounding landscape type
C. Proportion of inhabited *bilik*
D. Proportion of paddy cultivation households
E. Proportion of oil palm cultivation households

Fig. 14.11 Oil palm plantation. (Photograph: Yumi Kato 2012)

A full model was constructed as A~B + C + D + E. Using AIC, a set of variables among B–E were selected that best explain A. AIC is a measure of model quality. The model with the lowest AIC can be considered to have the highest relative quality among the models compared. The correlation among the five variables was also tested. The correlation of four continuous variables (A, C, D and E) with landscape types (B) was tested with a Kruskal-Wallis test and the correlation among four continuous variables (A, C, D and E) was tested by a t-test. The level of significance used was $p < 0.05$. All statistical analysis was conducted using the statistical software R (version 3.0.0; R Development Core Team 2013). Answers to some questions were not obtained in all villages. In such cases, the total number of responding villages is noted.

14.3 Results

14.3.1 Total Number of *Bilik* and the Proportion of Inhabited *Bilik*

In the 34 villages, the number of *bilik* per village ranged from 11 to 116, with an average of 29.9. The percentage of inhabited *bilik* ranged from 21% to 100%, with an average of 72%. Uninhabited *bilik* are the result of villagers working outside the village, in Bintulu, Tatau or other cities in Sarawak, in other states or even overseas. Some villagers also are working in logging camps and oil palm plantations.

The average percentage of inhabited *bilik* was the highest (87%) in areas with mixed natural forest and oil palm plantations (Fig. 14.12). This was followed by oil palm areas with the average rate of 79%. The villages in this landscape type are closest to Bintulu town. The third highest average percentage (78%) was recorded in natural forest areas, which are furthest from town. On the other hand, the average percentage of inhabited *bilik* was lowest (46%) in secondary forest areas, which are a moderate distance from town (Fig. 14.13).

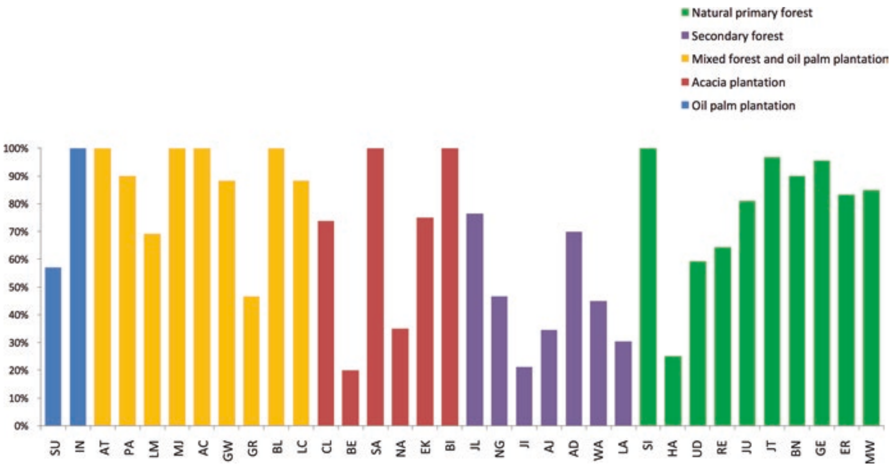


Fig. 14.12 Percentage of inhabited *bilik* in each village, grouped by the surrounding landscape type
Source: Author's field research

Fig. 14.13 JI village, where the proportion of inhabited *bilik* was one of the lowest among the study villages. (Photograph: Hiromitsu Samejima 2012)

14.3.2 Livelihood Activities

The combination of livelihood activities varied across the study villages. Below are the main livelihood types.

14.3.2.1 Paddy Cultivation

The proportion of paddy cultivation households substantially varied among the 34 villages. Paddy was still cultivated in 27 villages (Fig. 14.14). In total, 31% of all households cultivated paddy in 2012, although the percentage of households varied greatly between villages, ranging from 4% to 100%. Wet paddy cultivation was more common in downriver villages such as SA, IN and GW villages, while dry paddy cultivation was common on inland hills. Paddy cultivation was particularly popular in the upstream areas of the Anap River. In addition, paddy cultivation was practised in all households in SA village along the Tatau–Bintulu road, in BI village along the Samarakan road, and in SI village along the Tatau River.

The proportion of paddy cultivation households did not significantly correlate with the surrounding landscape type (Kruskal-Wallis test, $p < 0.05$). Even in the areas closest to oil palm plantations and Bintulu, the proportion of paddy cultivation households was high in some villages, such as GW and IN villages. On the other

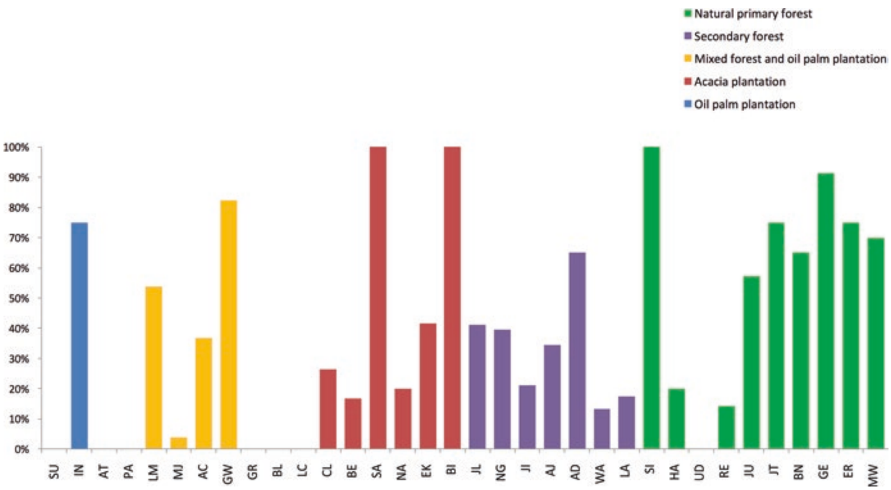


Fig. 14.14 Percentage of households cultivating paddy in each village, grouped by the surrounding landscape type
Source: Author's field research

hand, the proportion was not high in some villages located relatively far from Bintulu and surrounded by natural forest, such as HA and JI villages.

Factors contributing to the decline of paddy cultivation were the increase in oil palm smallholdings and opportunities for off-farm jobs. In four out of the seven villages not cultivating paddy at all, more than 85% of households were involved in oil palm cultivation. In the other three villages, off-farm jobs outside the village were popular and the proportion of inhabited *bilik* was low. In addition, only a few households farmed paddy in the villages along the Bakun road and in the Sebauh basin. The seven villages in which no one cultivated paddy are located around the junction of the Miri–Bintulu and Bakun roads. People in these areas reported that damage by sparrows flying from coastal regions caused serious damage to the paddy crops, if only a few households cultivate paddy. Therefore, these villages decided to stop cultivating paddy completely.

14.3.2.2 Oil Palm Cultivation

Oil palm cultivation was undertaken in 27 of the 34 villages (Fig. 14.15). In total, 34% of all households cultivated oil palm in 2012, slightly exceeding the proportion of those cultivating paddy. Oil palm cultivation began in these villages between 2005 and 2012. Inhabitants of IN, MJ and other villages cited oil palm as their most important agricultural activity. The proportion of households that cultivate oil palm in the 27 villages ranged from 5% to 100%, with an average of 51%. Oil palm cultivation was especially popular in villages around Tubau, along the Samarakan road

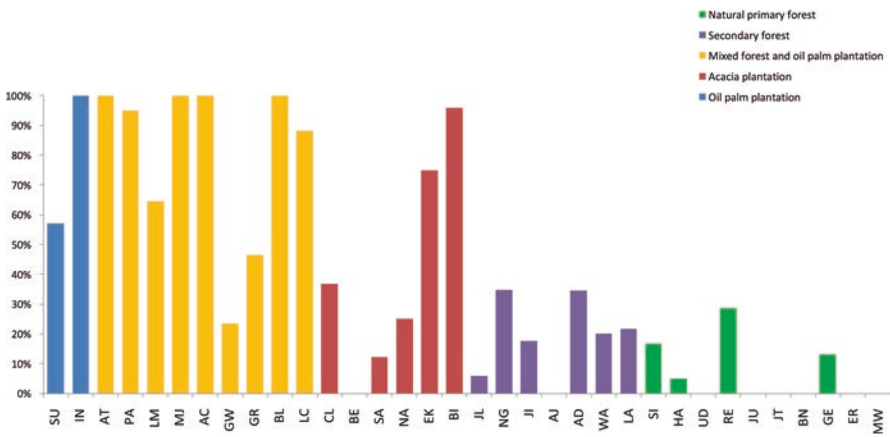


Fig. 14.15 Percentage of households cultivating oil palm in each village, grouped by the surrounding landscape type
Source: Author's field research

and along the Sebauh road. In five villages, all the households were involved in oil palm cultivation and in eight villages more than 80% of households were involved. However, the proportion of households cultivating oil palm was low in natural primary forest and secondary forest areas.

14.3.2.3 Rubber Farming

Households in 15 villages were engaged in tapping rubber and in total they represented only 9% of all households (Fig. 14.16). Tapping rubber was once very popular in Sarawak and many villagers in Bintulu Division planted the seedlings around their villages in the past (Cramb and Dian 1979). However, due to the low market price the popularity of rubber tapping has decreased in recent decades. However, villagers reported that the price of rubber was improving, fetching between RM4.50 and RM10 per kg in 2012.[2] Many villagers also explained they stopped tapping rubber because of termite infestations while others mentioned that it was inconvenient to access rubber gardens as they were located around their former longhouses near the river, but the longhouses had since been moved to the roadside. Many villagers still keep rubber trees even though they do not collect the sap, intending to begin tapping when the prices increase further. In addition, some villagers along the Anap River and in the Tubau area were starting to plant a new variety of rubber seedlings when this research was conducted in 2012. This was a new project implemented by the state's agriculture department (Wong 2011).

[2] RM1 was equivalent to approximately US$0.25 to US$0.32 in 2012.

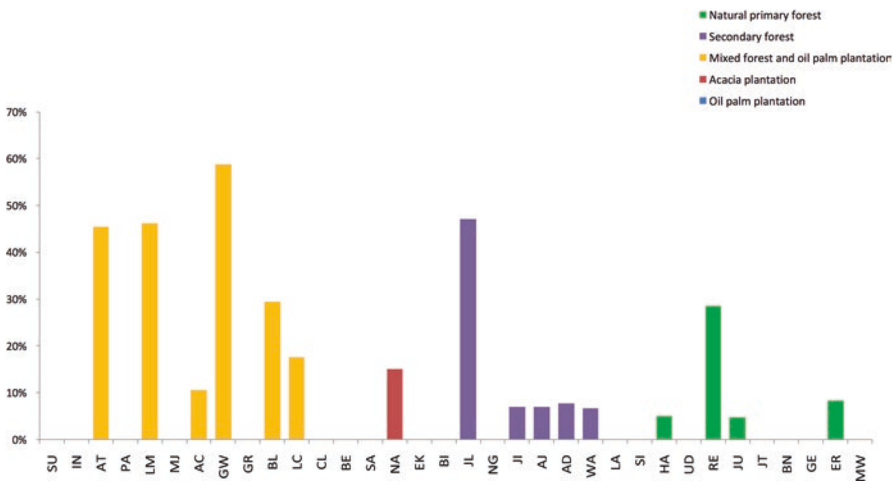


Fig. 14.16 Percentage of households cultivating rubber in each village, grouped by the surrounding landscape type
Source: Author's field research

14.3.2.4 Other Livelihood Activities

Pepper (*Piper nigrum*) was cultivated in only four villages (Fig. 14.17). Fewer than 2% of all households in this research cultivated the plant. Pepper—both white and black—was reported as a main income source in PA village along the Miri–Bintulu road. Pepper was once a very popular cash crop in Sarawak until the 1990s. Difficulties in cultivation and a spike in fertiliser prices caused many to give up on the crop in recent years.

The study found that vegetable and fruit cultivation was very popular in AT village along the Silas River. Villagers cultivated pineapple, cassava and other vegetables intensively, selling them at the local market in Bintulu. Pineapples from this area are called '*nanas silas*' and are one of the most famous varieties in Sarawak, making pineapple cultivation an important income source in the area. Some people in PA and LM villages also cultivated vegetables such as sweet leaf (*Sauropus androgynous*), pumpkin and cassava for sale.

Apart from agriculture, people in several villages in the upper Anap and Jelalong river areas actively fished for their livelihood. Rattan handicraft production was popular in SI, BN and JT villages along the Tatau basin, where natural rattan still existed in the surrounding forests. The SI villagers made rattan products and sold them in the market in Tatau. However, rattan was no longer collected in most of the villages. Timber production, especially of *belian* (ironwood) trees, and collecting *engkabang* or illipe nuts (from *Shorea* trees) were once common in this region, but few were engaged in either activity at the time of this research. The people in MW village collected illipe nuts once in 2011 but said that Chinese traders did not buy them anymore.

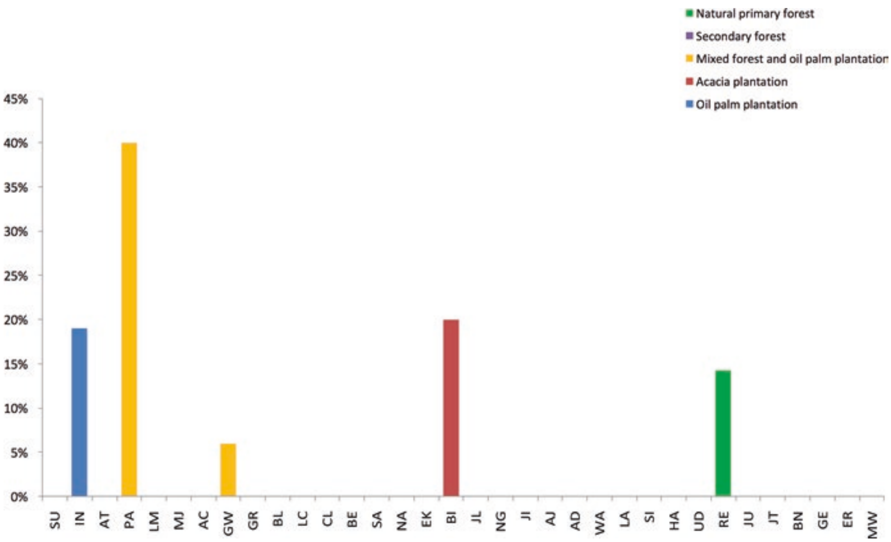


Fig. 14.17 Percentage of households cultivating pepper in each village, grouped by the surrounding landscape type
Source: Author's field research

14.3.3 Hunting

14.3.3.1 Major Game Animals

The bearded pig (*Sus barbatus*) was the most hunted animal in the 34 study villages. In 32 villages, an average of 8.6 bearded pigs were hunted during the previous year (Fig. 14.18). In MJ and JT villages information was not available for the whole year, but villagers reported that two and four bearded pigs were hunted respectively in the week prior to the interviews. In 26 of the 32 villages, at least one bearded pig had been hunted during the past year while no bearded pigs had been hunted in eight of the villages. In particular, hunters in BE, SA and NA villages along the Tatau–Bintulu road had not hunted bearded pigs for nearly 10 years.

The sambar deer (*Rusa unicolor*) was the second most hunted animal and information on sambar deer was collected from 28 villages (Fig. 14.19). In JU village, villagers merely reported that 'many' sambar deer were hunted in the past year. In the other 27 villages, the average hunt number was 5.2. People in 16 villages reported hunting sambar deer in the past year while none had been hunted over the past year or more in the other 12 villages. In AJ village, sambar deer were not hunted because the local people believe that eating their meat causes joint pain.

The number of barking deer (*Muntiacus muntjac* and *Muntiacu atherodes*) and mouse deer (*Tragulus napu borneanus* and *Tragulus kanchil*) that had been hunted was fewer, with only six out of 25 villages and six out of 20 villages reporting any successful hunts of barking deer or mouse deer in the past year, respectively

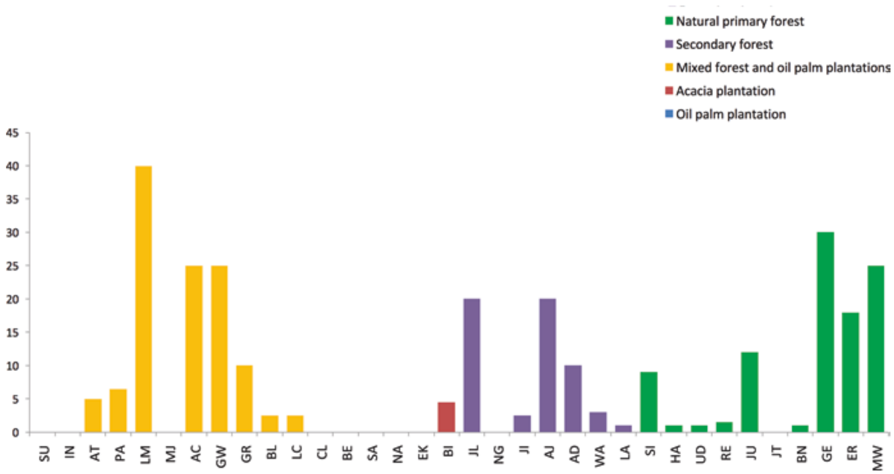


Fig. 14.18 Number of bearded pigs hunted in the last year with the surrounding landscape type of each village.
Source: Author's field research

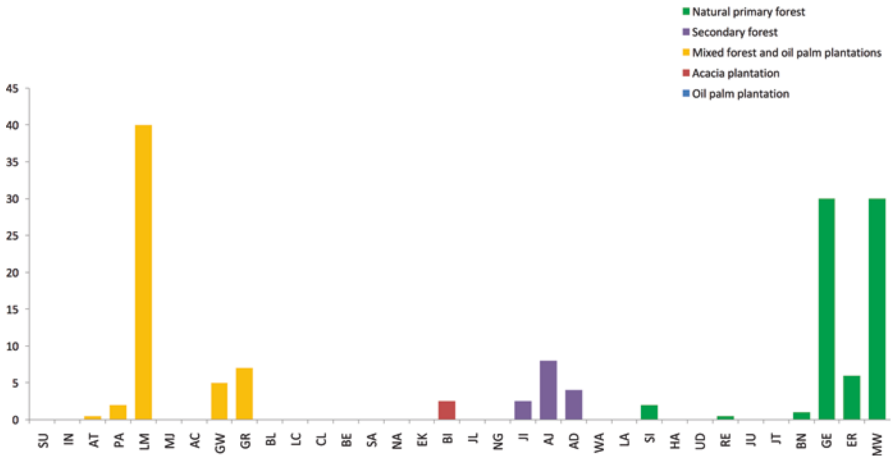


Fig. 14.19 Number of sambar deer hunted in the last year with the surrounding landscape type of each village
Source: Author's field research

(Figs. 14.20 and 14.21). Though the average of barking deer hunted in the previous year in five of the villages was altogether low, more than 20 barking deer were hunted in MW village, located the furthest upstream along the Anap River. While mouse deer were hunted in only six villages, the average number hunted in the previous year in these six villages was over 10, indicating a large gap in the number hunted between villages where mouse deer hunting is active and those where it is not.

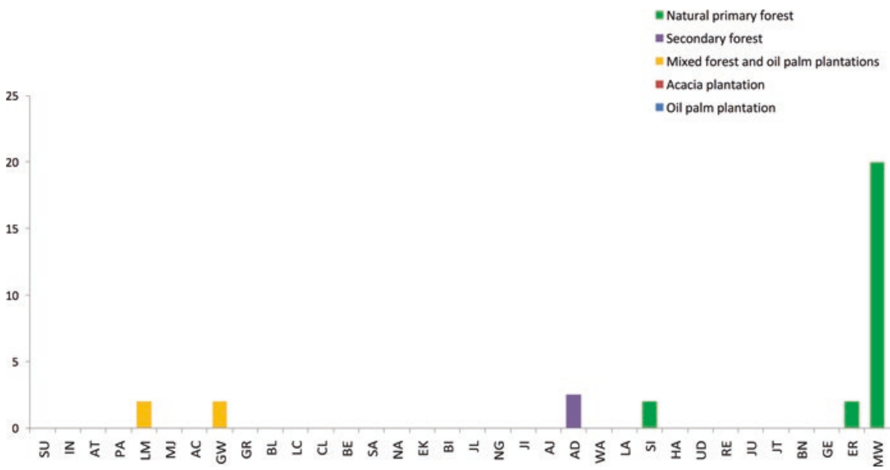


Fig. 14.20 Number of barking deer hunted in the last year with the surrounding landscape type of each village
Source: Author's field research

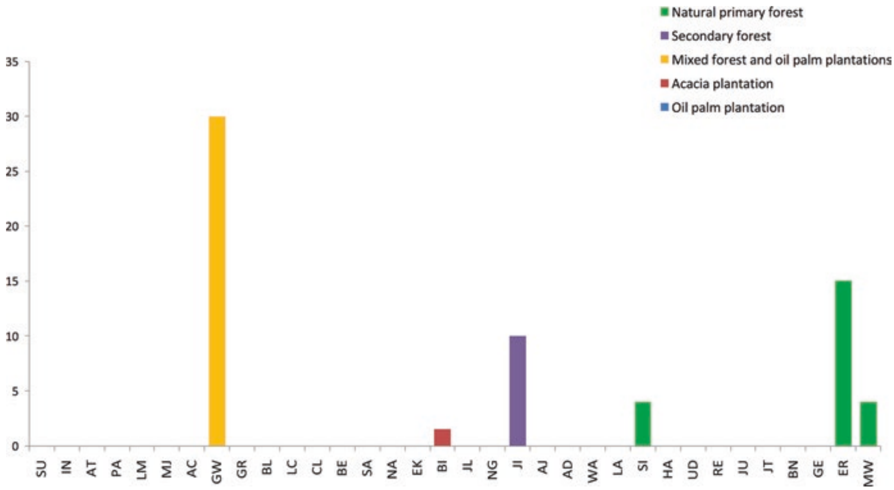


Fig. 14.21 Number of mouse deer hunted in the last year with the surrounding landscape type of each village
Source: Author's field research

14.3.3.2 Hunting Methods

Guns, snares and nets were the major hunting tools used. The most common method, practised in 17 out of 20 responding villages, was hunting with guns. In some villages, hunting dogs assisted with gun hunting. The second most popular hunting method after guns was snare hunting (*panjuk* in Iban). This method was used in nine

Table 14.2 Combinations of hunting methods employed in each village (N = 20)

Hunting tools	Number of villages
Gun	7
Gun + snare	3
Gun + snare + dog	2
Gun + snare + dog + net	2
Gun + dog + spear + box	2
Gun + snare + net	1
Gun + dog	1
Gun + net	1
Snare	1
Net	1

Source: Author's field research

Table 14.3 Means of access to hunting sites (N = 10)

Means of access to hunting sites	Number of villages
Foot + boat	3
Foot	2
Foot + boat + motorbike	2
Foot + boat + car	1
Motorbike	1
Foot + car	1

Source: Author's field research

out of 20 villages, particularly for hunting in oil palm plantations. A new hunting method with nets (*pukat* in Iban) was used in five villages along the Sebauh and Tatau rivers. The nets have a larger mesh (10–15 cm across) than the gill nets used for fishing. Nets were also set in acacia plantations. In JL, MJ, NA and several other villages, snare and net hunting alone were conducted. Only one village in the upper Anap River used spears (*sangkuh* in Iban) and box traps (*bubung* in Iban) for hunting. Spear hunting was once a popular method before the use of guns. Box traps were also employed for trapping monkeys. Combinations of hunting methods employed in the villages varied (Table 14.2).

Hunting frequency varied from daily to once a week, once a month and once a year, depending on the availability of the hunters' time. Hunting was mostly conducted during the night in many villages, while day hunting was done with hunting dogs. Most people went hunting on foot, while motorcycles and cars were also used in logging concessions and oil palm and acacia plantation areas (Table 14.3).

Hunting sites accessible by foot were mostly neighbouring natural primary and secondary forests around the villages, but the use of motorcycles and cars allows villagers to hunt in areas further afield. Road networks facilitate hunting activities; for example, people in PA village who used to go hunting in nearby natural forests on foot now bring their motorcycles and hunt in plantation areas. Bringing game back to the villages on motorcycles is much easier than on foot.

14.3.3.3 Hunting Locations

In 12 villages where hunting activity was significant, the most frequent hunting location was natural primary forests, followed by secondary forests, paddy fields, rubber plantations and oil palm plantations (Fig. 14.22). Sambar deer and barking deer in particular were mostly hunted in natural primary and secondary forests, but less in oil palm and acacia plantations. GW villagers explained that people from other areas also come to hunt in the neighbouring forests because their own villages are surrounded by oil palm plantations and no forests remain.

Bearded pigs were hunted mainly in natural primary forests, especially around the time when small jackfruits ripen. Bearded pigs, in contrast to other game species, were also actively hunted in oil palm plantations. Hunters often catch pigs in the boundary area between oil palm plantations and natural forests, as the pigs come out of the forests at night to feed in the plantations. Villagers along the Miri–Bintulu road reported frequently hunting along the boundary of oil palm plantations and the Bukit Tiban National Park. GW villagers also explained that they hunt in nearby remnant forests around the villages because the pigs often move between the

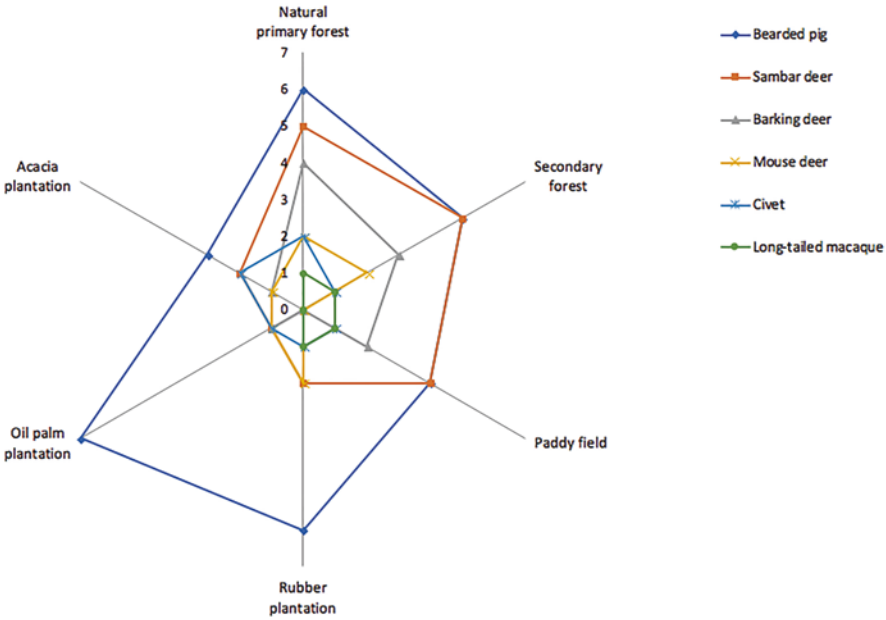


Fig. 14.22 Number of villages reporting each landscape type as a hunting site for six major game animals (total number of reporting villages = 12)
Source: Author's field research

remnant forests and neighbouring plantations. These small zones of remnant forests are known as *pulau* (island) (see Takeuchi et al., Chap. 21). In PA village along the Miri–Bintulu road a unique hunting method was employed; hunters there use oil palm fruits as bait, placing them on the forest floor and then waiting in a tree above for animals to come and feed on the fruit.

Hunting in oil palm plantations was also practised in the villages along the Sebauh River, the upper Labang River and others in mixed areas. Hunters usually set snares but due to safety concerns for plantation workers did not use guns in oil palm plantations.

In some villages such as AJ, GW and SI, people reported hunting bearded pigs in rubber gardens, as many bearded pigs came to the gardens after fruiting begins. People in GW and SI villages also hunted sambar deer. AD villagers reported hunting bearded pigs in cassava gardens.

Acacia plantations were the least popular hunting sites. In villages close to acacia plantations, such as AJ village, people rarely hunted because they did not expect to find many animals. However, in other villages, such as JL and SI, downstream along the Tatau River, people have learned that bearded pigs feed on acacia fruits in the plantations. They thus undertook snare hunting in the acacia plantations. According to SI villagers, along the lower Tatau River, while sambar deer do not come to oil palm plantations, they sometimes come to acacia plantations to feed on the young leaves. They also estimated that more sambar deer than bearded pigs inhabited the acacia plantations. Sambar deer were also reported to visit paddy fields after the harvest to eat paddy leaves.

14.3.4 Factors Influencing the Number of Animals Hunted

14.3.4.1 Landscape Type

There was a strong correlation between the number of wild animals hunted and the major landscape types around the village and in this section this relationship for bearded pigs, sambar deer, and other animals is discussed. The differences in hunting methods by landscape type are examined.

Bearded Pig As indicated in Fig. 14.18, the number of bearded pigs hunted was highest in villages in areas with mixed forest and oil palm plantation, followed by natural primary forest areas. The average number of hunted animals in the previous year by landscape type was 14.6 in the mixed area and 10.9 in the natural forest area, followed by 8.1 in the secondary forest area. The number was lowest in acacia and oil palm areas, at 0.8 and 0.0, respectively.

Hunting in natural primary forest areas was particularly popular upstream of the Anap River, adjacent to logging concessions. In this area, villagers not only walk through forests with their dogs looking for animals during the day but they also take motorcycles at night to hunt animals crossing the logging roads. In this area, villagers informed us that the number of successful hunts varies substantially depending on the year. In lowland and hill regions of Borneo such as this, the dominant natural forest type is a mixed dipterocarp forest. It is known that in this type of forest, *Dipterocarpus* trees and many other tree species from several genera blossom synchronously and bear fruit once every several years in what is known as a mast fruiting season. The fruit of these trees are a major food source for bearded pigs in primary forests, and they therefore proliferate in these years of high fruit production. People in upper Anap River near MW village reported that about five bearded pigs were successfully hunted in normal years and 20 to 30 in a mass fruiting year. The number of successful hunts was highest in areas of mixed forest with oil palm plantations, due to the phenomenon of hunting at the boundary of these two landscape types.

On the other hand, hunting had not been practised in the past several years in regions predominantly covered by acacia and oil palm plantations with little natural primary or secondary forests remaining near the village. In PA village, located in an area with mixed forests and oil palm plantations, villagers explained that the highest numbers of bearded pigs were hunted around 2004 and 2005 when oil palm plantations were expanding but natural primary forests still remained nearby. Subsequently, the number of hunted bearded pigs has declined as these forests became extremely sparse and plantations became the dominant vegetation.

Sambar Deer In Fig. 14.19, it is clear that the overall number of sambar deer hunted was lower than that of bearded pigs. The average number hunted by landscape type was highest in the natural primary forests at 9.9, followed by 6.8 in the secondary forests, and 3.6 in the mixed forest and oil palm areas. The lowest numbers of sambar deer hunted were in villages in the acacia and oil palm plantations, where the numbers were 0.4 and 0.0, respectively.

Other Animals Hunting of barking deer and mouse deer was even more limited to natural primary forests than it was for bearded pigs and sambar deer. In the oil palm and acacia plantations, these animals had not been successfully hunted over the past year or longer, except in BI village, where at least one mouse deer was hunted in the previous year. In the mixed forest and oil palm areas, barking deer were reported to be hunted in only two out of the seven responding villages, and mouse deer in only one out of the four responding villages. This result is different from bearded pigs, because the majority of them were hunted in this mixed vegetation habitat. In the secondary forests, both barking deer and mouse deer were hunted in only one out of the four responding villages. In contrast, in the natural primary forests, four out of the six responding villages and four out of the five responding villages reported successful hunts of at least one barking deer or mouse deer respectively. Hunting of civets or long-tailed macaques was much more limited with only a few villages engaged in hunting these animals.

14.3.4.2 Livelihood Activities

In this section, the effects of livelihood activity and landscape type on the number of bearded pigs hunted in the previous year are examined using model selection. The model selection was conducted for data from 32 villages where a full data set was obtained. According to the findings, the number of bearded pigs hunted during the past year is best explained by landscape type and the proportion of paddy and oil palm cultivating households (AIC = 221.1). The landscape type and the proportion of paddy cultivating households correlated significantly with the number of successful hunts (Kruskal-Wallis test, $p < 0.05$), with a high number correlating to a mixed vegetation landscape and a high proportion of paddy cultivating households. The number was slightly lower in acacia landscapes with a high proportion of oil palm farming households. As landscape type and the proportion of paddy cultivation households of the 32 villages were not significantly correlated (Kruskal-Wallis test, $p < 0.05$), the two variables were independently related to the number of bearded pigs hunted in the past year. The proportion of inhabited *bilik* was not selected as an explanatory factor due to its low correlation.

The respective conditions of the livelihood activities are described below with possible explanations for their relationship with the number of bearded pigs hunted in the past year.

Relationship Between Paddy Cultivation and Hunting In addition to landscape type, the proportion of paddy cultivating households in a village also correlated to the number of bearded pigs hunted in mixed forest and oil palm plantation areas, natural primary forests and secondary forests. In the eight villages where more than 70% of households cultivated paddy, the number of bearded pigs hunted in the past year was 15.9, substantially exceeding the average of 8.2. In contrast, in the nine villages where fewer than 10% of households practised paddy cultivation, the average number of bearded pigs hunted in the past year was only 3.1.

Relationship Between Oil Palm Cultivation and Hunting The proportion of oil palm cultivating households was also selected as a weak explanatory factor for the number of bearded pigs hunted. This number in the previous year was slightly lower when the proportion of oil palm cultivating households was high. The average number of bearded pigs hunted in the past year was 5.75 in the eight villages around the Tubau, Samarakan and Sebauh roads, where more than 70% of households were involved in oil palm cultivation. This was slightly less than the average of all villages. In contrast, in the nine villages where fewer than 10% of households cultivated oil palm, the average number of bearded pigs hunted in the past year was closer to the overall average, at 8.7.

Relationship Between the Proportion of Inhabited* Bilik *and Hunting As mentioned earlier, the proportion of inhabited *bilik* was not selected as an explanatory factor for the number of bearded pigs hunted in the previous year. Some villages, for example BN and JT villages located in natural primary forest areas, had a high proportion of inhabited *bilik*, but not many villagers hunt and thus the number of bearded pigs hunted was low. On the other hand, the proportion of inhabited *bilik* was high in BL and LC villages but the number of bearded pigs hunted was not. This is because usually only elderly people or women stayed in these villages while most of the younger villagers were working in cities.

14.3.5 Perceptions of Animal Population Trends

Table 14.4 shows how people in 23 villages perceived changes in the populations of eight animal species in 2012 compared to the 1980s, though not all villages gave an opinion for each species and its population trend. All informants believed that the number of sambar deer and barking deer had decreased, but some reported that the populations of mouse deer, southern pig-tailed macaque, long-tailed macaque, civet and porcupine had not changed. This view was observed particularly in villages located in natural primary forests, secondary forests, mixed forests and oil palm areas (Fig. 14.23). However, all informants in acacia plantation areas reported decreases in animal populations. In addition, two villages (AD village in a secondary forest and GR village in a mixed forest and oil palm area) reported that the mouse deer was becoming extinct.

Most people pointed to the decrease or degradation of forests as the reason for the declining animal populations; they explained that after large-scale logging operations began animal populations declined. On the other hand, most people did not consider the expansion of plantations as directly affecting the animal population, explaining that the number of animals had already declined due to past commercial logging. However, in SU and IN villages, which are both surrounded by oil palm

Table 14.4 Number of villages reporting perceived changes in animal population trends compared to the 1980s

	Perceived changes in in animal population trends		
Game animal	Increasing	No change	Decreasing
Bearded pig	1	0	17
Sambar deer	0	0	16
Barking deer	0	0	18
Mouse deer	0	3	11
Southern pig-tailed macaque	2	5	6
Long-tailed macaque	0	3	8
Civet	0	4	8
Porcupine	0	3	9

Source: Author's field research

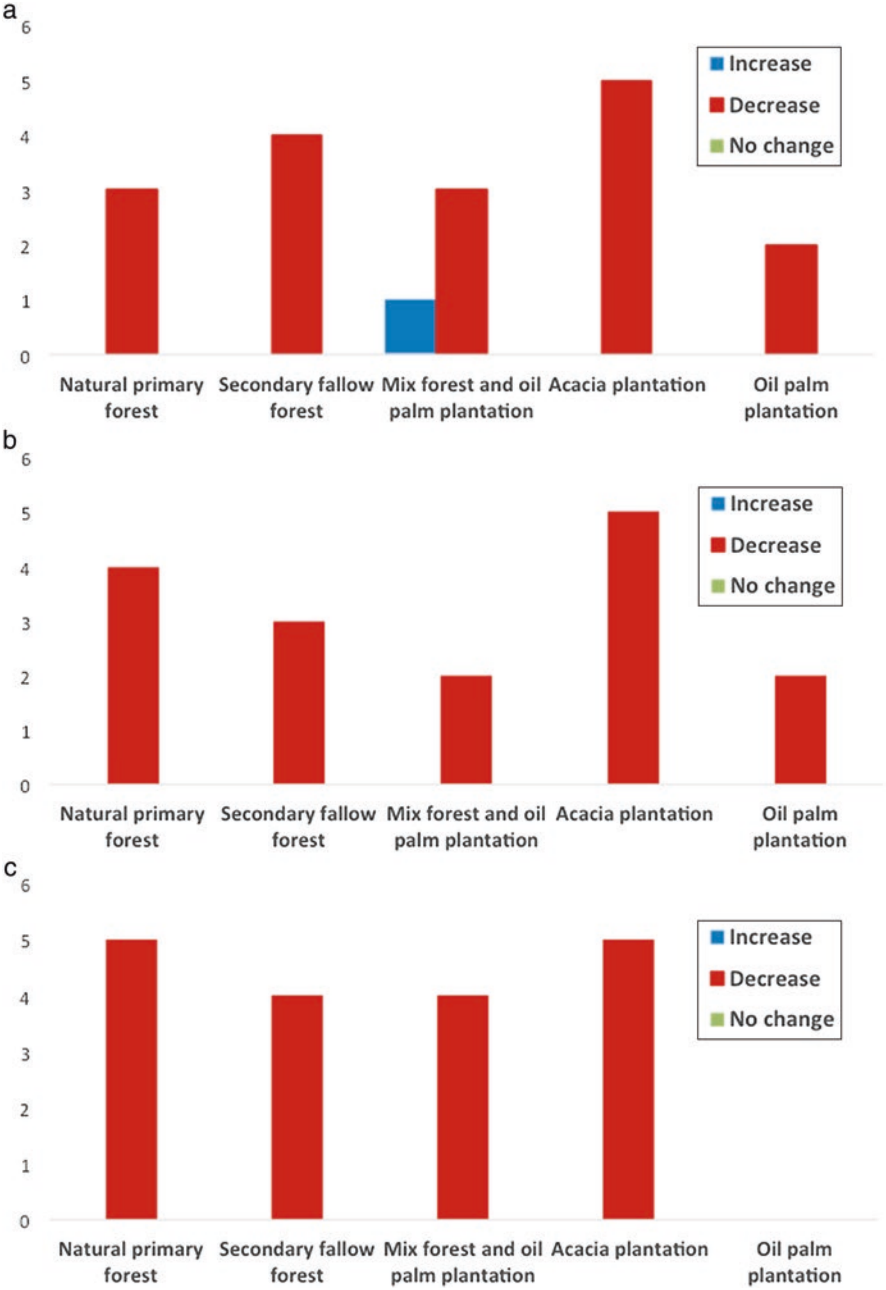


Fig. 14.23 Number of villages by landscape type that perceived changes in the population trends of (**a**) bearded pig (total number of reporting villages = 18), (**b**) sambar deer (total number of reporting villages = 16), and (**c**) barking deer populations (total number of reporting villages = 18)
Source: Author's field research

plantations, villagers reported that the expansion of oil palm plantations had forced animals deeper into forest areas. GW villagers in particular said that hunting activity had not affected populations of bearded pigs and mouse deer. Moreover, they noted that hunting pressure has been dropping due to a declining number of people hunting mouse deer. They also mentioned that hunting bearded pigs had become easier whereas in the past a hunter might have had to journey several days to hunt a single pig.

14.3.6 Wildlife Damage to Agricultural Crops

Information regarding wildlife damage to agricultural crops in 11 villages was collected. Three villages in mixed forest and oil palm areas, one village in an acacia plantation, five villages in secondary forests, and two villages in natural primary forests reported damage, although damage to paddy and oil palm by southern pig-tailed macaques and porcupines was observed in other villages. Figure 14.24 shows the reported agricultural damage by each animal species. Damage by porcupines (who eat young shoots of oil palms) and southern pig-tailed macaques (who eat paddy prior to harvesting) was mentioned in most villages. Although small in number, there were also reports of rats eating young oil palm shoots and long-tailed macaques eating unharvested paddy. In addition to these animals, some villagers also reported that rats and sparrows eat their paddy. Bearded pigs, sambar deer and barking deer caused relatively less damage to crops.

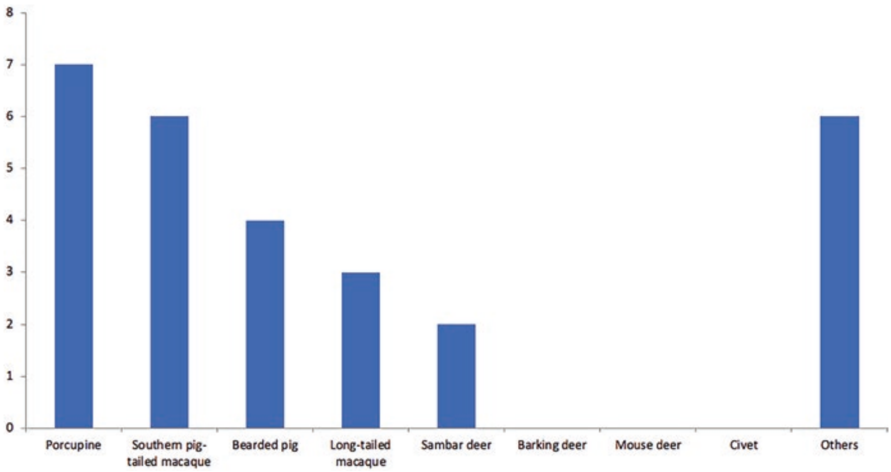


Fig. 14.24 Number of villages reporting animals as agricultural pests (total number of reporting villages = 11)
Source: Author's field research

Table 14.5 Number of successfully hunted animals per *bilik* by each ethnic group

Ethnic group	Game animal			
	Bearded pig	Sambar deer	Barking deer	Mouse deer
Iban	0.35	0.22	0.05	0.11
Kayan	0.04	NA	NA	NA
Bekatan	NA	0.02	NA	0.02
Punan Bah	0.15	0.06	0.01	0.00
Penan + Iban	0.23	0.01	NA	NA
Tatau + Iban	1.18	NA	NA	NA

Source: Author's field research

14.3.7 Ethnicity and Hunting Activity

Six ethnic groups were studied in this research. Although differences in hunting patterns and methods among ethnic groups were not found, different taboos concerning hunting and eating animals did emerge. The average number of hunted animals per *bilik* was higher in Iban and Tatau villages than in villages where other ethnic groups predominate (Table 14.5). However, more analysis is needed due to the disproportionate amount of data collected across ethnic groups.

14.4 Discussion

14.4.1 Changes over Time

Several social and economic studies were conducted in Bintulu Division prior to this study. Cramb and Dian (1979) surveyed 14 villages in the Kemena and Tatau basins in 1978 while Phillip S. Morrison (1993) surveyed 18 villages along the Kemena in 1990. Taylor et al. (1994) and Parnwell and King (1998) also surveyed 13 villages along the Kemena in 1992–1993. Although the villages in the previous studies do not correlate exactly to the 34 villages in this study, the data of the five studies are comparable because they all cover areas from upstream to downstream in the same division of Sarawak.

14.4.1.1 Migration from Villages

Migration from rural villages for off-farm work increased around the 1970s and 1980s in this area (Morrison 1993; Kedit and Chang 2005), as well as in other parts of Sarawak (Ko 1985; Sutlive 1985). Parnwell and King (1998) reported that when the quality of the surrounding environment and the ability to gain a sufficient income are low, migration to towns increases. Cramb and Dian (1979) found that 12% of the total population was absent from the villages they studied in 1978, meaning that the proportion of uninhabited *bilik* at that time was at most 12%. Morrison (1993) found 15% of *bilik* were not inhabited in 1990. He also reported that over a half of all working males were working off-farm jobs for part or all of the year. In 2012 we found 28% of 1050 *bilik* were not inhabited and far from relying solely on subsistence production and returns from cash cropping, over two-thirds of all households relied heavily on income generated from off-farm work.

Off-farm work started with the boom in logging companies in the 1970s. Cramb and Dian (1979) reported that almost all off-farm work was in nearby logging camps in 1978. The destination of off-farm jobs has since shifted to Bintulu town and oil palm plantations. An increasing number of off-farm jobs are now also related to the industrial development of the port and township of Bintulu. Bintulu was designed to provide the infrastructure needed for resource development offshore (natural gas and oil), along the coast (oil palm plantations) and in the interior (mainly timber logging for export). These developments have led to a substantial growth in the population of the Bintulu urban area. A slump in the prices of agricultural products is another major factor contributing to village outflow migration for off-farm jobs (Morrison 1993). In 2012 villagers were engaged in various jobs in town, including in the manufacturing, transportation, service, education and government sectors.

In this study, the proportion of inhabited *bilik* was found to differ depending on the village's distance from town and the surrounding landscape type. The proportion of inhabited *bilik* was high in acacia and oil palm plantations near Bintulu, in natural primary forests upriver, and in mixed forest and oil palm areas, while the proportion was low in secondary forest areas. Ease of commute is a major contributing factor to the high proportion of inhabited *bilik* in areas near Bintulu and to the lower proportions further from town. In villages located more than 30 km from town, many migrants start living in apartments or houses in town. Family members can follow to attend schools and find jobs themselves (see Soda and Kato, Chap. 17). From the interviews conducted for this research, the high rate of inhabited *bilik* in upriver areas is due to the availability of work in nearby logging camps and plantations. Family members tend to stay in the village, because the camps and plantations do not have schools and do not offer a variety of jobs. In the mixed vegetation areas, most villagers do not leave their villages as they have their own oil palm smallholdings.

14.4.1.2 Transition of Livelihood Activities

Village livelihoods in this region were once based on a subsistence-orientated economy. Over the past few decades this has shifted to an economy based on intensive commercial farming of oil palm, acacia, rubber and pepper (Cramb 1988).

Paddy cultivation has historically been the most important livelihood for residents of inland Sarawak (Cramb and Dian 1979). As Fig. 14.25 shows, the proportion of paddy cultivation households was 98% in 1979. This had dropped to only 32% by 2012. The significance of subsistence agriculture has been declining as employment in urban areas has become increasingly common and oil palm small-

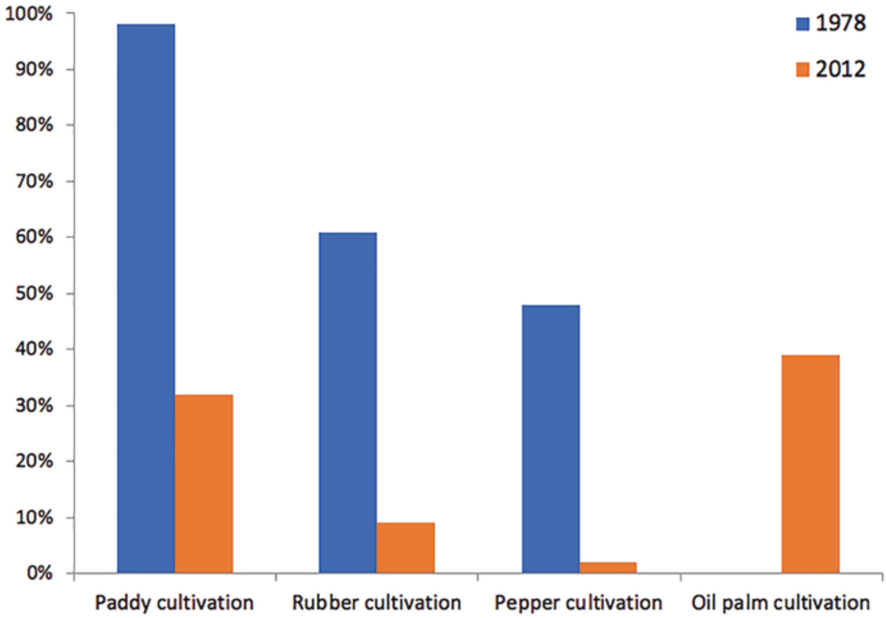


Fig. 14.25 Comparison of agricultural activities by the proportion of households in 1978 (Cramb and Dian 1979) and 2012 (this study)
Note: 59 households in 14 villages were surveyed in 1978, 1050 households in 34 villages were surveyed in 2012
Source: Author's field research

holdings have spread (Mertz et al. 2013). Paddy cultivation has completely stopped in seven villages and more than half the households have stopped cultivating paddy in the remaining 27 villages. The decline in paddy and other subsistence farming is not new in this region. Taylor et al. (1994) recorded that seven out of 13 villages in Bintulu Division had already stopped shifting agriculture in 1992–1993, although they did not analyse the proportion of paddy cultivation households.

On the other hand, oil palm cultivation by smallholders is becoming the most important economic activity in many lowland villages (Kato and Soda 2012). As indicated in Fig. 14.25, there were no households with oil palm smallholdings in 1979 but 39% of total households had such smallholdings in 2012. This smallholder-based cultivation started in coastal villages in the early 1990s and has rapidly spread to inland villages since the 2000s (Morrison 1993). On average, oil palm farming started in 2008 in the villages surveyed for this study. However, oil palm smallholdings are still limited to lowland areas with road access. Many villages in secondary forests and natural primary forests lack road accessibility and thus the villagers do not have oil palm smallholdings.

This tendency is not same as other cash crops. Cramb and Dian (1979) investigated the introduction of cash crops, such as rubber, pepper, coffee and cocoa, to this region in the 1970s. The proportion of households engaged in tapping rubber in

1979 was 61%. This number had dropped to 9% by 2012. Similarly, the proportion of households cultivating pepper in 1979 was 48% but this had dropped to a mere 2% by 2012.

Other subsistence activities, such as fishing, also seem to have declined in recent years. Cramb and Dian (1979) reported that most households engaged in fishing from time to time in 1978. However, this study observed limited fishing activity in 2012. This is due in part to the spread of the cash economy and decreasing populations of villages; people now buy food supplies in town or from itinerant sellers. Cramb and Dian (1979) reported that the most important jungle product collected was timber in 1978. Apart from working in logging camps, 54% of all households were involved in extracting *belian* (ironwood) in 1978, but the stands of *belian* were rapidly decreasing and people had to travel further and further from the village to obtain the wood. According to the interviews conducted in this study, almost all of them were extracting *belian* in 2012, but as Cramb and Dian (1979) predicted, *belian* is no longer available around the villages.

14.4.1.3 Animal Population Trends

Many villagers said that the population density of wildlife had decreased in the past 30 years. Cramb and Dian (1979) reported that most households practised hunting in 1978. They said that game was plentiful in most areas but the presence of logging camps along with an increase in human population in rural areas before the 1980s had caused a decline in the number of wild animals. As Cramb and Dian predicted, hunting has since declined in this area, with eight villages out of 34 studied reporting no hunting activity at all in 2012.

The effect of hunting pressure on animal populations is not yet quantified. Cramb and Dian (1979) and Elizabeth Bennett et al. (2000) found that hunting pressure is the main reason for the decline in wild animal populations, but this research shows that most of the locals consider past logging as the main reason for the decrease in populations.

14.4.2 Factors Affecting Hunting Activity

14.4.2.1 Landscape Transitions

As with other parts of Borneo (Wadley et al. 1997; Bennett et al. 2000), bearded pigs were hunted in the largest number of villages and represented the highest number of all hunted animals. The number of hunted bearded pigs is high in both natural primary forests and in mixed vegetation areas. As previous studies have indicated, the expansion of oil palm and acacia plantations has negatively affected animal habitats, therefore few bearded pigs were hunted in villages in acacia and oil palm plantations. However, bearded pigs have adapted to the mixed landscape of natural forest and oil palm plantations, using the forest as a resting site and the plantation as a feeding site. Local hunters have subsequently developed new techniques to take advantage of this new behaviour pattern.

While sambar deer, barking deer and mouse deer are also major game animals in Sarawak, fewer villagers reported hunting them compared to bearded pigs. These animals were hunted mainly in the natural primary forests even though they also live in secondary fallow forests and acacia plantations.[3] Sambar deer often come to feed on the young leaves of acacia and paddy after harvesting while long-tailed macaques also feed on rubber leaves. Villagers reported that hunting these species is more difficult in the mosaic habitat compared to the bearded pig.

One potential reason why few bearded pigs are hunted in acacia and oil palm areas is that these villages are mostly located in coastal areas where road networks are more developed. These roads cut through habitats and the noise of lorries and trucks frightens wild animals away. Human population densities are also higher in coastal areas, affecting the behaviour patterns of these animals. On the other hand, some species (especially porcupines and southern pig-tailed macaques) are known as agricultural pests in several villages and these species have high adaptability in human-induced landscapes.

14.4.2.2 Livelihood Factors

Ecological resource use is said to be defined by the quantity and seasonality of the resource. However, Bennett et al. (2000) and Jeffrey P. Jorgenson (2000) reported that hunting activity decreases when many villagers have opportunities to work in off-farm jobs such as tourism. This research also indicates that the number of hunted bearded pigs was not only affected by environmental factors, that is landscape type, but also by social factors, such as the proportion of paddy and oil palm cultivating households (Fig. 14.26). The relationship between landscape type and the number of bearded pigs hunted is largely determined by the differences in the carrying capacity of each landscape, that is the food resources available for the pigs in each landscape.

Livelihood changes can also affect the number of pigs hunted. In the past people stayed overnight in huts constructed in paddy fields and this facilitated hunting activities. Paddy cultivation was for subsistence and farmers were therefore based in the village. Now that young people of working age have migrated out of villages, there are fewer hunters.

Although the correlation is not strong, the proportion of oil palm cultivating households negatively affected the number of bearded pigs hunted in a year. Unlike paddy cultivation, oil palm cultivation does not necessarily indicate a village-based lifestyle. People can cultivate oil palm without staying in the village; many small-

[3] In Chap. 8, Hiromitsu Samejima and Jason Hon indicate that those species are abundant in secondary forests around the villages. Villagers surveyed for this study also explained that sambar deer, barking deer and mouse dear inhabit secondary forests and acacia plantations.

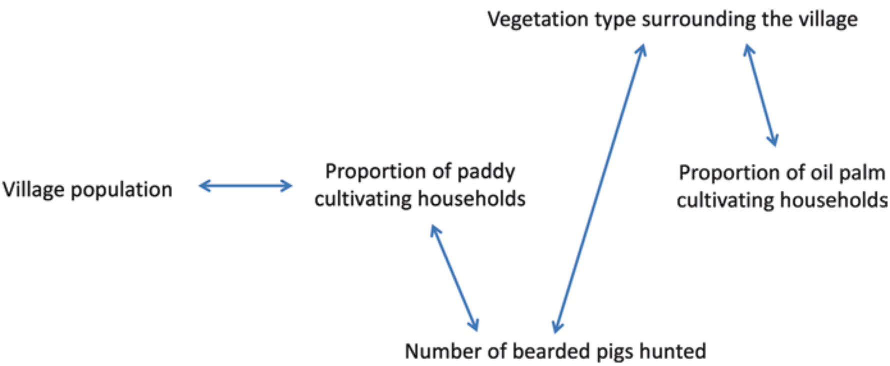


Fig. 14.26 Factors related to changes in hunting activity
Source: Author's field research

holders stay in town and return to the village only on weekends or employ Indonesian workers to tend to the smallholdings without staying in the village themselves (see Soda and Kato, Chap. 17). In addition, villagers may be too occupied with oil palm cultivating to go to hunting. Further studies are necessary to understand the exact correlation between paddy cultivation and oil palm farming with hunting activity.

14.4.2.3 Ethnicity and Hunting Activity

This study found no strong correlation between ethnicity and hunting activity. The Penan and Bekatan are former hunter-gatherers (see Kato et al., Chap. 5); however, the number of animals hunted by these two ethnic groups did not exceed that of other ethnic groups. On the other hand, some Iban engaged in hunting more actively. It was assumed that the number of hunted animals was mainly affected by landscape type and livelihood activity.

14.5 Conclusion

This research examined the structure of riverine society in Borneo and demonstrates the importance of considering both ecological and social factors when evaluating hunting activities. Transitions in landscapes and livelihoods were found to be the factors most affecting hunting activities.

The landscape of the river basin has historically been covered by natural primary and secondary forest but today it is a mosaic that includes oil palm, acacia and rubber plantations. Focusing on this mixed landscape of natural forest and monocrop plantations, it was found that many wild animals, including sambar deer and barking deer, cannot adapt to the new human-induced landscape, and their populations are in decline. However, the bearded pig has adapted to using the plantations as a new feeding source. Hunting of bearded pigs has correspondingly shifted, becoming most active in the boundary areas between oil palm plantations and primary forests. The expansion of road networks has also changed hunting patterns by easing access to hunting areas.

The social environment has also transformed. Historically, livelihoods in the river basins were based on paddy cultivation (Cramb and Dian 1979) and collecting and trading various non-timber forest products (Wadley 2005; Ishikawa and Ishikawa, Chap. 6). Hunting was a part of many subsistence-based village economies. This has changed as livelihoods have shifted to commercial crop cultivation and off-farm jobs. Hunting is not an important subsistence activity for most people today. The number of animals and the species killed, as well as the hunting methods, are all defined by the balance with other subsistence activities including oil palm cultivation and off-farm jobs.

Acknowledgements This research was conducted with permission of the Sarawak Planning Unit and Sarawak Forest Department. We thank Universiti Malaysia Sarawak and the Sarawak Forestry Corporation for supporting this research. Research funds were provided by Grant-in-Aid for Scientific Research (S) 22221010 'Planted Forests in Equatorial Southeast Asia: Human-Nature Interactions in High Biomass Society' from the Japan Society for the Promotion of Science. We greatly appreciate the help and understanding of the people in the study villages. We also thank Jackie Imamura for helping us with English editing.

References

Bala, Poline. 2007. From highlands to lowlands: Kelabit women and their migrant daughters. In *Village mothers, city daughters: Women and urbanization in Sarawak*, ed. Hew Cheng Sim, 120–139. Singapore: Institute of Southeast Asian Studies.

Bennett, Elizabeth L., Adrian J. Nyaoi, and Jephte Sompud. 2000. Saving Borneo's bacon: The sustainability of hunting in Sarawak and Sabah. In *Hunting for sustainability in tropical forests*, ed. John G. Robinson and Elizabeth L. Bennett, 305–324. New York: Columbia University Press.

Bennett, Elizabeth L., and Melvin T. Gumal. 2001. The inter-relationships of commercial logging, hunting, and wildlife in Sarawak: Recommendations for forest management. In *The cutting edge: Conserving wildlife in managed tropical forests*, ed. Robert A. Fimbel, Alejandro Grajal, and John G. Robinson, 359–374. New York: Colombia University Press.

Caldecott, Julian Oliver. 1988. *Hunting and wildlife management in Sarawak*. Vol. 7. Gland: International Union for Conservation of Nature, ICUN Tropical Forest Programme Monographs.

Cramb, Rob A. 1988. The commercialization of Iban agriculture. In *Development in Sarawak: Historical and contemporary perspectives*, ed. Rob A. Cramb and R.H.W. Reece, 105–134. Melbourne: Centre for Southeast Asian Studies, Monash University, Monash Papers on Southeast Asia No. 17.

———. 1990. The role of smallholder agriculture in the development of Sarawak: 1963–88. In *Socio-economic development in Sarawak: Policies and strategies for the 1990s*, ed. Abdul Majid Mat Salleh, Hatta Solhee, and Mohd. Yusof Kasim, 83–110. Kuching: Angkatan Zaman Mansang.

———. 2007. *Land and longhouse: Agrarian transformation in the uplands of Sarawak*, Monograph series no. 110. Copenhagen: NIAS Press.

Cramb, Rob A., and J. Dian. 1979. *A social and economic survey of the Bintulu extension region—Report no. 8*. Kuching: Department of Agriculture, Planning Division.

Cramb, Rob A., and Patrick S. Sujang. 2013. The mouse deer and the crocodile: Oil palm smallholders and livelihood strategies in Sarawak, Malaysia. *Journal of Peasant Studies* 40 (1): 129–154.

Duff, A.B., R.A. Hall, and Clive W. Marsh. 1984. A survey of wildlife in and around a commercial tree plantation in Sabah. *Malaysian Forester* 47 (2): 97–213.

Hon, Jason, and Shozo Shibata. 2013. A review on land use in the Malaysian state of Sarawak, Borneo and recommendations for wildlife conservation inside production forest environment. *Borneo Journal of Resource Science and Technology* 3 (2): 22–35.

Ichikawa, Masahiro. 2011. Factors contributing to different rates of depopulation in rural villages in Sarawak. *Borneo Research Bulletin* 42: 275–288.

———. 2013. Sato no mozaiku keikan to chino yukue: Aburayashi saibai no kakudai to toshika no motode. [Forest mosaic landscape and people's knowledge: Urbanisation and oil palm cultivation]. In *Boruneo no sato no kankyō-gaku — henbō suru nettai-rin to senjūmin no chi* [Ethnography of Borneo anthropogenic landscape: Changing tropical forests and indigenous knowledge], ed. Masahiro Ichikawa, Ryoji Soda, and Daisuke Naito, 94–127. Kyoto: Shōwadō.

Jorgenson, Jeffrey P. 2000. Wildlife conservation and game harvest by Maya hunters in Quintana Roo, Mexico. In *Hunting for sustainability in tropical forests*, ed. John G. Robinson and Elizabeth L. Bennett, 251–266. New York: Columbia University Press.

Kato, Yumi. 2014. Changes in resource use and subsistence activities under the plantation expansion in Sarawak, Malaysia. In *Social-ecological systems in transition*, Global environmental series, ed. Shoko Sakai and Chieko Umetsu, 179–194. Tokyo: Springer.

Kato, Yumi, and Ryoji Soda. 2012. Malaysia Sarawak shu ni okeru shounou aburayashi saibai no doukou. [Emerging trends in oil palm smallholdings in Sarawak, Malaysia]. *Geographical Studies* 87 (2): 26–35.

Kato, Yumi, and Hiromitsu Samejima. 2013. Knowledge about animals in the changing tropical environment. In *Boruneo no sato no kankyō-gaku — henbō suru nettai-rin to senjūmin no chi* [Ethnography of Borneo anthropogenic landscape: Changing tropical forests and indigenous knowledge], ed. Masahiro Ichikawa, Ryoji Soda, and Daisuke Naito, 127–163. Kyoto: Shōwadō.

Kedit, Peter Mulok, and William Chang Wei Say. 2005. *The peoples of the planted forest in Sarawak*. Kuching: Forest Department Sarawak.

Ko, J.T.H. 1985. Iban on the move: An empirical analysis. *Sarawak Gazette* 111 (1494): 5–21.

McCarthy, John F., and Rob A. Cramb. 2009. Policy narratives, landholder engagement, and oil palm expansion on the Malaysian and Indonesian frontiers. *The Geographical Journal* 175 (2): 112–123.

McShea, William J., Chad Stewart, Liesl Peterson, Peter Erb, Robert Stuebing, and Belden Giman. 2009. The importance of secondary forest blocks for terrestrial mammals within an Acacia/secondary forest matrix in Sarawak, Malaysia. *Biological Conservation* 142 (12): 3108–3119.

Meijaard, Erik, Douglas Sheil, Robert Nasi, David Augeri, Barry Rosenbaum, Djoko Iskandar, Titiek Setyawati, Martjan Lammertink, Ike Rachmatika, Anna Wong, Tonny Soehartono, Scott Stanley, and Timothy O'Brien. 2005. *Life after logging: Reconciling wildlife conservation and production forestry in Indonesia Borneo*. Bogor: Center for International Forestry Research.

Mertz, Ole, Kelvin Egay, Thilde Bech Bruun, and Tina Svan Colding. 2013. The last swiddens of Sarawak, Malaysia. *Human Ecology* 41 (1): 109–118.

Momose, Kuniyasu. 2006. Yakihata wa shitsujun nettai niokeru gouritekina shokuryou seisan shudan. [Shifting cultivation is reasonable food production in tropical forest]. *Risen* 85: 146–155.

Morrison, Phillip S. 1993. Transitions in rural Sarawak: Off-farm employment in the Kemena basin. *Pacific Viewpoint* 34 (1): 45–68.

Needham, Rodney. 1964. Blood, thunder, and mockery of animals. *Sociologus* 14 (2): 136–149.

Okuno, Katsumi. 2012. Natural disaster, men and animals among the Penan: Beyond 'thunder complex'. *Malaysian Studies Journal* 1: 59–72.

Parnwell, Michael J.G., and Victor T. King. 1998. Environmental changes and population movements: The Iban of Sarawak. In *Environmental challenges in South-East Asia*, ed. Victor T. King, 137–168. London: Curzon.

Payne, Junaidi, and Charles M. Francis. 1985. *A field guide to the mammals of Borneo*. Kota Kinabalu: The Sabah Society with WWF-Malaysia.

Potter, Lesley. 2008. The oil palm question in Borneo. In *Reflections on the heart of Borneo*, ed. Gerard A. Persoon and Manon Osseweijer, 69–89. Wageningen: Tropenbos International, Tropenbos Series No. 24.

R Development Core Team. 2013. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Sakai, Shoko, Choy Yee Keong, Miyako Koizumi, Keiko Kishimoto-Yamada, Yumi Kato, Kohei Takenaka Takano, Ryoji Soda, Hiromitsu Samejima, Tohru Nakashizuka, Takao Itioka, and Masahiro Ichikawa. 2014. *Geographical variation in the lives of local people and socio-economic environment in Sarawak*. Kyoto: Centre for Ecological Research, Kyoto University.

Sasaki, Hideyuki. 1999. Tenkanki niaru Kalimantan: Shinrin bassai no frontier kara tochi kaihatsu frontier he. [Kalimantan: A region in transition from timber extraction frontier to land development frontier]. *Tropics* 9 (1): 73–82.

Seitz, Stefan. 2008. Game, pets and animal husbandry among Penan and Penan groups. In *Beyond the green myth: Borneo's hunter-gatherers in the twenty-first century*, ed. Peter Sercombe and Bernard Sellato, 177–191. Copenhagen: NIAS Press.

Soda, Ryoji. 2001. Rural-urban migration of the Iban of Sarawak and changes in long-house communities. *Geographical Review of Japan Series B* 74 (1): 92–11.

Sutlive, Vinson H. 1985. Urban migration into Sibu, Sarawak. *Borneo Research Bulletin* 17 (2): 85–94.

Taylor, David M., D. Hortin, Michael J.G. Parnwell, and T.K. Marsden. 1994. The degradation of rainforests in Sarawak, East Malaysia, and its implications for future management policies. *Geoforum* 25 (3): 51–369.

Wadley, Reed L. 2005. *Histories of the Borneo environment: Economic, political and social dimensions of change and continuity*. Leiden: KITLV Press.

Wadley, Reed L., Carol J. Pierce Colfer, and Ian G. Hood. 1997. Hunting primates and managing forests: The case of Iban forest farmers in Indonesian Borneo. *Human Ecology* 25 (2): 243–271.

Wadley, Reed L., and Carol J. Pierce Colfer. 2004. Sacred forest, hunting, and conservation in West Kalimantan, Indonesia. *Human Ecology* 32 (3): 313–338.

Wong, Jack (2011) Big rubber plans for Sarawak. *The Star*, 14 October

Chapter 15
From River to Road? Changing Living Patterns and Land Use of Inland Indigenous Peoples in Sarawak

Ryoji Soda, Noboru Ishikawa, and Yumi Kato

Abstract This chapter discusses the restructuring process of the basin society of the Jelalong River in the Malaysian state of Sarawak, with a particular focus on the history of trade in forest resources and recent forest development. The Jelalong basin has long been a source of forest resources. Since the nineteenth century, many different ethnic groups have settled in the basin to access forest resources, resulting in various interactions among the groups. The basin society created through this process is currently undergoing significant changes because of the recent expansion of oil palm plantations. People who previously lived in villages along the river (for example, in longhouses) and made their living through slash-and-burn rice cultivation as well as hunting and gathering now build huts along the roads constructed for the plantations and have begun planting their own oil palm crops. They have not necessarily abandoned the longhouses completely; rather, they regularly commute between the riverside and roadside. In addition, some of these people are also wage earners in the neighbouring town of Bintulu. By moving opportunistically between the three residential hubs, they are building a spatial infrastructure that allows them to thrive in all three economies: the natural economy along the river, the plantation economy along the road and the urban economy in Bintulu.

Keywords Sarawak · Ethnicity · Residential patterns · Land use · Basin society · Oil palm

R. Soda (✉)
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

N. Ishikawa
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

Y. Kato
Center for Arts and Sciences, Fukui Prefectural University, Eiheiji, Japan

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_15

15.1 Introduction

The societies formed in the river basins of Sarawak state of Malaysia are generally called 'basin societies' or 'riverine societies' (Rousseau 1990; Ishikawa 2010; Soda and Mokudai 2013). In general, these basins are home to many ethnic groups that traditionally traded in non-timber forest products transported via the rivers. Because of this trade, the village groups dotting a basin appear to be a cohesive 'community', despite differences in language and ethnicity. This is characteristic of a basin society.

When considering the societies of Sarawak and Borneo, it is absolutely crucial to study these basins, since such analyses overcome the limitations of examining either individual villages or ethnic groups. However, in recent decades the movement of people from riverside to roadside has been remarkable. As a result, Sarawak basin societies have undergone significant changes due to the extension of inland transport networks. A majority of inland roads, originally built for commercial logging, are unpaved. These roads require constant maintenance, and if logging operations are withdrawn due to a shortage of forest resources the roads become dilapidated and unusable within a few years. But some of the logging roads have been rebuilt and are now being used as agricultural roads with the inland expansion of oil palm and acacia plantations.

Migrations from riverside to roadside have previously been observed in numerous locations, but the recent expansion of oil palm plantations appears to be accelerating this trend (Takeuchi et al., Chap. 21). At first glance, the migration of local peoples from riverside to roadside seems to represent a traditional basin society shifting into an unconnected land-based society. However, as this chapter demonstrates, the manner in which people are moving is not as simple as it first appears. The movement of inland indigenous people to the roadside should be seen as a vital element of a livelihood strategy, reflecting various intentions, motives and factors aside from the pursuit of accessibility, such as the introduction of a revenue source (oil palm) and the securing and enhancement of land usufruct.

In the following sections, we consider the realities and implications concerning indigenous people's movement from the river basin to roadside land near the Jelalong River that flows in Bintulu district, Sarawak (Fig. 15.1). Villages along the Jelalong River were surveyed in March 2007, January–February 2008, August 2008 and March 2011. Roadside dwellings were surveyed in August 2013.

15.2 The Basin Societies of the Jelalong River

If you trace the Kemena River upriver from Bintulu you arrive at a small market town called Tubau in the middle basin. The portion of the Kemena River from Tubau and further upriver is called the Jelalong River. When we began surveys along the Jelalong River in 2007, there were practically no roads that led to the villages in the

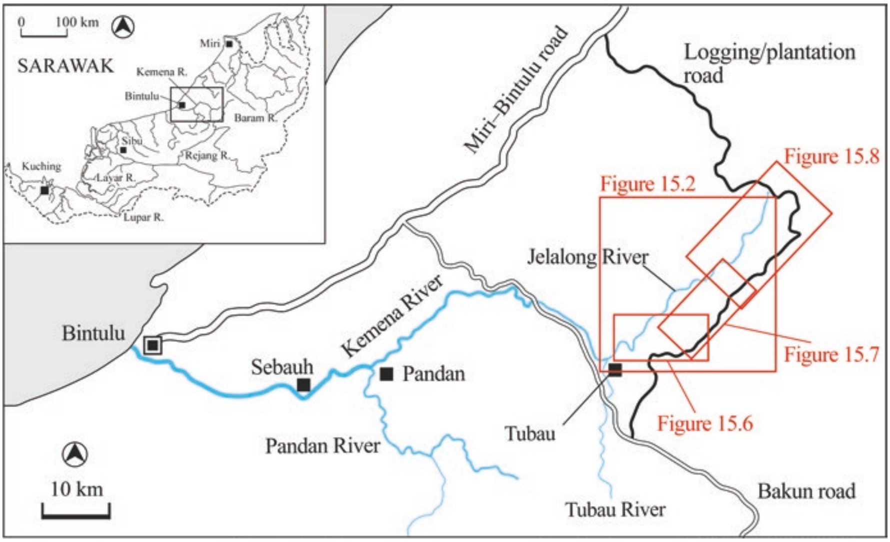


Fig. 15.1 Study area

Jelalong basin. Journeys to the villages could only be undertaken in small boats and were dependent on the water level. When water levels were too low it was impossible to travel upstream and we had to wait in Tubau until there was sufficient rainfall.

As mentioned elsewhere (Kato et al., Chap. 5), there are many ethnic groups living in the Jelalong basin. The basin is dotted with the villages of the Penan, Iban, Kayan, Punan Bah and Vaie Segan and is thus considered to be a multiethnic and mixed-group basin. However, it is almost certain that it was the Penan who first settled in the basin.

It is said that the first groups to settle in the Jelalong basin were the people of KT/JL village (33 households at the time of our August 2008 survey) and RS village (15 households). In KT/JL village, the chief's family is said to have lived in the Jelalong basin for 11 generations.[1] They have a great knowledge and awareness of the area given that they have lived there for a relatively long period. According to them, there were three *pengiran* in the Jelalong basin during the precolonial Brunei period in the mid-nineteenth century, all of whom were Penan.[2] They also emphasise their indigenousness by stressing that they were living in the Jelalong basin prior to the British colonisation of Sarawak, specifically before the arrival of James Brooke. Among the people dwelling in the Jelalong basin, it is an accepted fact that 'the

[1] According to Rob Cramb and J. Dian (1979), the people of KT/JL village had lived in the area for 12 generations.

[2] *Pengiran* is a title for Brunei nobles, but in reality they are said to have fulfilled the role of a local bureaucrat or a tax collector.

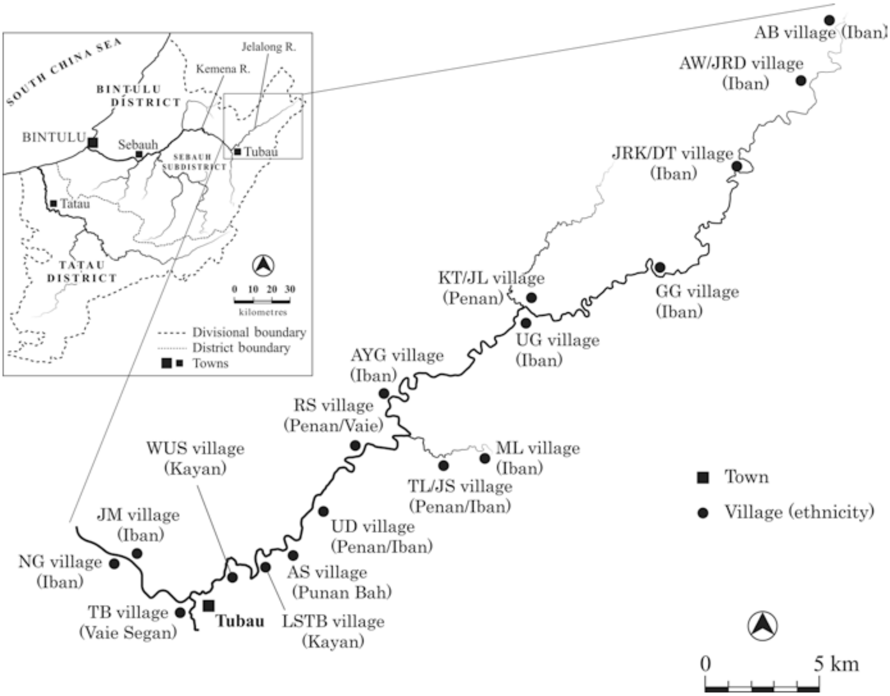


Fig. 15.2 Distribution of villages in the Jelalong basin

Penan came first, then the Kayan and finally the Iban'. Local Penan claim 'the Penan have the best land' and other groups also acknowledge this.

It is probable that other ethnic groups began to settle in the Penan-dominated Jelalong basin in the early nineteenth century (see also Kato et al., Chap. 5). The Kayan first entered via the Tubau tributary of the Kemena River at the beginning of the nineteenth century as they fled conflict along the Balui River. Some of these Kayan most probably entered the lower Jelalong basin. At some uncertain point thereafter the Punan Bah arrived and the Iban also began to settle there around the middle of the twentieth century. They moved into or from the area as a village community, and other ethnic groups such as the Kejaman, Vaie Segan and Chinese entered the Penan community either through marriage or adoption. The current distribution of villages in the Jelalong basin is represented in Fig. 15.2.[3] This basin has three unique characteristics: (1) the Penan (who were traditionally a nomadic hunter-gatherer society) have lived in fixed dwellings and pursued slash-and-burn hill rice cultivation for a long time; (2) when other ethnic groups settled in the area they lived adjacent to the

[3] Figure 15.2 represents the names of the ethnic groups dwelling in each village but, as previously discussed, it is difficult to clearly differentiate villages and ethnic groups because of the complexity of the ethnic intermingling in Jelalong, which is extreme even compared with other areas in Sarawak.

Penan; and (3) Penan villages include residents from other ethnic groups. For example, UD village (with 26 households at the time of our August 2008 survey) and TL/JS village (with 15 households at the time of the same survey) are considered to be Penan villages, but approximately half of their residents are Iban. Seven families of the Vaie Segan live in RS village, and mixing between the Penan and the Kejaman, Kayan and Kenyah occurs through intermarriage in KT/JL village.

We have previously argued that one factor involved in this ethnic intermingling is that many people were drawn to the Jelalong basin due to its abundance of forest resources (Kato et al., Chap. 5). The formation of the basin society has also been discussed by focusing on the use of forest resources and intergroup relationships (Soda and Ishikawa 2014). However, the recent movement of basin inhabitants during the expansion of oil palm plantations is ushering in a new phase of relocation in the area. Therefore, in this chapter, after outlining the Jelalong basin inhabitants' use of forest resources, we discuss the recent migration to roadsides.

15.3 Resource Use in the Jelalong Basin: A 'Flow' Society

In addition to slash-and-burn rice cultivation, the people of the Jelalong basin also hunted large mammals (such as wild boar and deer) and collected forest products including rattan, wild rubber (gutta-percha and jelutong), hardwood shingles (*attap belian*) and fruits such as illipe nuts (known locally as *engkabang*). These forest products were traded at nearby marketplaces such as Tubau. It is recorded that Tubau was booming during the early twentieth century and that so many forest products were brought to the bazaar there that there was a shortage of cash for trading.[4] While the goods being traded and the scale of those trades varied over time, such trade of forest products continued until at least the 1970s (Ishikawa 2010).

Until the 1970s the principal means of livelihood for the inhabitants of the Jelalong basin were slash-and-burn rice cultivation, hunting and gathering, and trading non-timber forest products. Timber forest products became important trade goods during the early 1970s. Around this time, companies began actively logging in Sarawak and inhabitants began following in their footsteps by undertaking their own timber harvesting. This harvesting was not at all similar to the large-scale logging done by companies; on the contrary, it was a small-scale, limited and seasonal activity in which they selectively cut down valuable trees in riverside forests. As the rainy season approached, residents of the Jelalong basin would cut down these trees in low-lying areas by the river. As the water level rose and the low-lying areas flooded, they would assemble the logs onto rafts and float them downstream to sell to Chinese middlemen or to sawmills (Fig. 15.3).[5]

[4] Rattan is cited as a particularly popular trade item. See Takeuchi et al. (Chap. 22) for an in-depth history of rattan trade in the region.

[5] Many of these low-lying areas are wetlands so it is difficult to bring in heavy machinery and logging by timber companies is nonexistent. As these places are frequently flooded during the rainy season and not suitable for rice cultivation, relatively abundant forests still remain.

Fig. 15.3 Riparian timber harvesting conditions during (**a**) the dry season where boats are kept on land and wood is harvested, and (**b**) during the rainy season when the area floods and the wood is gathered into rafts to be carried downstream. (Photograph: Ryoji Soda 2008)

These activities were only possible though when the water level of the river was high, that is, for only 4 or 5 months a year. Incomes were also uncertain in years with low rainfall because of the difficulty in transporting the wood when there was no flooding. Growing rice was seen as an important form of economic insurance when other sources of income were insufficient, so most people made their living from a combination of slash-and-burn rice cultivation and riparian timber harvesting.

This timber harvesting in riparian forests peaked during the mid-1990s, after which it gradually declined because of strengthened regulations on illegal logging and reduced timber demand (Soda 2005). In the early 2010s harvesting was still being undertaken at a reduced level and it has continued to be an important source of monetary income for basin inhabitants.

While various products were gathered and traded in the Jelalong basin until the early twenty-first century, with the products traded changing over time (see Ishikawa and Ishikawa, Chap. 6), the use of resources displays a consistent character. Rather than drawing out the asset value of the land itself or seeing the land as a production site and investing labour, capital or technology, the inhabitants have emphasised capitalising on fast-growing and abundant forest resources and harvesting these resources at the right time to transform them into economic value. They have been making their livelihoods by extracting resources from natural forests in this manner for a long time. We refer to this forest resource-dependent economy as a 'natural economy' and refer to a society that creates opportunistic profit by commercialising these resources as a 'flow society' (Soda 2009; Ishikawa 2010; Soda and Ishikawa 2014). Such flow societies have been formed in Sarawak, based in and around river systems, and they are closely related to the multilayered 'ethnic gradation' found there (Ishikawa 2010).

However, the Jelalong basin society has experienced a massive change since 2010. People who previously lived in longhouses along the riversides have begun to build agricultural huts (*langkau* in Iban and hereafter referred to as such) along old logging roads and are relocating to these huts. Commercial logging in the Jelalong basin continues to decrease, but in the past few years large-scale oil palm and acacia plantations have been established. The old roads that were initially used for logging have been repaired and repurposed to now serve the plantations. People are generally building *langkau* along these roads. The recent drastic transformation in living settings and the significance of these livelihood changes are discussed below.

15.4 From River to Road: The Formation and Distribution of *Langkau*

As previously noted, it was generally not possible for ordinary travellers to voyage upstream of the Jelalong River by car until only a few years ago. We also travelled by boat when visiting the longhouses along the river. However, we heard that many longhouses had been virtually depopulated because the vast majority of their inhabitants have moved to roadsides. In August 2013 we conducted an observational study of the distribution of roadside *langkau* and interviewed residents to determine the nature of this change and the socioeconomic factors that caused it. The survey included questions concerning why people had moved to the roadside, how *langkau* were distributed, what types of subsistence activities people had by the roadside, and whether the longhouse communities had been maintained, and, if so, how and to what extent.

While the migration from riversides to roadsides has been seen in other places in Sarawak (Kato 2014), the recent changes in the Jelalong basin appear to have a relatively more complicated relationship to Sarawak's landscape changes than the other cases. These factors present an opportunity to consider the changes in a living setting from river basin to land in a contemporary context.

Most *langkau* are located close to the previous longhouses of their inhabitants; this is evidenced by the distribution of *langkau* compared to that of the original longhouses. There are many different kinds of *langkau*, from simple huts that offer protection from the wind and rain (Fig. 15.4a) to sturdy buildings made of meranti or *kapur* (Fig. 15.4i), and to buildings that can more appropriately be called *rumah* (house) rather than *langkau* (Fig. 15.4p).[6] Around LSTB village, we visited one such *rumah* belonging to a Fuzhou Chinese who married a local Kayan; it was a huge five-bedroom house with a swiftlet farmhouse in the backyard (Fig. 15.5).[7]

The following is an overview of the distribution of *langkau* observed during our trip in August 2013.

Not far from an unpaved logging road (currently used as a road to an oil palm plantation) that runs off the Bakun road, there are *langkau* belonging to the Kayan who moved from longhouses along the Tubau and Jelalong rivers. A little further down the road, *langkau* belonging to the Penan and Iban begin to appear. Most of the Penan and Iban observed in the area moved from longhouses along the Jelalong River and its tributaries.

Langkau marked with ◆ in Figs. 15.6 and 15.7 belong to inhabitants originally from longhouses in TL/JS village in the middle basin of the Kebulu River (a tributary of the Jelalong River). *Langkau* marked with □ (Figs. 15.6, 15.7 and 15.8) belong to people originally from ML village in the upper Kebulu basin. The boundary between their longhouse territories roughly corresponds to that of the Kebulu River (TL/JS village is on the left bank and ML village on the right bank) and both sides are strongly conscious of this border.

The ■, ◇ and ▲ marks in Figs. 15.7 and 15.8 correspond to *langkau* belonging to people originally from UG, MS and AW/JRD villages, respectively.[8] A ⊗ mark (Figs. 15.6

[6] Simple huts are also called *langkau jungap* in Iban. Many use sago, *lilik* and *biru* leaves as roofing material.

[7] See Suzuki et al. (Chap. 20) and Chew et al. (Chap. 18) for more information regarding swiftlet farmhouses and the edible birds' nest business in Sarawak.

[8] After a fire in March 2011, AW/JRD village was separated into AW village (five households) and JRD village (20 households).

Fig. 15.4 (**a**)–(**r**) Examples of roadside *langkau*, ranging from simple shacks to well-established homes. (Photographs: Noboru Ishikawa 2013)

Fig. 15.4 (continued)

Fig. 15.4 (continued)

Fig. 15.5 House belonging to a Fuzhou Chinese who married into a Kayan village. (Photograph: Ryoji Soda 2013)

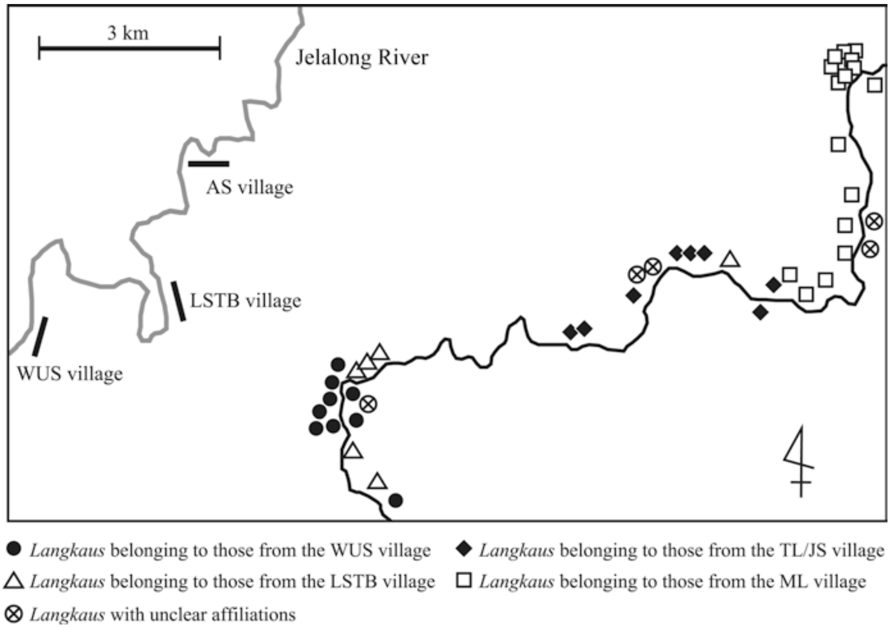


Fig. 15.6 Distribution of *langkau* in the vicinity of WUS and LSTB villages

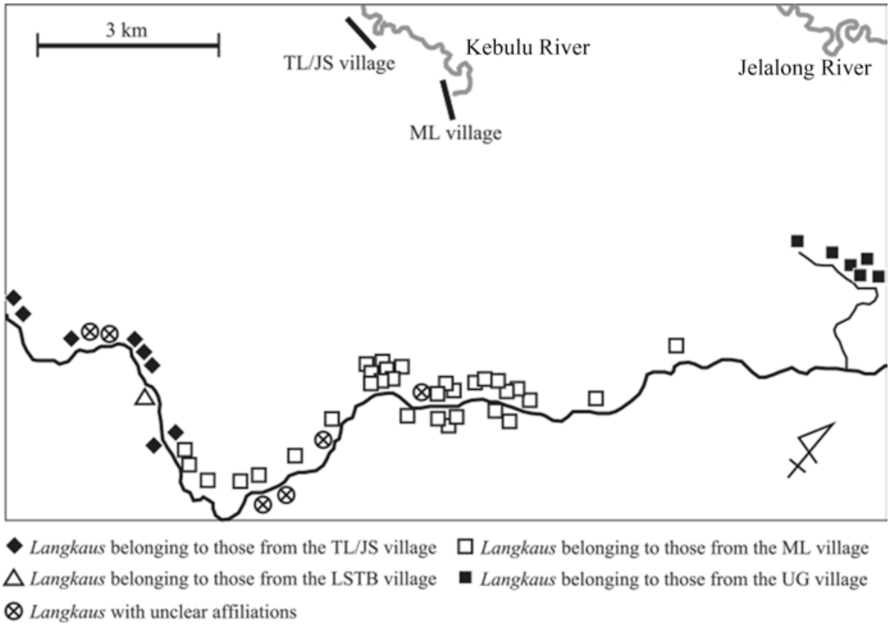


Fig. 15.7 Distribution of *langkau* in the vicinity of TL/JS and ML villages

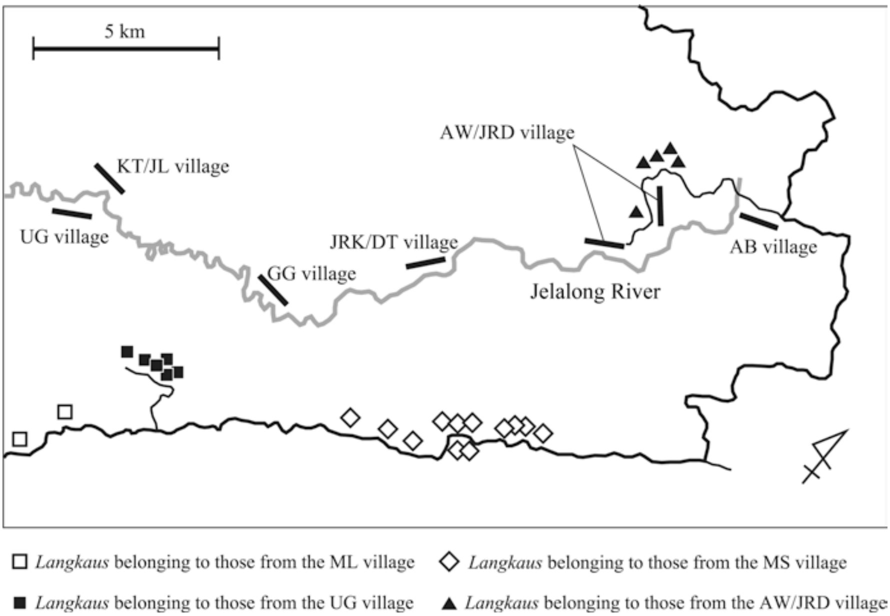


Fig. 15.8 Distribution of *langkau* in the vicinity of UG and AW/JRD villages

Table 15.1 Number of *langkau* affiliated with each original village and ethnicity

Village of origin	Ethnicity of original village	Number of *langkau*
WUS	Kayan	9
LSTB	Kayan	6
TL/JS	Penan/Iban	8
ML	Iban	32
UG	Iban	6
MS	Iban	12
AW/JRD	Iban	5
Unclear affiliations	NA	7

and 15.7) indicates a *langkau* with unclear village affiliations. The number of *langkau* affiliated with each original village enumerated during this survey are in Table 15.1.

These figures are approximations—there seemed to be a number of *langkau* on branch roads and some on the main road may have been overlooked—but a trend can be identified. Distribution of these *langkau* can be summarised as follows.

1. *Langkau* originally from TL/JS, ML and MS villages are distributed along the main logging road built by a logging company in the 1970s.
2. In the territories of UG and AW/JRD villages, *langkau* have been built along branch roads that lead to individual longhouses with a small number of *langkau* located on the main road. Similarly, in LSTB village, there are many *langkau* on branch roads leading towards longhouses. Though no observational survey was conducted on branch roads leading to LSTB village in this trip, this was clarified through interviews.
3. There are very few *langkau* established by the inhabitants of AB village as the longhouse is located along both the Jelalong River and the main road (Fig. 15.9).

The distribution pattern indicates that *langkau* whose inhabitants are originally from certain longhouses are generally situated quite close to those longhouses.[9] The next section describes inhabitants' motivations for building *langkau* by the roadside, as elucidated from our interviews.

15.5 Why Live by the Road? Changes in Livelihood and Lifestyle

In order to conduct interviews on the changes in livelihood and lifestyle of the basin society, we visited one *langkau* owned by a villager from WUS village, two from LSTB village, two from TL/JS village, two from ML village, one owned by the headman of UG village, as well as longhouses in AB and AW/JRD villages. We also

[9] MS village can be considered an exception as it is located along the Tubau River. This is discussed further in Sect. 15.6.

Fig. 15.9 Exterior of a longhouse in AB village. (Photograph: Ryoji Soda 2013)

visited the headman of MS village who usually lives in a residential area in the town of Bintulu and interviewed village members who gathered there.

15.5.1 Convenience

Many of the people who moved to the roadside cited the difficulties involved in travel when living by the riverside. The water level of the Jelalong River can change dramatically on both a seasonal and daily basis. Once, during the annual Gawai harvest festival held in early June, residents were unable to return to their long-houses because of low water levels. Conversely, when illness struck the residents of longhouses, inhabitants had frequently been unable to receive timely treatment due to low water levels that impeded travel to nearby medical centres.

The permanent population of the longhouses and the frequency of urban workers returning to their longhouses appear to have declined as a result of the construction of roadside *langkau*. The longhouse in TL/JS village is almost vacant; people from TL/JS village currently living in *langkau* told us, albeit exaggeratedly, that ‘all that was left in the longhouse were dogs and fowls’. However, they had not completely abandoned the longhouse as they return there for weekends every fortnight. Their children reside in the primary school dormitory of Sekolah Kebangsaan Kuala Kebulu at the confluence of the Jelalong and Kebulu rivers and twice a month the students must visit their parents. Parents who pick up their children spend the weekend at the longhouse. Once the children arrive at school on Mondays, the parents return to the roadside *langkau*. Additionally, each household returns to their longhouse at least once a month because the village still follows the tradition of *nungkun api*.[10]

In contrast to TL/JS village, all households from ML village have built roadside *langkau* and have already abandoned the longhouse along the Kebulu River. They are building a new longhouse by the roadside in an attempt to completely shift their residence from the riverside to the roadside. Until now, only ML village has completely moved their longhouse to the roadside.

15.5.2 Cultivating Oil Palm

Many people who built roadside *langkau* have begun planting oil palm. Although the majority only have a few hundred saplings, a small number have begun selling oil palm fresh fruit bunches. There are different ways of planting oil palm. Villagers can either buy seedlings or seeds and transplant the saplings after growing them or they can obtain ripe fruit from other oil palm farms and use those seeds. Villagers who own cars carry their fresh fruit bunches to sell to a nearby dealer (an intermediate buyer) or directly to the oil mill at a company plantation.[11] Another plantation company also plans to build an oil mill nearby within the next few years and some local people plan to sell their fresh fruit bunches there once it is completed.

Those who do not own cars sell their fresh fruit bunches to middlemen. Many middlemen in the upper Jelalong are Kayan from the Tubau area and the village head of LSTB village also travels around in a lorry making purchases. The transport fee can be half of the fresh fruit bunches' price though there are other middlemen with lorries who only charge one third of the price for transport. The number of middlemen is generally low as there has not been much fresh fruit bunch trade in the area and the residents seem to have insufficient information about these middlemen and fresh fruit bunch prices.

Although small-scale oil palm farming by local residents in the area began relatively late compared with the indigenous villages along the Bakun road, they hoped that it would become an important source of income in the future. Road infrastructure is absolutely essential for oil palm farming and, consequently, those who wish

[10] *Nungkun api* is an Iban tradition that requires its followers to light a fire in the kitchen once a month, even if the longhouse is vacant. If the tradition is not followed, a penalty must be paid. Although TL/JS village is of Penan origin, Iban traditions have been incorporated into their customs.

[11] Locally, the small-scale fresh fruit bunches dealing sites dotting the region are called 'ramps'. The fresh fruit bunches that small farmers bring to the ramps are later transported to plantation oil mills by lorry.

to piggyback on the small-scale oil palm farming boom must shift their subsistence activities to the roadside, rather than riverside longhouses.

15.5.3 Land Usufruct

There is another reason for people living along the Jelalong River to move to the roadside. Concerned that their land (fallow fields from slash-and-burn cultivation or *temuda*) is being eroded by the expansion of plantations owned by development companies, they are trying to secure and strengthen their land usufruct or proprietary privilege. According to villagers, land left fallow for too long may be considered 'idle land' and their traditional native customary rights to the land are sometimes ignored. This makes it easier for companies to develop villagers' fallow lands for plantations. The recultivation of fallow lands and planting of oil palm emphasise that the lands still belong to the indigenous people.

Villagers say that both government and private developers frequently come to 'scout out' the indigenous people's land. As the economic value of land along the roads has increased, the demand for land development has followed. In fact some of the villagers suspected we were developers and therefore we were occasionally unable to conduct proper surveys during our research. Land issues are thus becoming more sensitive and heated in areas along the road rather than along the river. While there were frequent negotiations and conflicts over the use of forest resources during the commercial logging period, there were relatively fewer problems concerning the buying and selling or takeover of the land itself. In contrast, the current development of acacia and oil palm plantations is causing indigenous people to deeply reconsider problems surrounding land ownership, occupancy rights and usufruct.

According to a staff member of the state forest department who is familiar with the region, not many people wanted to live along the road in the era of commercial logging because there was a terrible and persistent dust problem due to the passage of timber lorries. There were a few occasions when indigenous inhabitants worried about the land being requisitioned or when they sought to emphasise their land usufruct or ownership even when it concerned the deterioration of forests. However, commercial logging was coming to an end and oil palm plantations began to be established. Unlike the previous strategy of selectively taking harvest goods from the forest, plantations invest money in the land itself. It is only once the investment has been recouped that revenue begins to flow. Therefore, the economic acts of enclosing the land and continuously managing it are essential.

We can theorise that many of the indigenous people living along the Jelalong River are strongly aware that the current problems surrounding their living space are not the conventional scrambling for resources, but are increasingly becoming the new 'struggle for land' that is seen across the state of Sarawak. In response, their move to the roadside has accelerated over the last few years.

As can be seen, behind the proliferation of roadside *langkau* lie a desire for convenient access to other areas (particularly urban areas), the hope of an income from oil palm smallholding and an intention of establishing exclusive land rights as a fait accompli due to the wariness of vigorous plantation development.

15.6 Mobility of People

Many of the people using *langkau* as a base for oil palm farming continue to travel back and forth between the *langkau* and longhouses. In some cases, this is because of their children's schooling; in others, it is because their slash-and-burn hill rice cultivation is done near the longhouses. Some visit the longhouses because of tradition; major festivals such as Gawai are still held at the longhouses. The method of travel back to the longhouses depends on the longhouse location. It varies from travelling on roads by car, navigating the river by boat, walking or a combination of these, with many using both land and river-based transportation. At the very least, though, it is clear that living in roadside *langkau* makes access to the city easier than ever before.

As others have pointed out, the indigenous peoples of Sarawak often undertake wage labour in the cities (Kedit 1993). This may be in the form of contract labour for a few months or they may receive a regular monthly salary. Many of the *langkau* we visited were empty. When asked, some neighbours told us that the residents were at their longhouse, but more often we were told that they were working in Bintulu town and would return to their *langkau* on weekends to look after their oil palms.

The advent of this new crop (oil palm) is changing people's way of living significantly, their residence patterns in particular. The complex interaction between residential patterns and land claims in MS village is particularly interesting. In the late 1950s, the people of MS village moved to the Jelalong basin from Lubok Antu. At the time, slash-and-burn hill rice cultivation as well as hunting and gathering were the main sources of their livelihoods. Nearly a decade later, they moved again, this time from the upstream of the Jelalong River to the vicinity of Tubau further downstream. They then bought land from the Kayan and built a longhouse by the side of the Tubau River. Currently the Tubau riverside longhouse is primarily occupied by elderly villagers who cultivate rice whereas most of the younger villagers have moved to Bintulu to work for wages. A few years ago, the villagers began building *langkau* and growing oil palm in the roadside fallow fields they once tilled for rice cultivation upstream of the Jelalong River. While the longhouse community may seem to have abandoned the land upstream of the Jelalong River some decades ago, they have actually been expanding their economic activities in land investment by planting oil palm in this area. Simultaneously, they are shifting their living base to the town of Bintulu and maintaining their longhouse by the Tubau River. This is a very interesting case of how Sarawak's indigenous people maintain multiple residences and propose a new method to claim their land rights.

15.7 From a Riverine to a Terrestrial Society

The social landscape of Jelalong basin societies has changed greatly with the arrival of the plantations. These changes can be summarised as follows.

15.7.1 Changing from a Riverine Basin Society to a Terrestrial Society

In the Kemena–Jelalong basin, most indigenous groups lived in riverine societies centred on longhouses. Their life was largely based on the river basin and the river was the main channel connecting people. In the Brunei sultanate era and during British colonial rule, Malay merchants from Brunei and Chinese from Bintulu and Tubau were trading with the Penan and others by travelling up the many river channels. In addition, during the commercial logging era from the late 1970s onwards, the river was used to send large amounts of wood downstream, bringing substantial wealth inland.

The river was the source of people's livelihood in terms of the extraction of forest resources, specifically the harvesting and trading of non-timber forest products and riparian timber logging. However, the foundation of basin society life has begun to shift inland over the past few years. In the mid-2000s the highway connecting Bintulu and Bakun was completely paved. In addition to the logging roads that run inland like capillaries, the road network around the oil palm plantations has been extended in the past two decades. Recently, the number of cars and pick-up trucks parked in the villages has also significantly increased.

Oil palm is different from traditional forest products and wood because roads are absolutely necessary to transport the fruit bunches. If the palm oil is not extracted from the fruit bunches within 24 h of harvesting, it degrades and loses both its quality and yield. This chemical factor has a great impact on the social network. As roads quickly increase in importance as a prerequisite for small-scale oil palm cultivators, we can expect a pivotal change in social organisation through the 'terrestrialisation' of the riverine society, that is, a switch from a riverine to a terrestrial society.

15.7.2 'Terrestrialisation' as an Adaptation Process of Inhabitants

As previously noted, the activity in the Jelalong basin is not merely a conventional scrambling for resources but could more accurately be called a struggle over land. During the era of commercial logging, the readily available harvest goods or renewable biomass resources were subject to exploitation. In contrast, during this current period of plantation development the land is seen as an asset. The local inhabitants are concerned that development companies will seize their land. Loss of land is a serious concern for them as they would also permanently lose access to the various forest products that are produced on that land. This struggle for land, triggered by plantation development, reflects the power relations between a multitude of players including the state government, development companies and local residents. It should also be understood as a manifestation of plantation politics, rather than the permeation of the plantation economy.

Under these changing circumstances, instead of negotiating with the companies by blockading the roads or interfering with operations, as was often done during the commercial logging era, local people are prioritising the act of effectively dominating the land by building roadside *langkau* and then performing slash-and-burn cultivation and oil palm farming. This is considered an undertaking through which they seek to establish their land usufruct as a fait accompli by the actual utilisation of their land.

The villages in the Jelalong basin possess the documents and maps exchanged with the district officer and the Penan chiefs during the colonial period. These documents have been used for claiming land rights. However, during a perimeter survey, the ownership of some land could not be determined.[12] Obviously, this is considered an extremely sensitive and pressing issue for the region's inhabitants as it affects their ability to make a living.

15.8 Conclusion

Over the past few years, the occupancy rates in longhouses and villages along the banks of the Jelalong River have decreased with empty *bilik* (rooms) and longhouses becoming more noticeable. Perhaps this should be considered as one phase of a changing process from the basin to the land, rather than as a representation of the destruction of the village communities. In this process, local people develop migration strategies related to complex, intertwined political, economic, ethnic and ecological elements. At present, it is difficult to determine whether this should be regarded as a migration from or a replacement of a basin society with a terrestrial society, or whether it should be seen as a reorganisation of a basin society in a broader sense. What can be affirmed is that the maintenance of multiple dwellings in longhouses, *langkau* and the city allows indigenous communities to secure a spatial base from which they can adapt as needed to either the natural economy, the plantation economy or the urban economy. In other words, they create a number of

[12] In 2010 a perimeter survey conducted by the Sarawak state government represented a new way of surveying and registering land in the inland indigenous communities. However, details regarding the survey and registration process are still lacking. The state government has emphasised that this is a new concept developed to maintain the indigenous inland inhabitants' land rights, but many within the inland indigenous community remain sceptical.

bases in order to facilitate a flexible and opportunistic selection of their livelihoods in response to changes in their external living environment. This mobility could be deemed as their new survival strategy in a modern context.

Acknowledgments This study was partly supported by the Japan Society for the Promotion of Grant-in-Aid for Scientific Research (issue numbers 18401008, 18720224 and 22221010).

References

Cramb, Rob A., and J. Dian. 1979. *A social and economic survey of the Bintulu extension region—Report no. 8*. Kuching: Department of Agriculture, Planning Division.

Ishikawa, Noboru. 2010. Rekishi no naka no baiomasu shakai—nettai ryūiki shakai no dansei to isō ten'i [Tropical biomass society in history: Resilience and transformation of riverine communities]. In *Chikyū-ken seimei-ken ningen-ken: jizoku-tekina seizon kiban o motomete* [Geosphere/biosphere/humanosphere: Seeking a sustainable and survival base], ed. Kaoru Sugihara, Shuichi Kawai, Yasuyuki Kōno, and Akio Tanabe, 251–280. Kyoto: Kyoto University Academic Press.

Kato, Yumi. 2014. Changes in resource use and subsistence activities under the plantation expansion in Sarawak, Malaysia. In *Social-ecological systems in transition*, ed. Shoko Sakai and Chieko Umetsu, 179–194. Tokyo: Springer.

Kedit, Peter Mulok. 1993. *Iban bejalai*. Kuala Lumpur: Ampang Press.

Rousseau, Jérôme. 1990. *Central Borneo: Ethnic identity and social life in a stratified society*. Oxford: Clarendon Press.

Soda, Ryoji. 2005. Mareishia Sarawaku shu o meguru kokusai rōdō idō [International labour migration from and to Sarawak, Malaysia]. In *Ajia Taiheiyō no jinkō idō* [Migration in the Asia-Pacific region], ed. Yoshitaka Ishikawa, 299–326. Tokyo: Akashi Shoten.

———. 2009. Sutokku no shakai, furō no shakai—nomaddo no shigen riyō [Stock societies and flow societies: Resource use of nomadic people]. In *Ningen katsudō-ka no seitaikei nettowāku no hōkai to saisei—Heisei 20-nendo FR 1 kenkyū purojekuto hōkoku* [Collapse and restoration of ecosystem networks with human activity: Fiscal report on FR 1 Research Project, 2008], ed. Shoko Sakai, Reiichiro Ishii, and Norio Yamamura, 98–99. Kyoto: Research Institute for Humanity and Nature.

Soda, Ryoji, and Noboru Ishikawa. 2014. Shuryō saishū-min' to shinrin no shōhin-ka—Boruneo hokubu punan no senryaku-teki shigen riyō [Hunters and gatherers and the commodification of forest produce: Strategic resource utilisation in the Jelalong basin catchment in northern Borneo]. In *Shigen to seigyō no chiri-gaku* [Geography of resources and livelihood], ed. Satoshi Yokoyama, 137–164. Shiga: Kaiseisha Press.

Soda, Ryoji, and Kuniyasu Mokudai. 2013. Ryōkai kanōna monogatari o tsukuru: kasen saigai to tsukiau tame ni [Creating a story people can understand: For dealing with riverine disasters]. In *Boruneo no sato no kankyō-gaku—henbō suru nettai-rin to senjūmin no chi* [Ethnography of Borneo anthropogenic landscape: Changing tropical forests and indigenous knowledge], ed. Masahiro Ichikawa, Ryoji Soda, and Daisuke Naito, 55–93. Kyoto: Shōwadō.

Chapter 16
The Impact of RSPO Certification on Oil Palm Smallholdings in Sarawak

Yumi Kato and Ryoji Soda

Abstract This chapter investigates the efficiency of the Roundtable on Sustainable Palm Oil (RSPO) certification system on smallholders in the Malaysian state of Sarawak. It focuses on a plantation that is an RSPO holding company, as well as surrounding villages in the state. The RSPO system was introduced in 2004. First, smallholders can reap substantial profits by cultivating oil palm. Compared to conventional crops, oil palm is currently one of the most attractive cash crops for inland dwellers. Smallholders view it as a flexible livelihood because they can combine it with other economic activities based on each household's manpower and current financial situation. Second, RSPO certification has the potential to give smallholders more autonomy. Various forms of company support (based on the RSPO system), such as initial investment subsidies, free seedlings, technical support and fertiliser, are very important for smallholders' success. Such support allows them to cultivate oil palm independently because company aid does not directly compel them to sell oil palm fruits to the company's mill. Third, this chapter shows that the two-way relationship model gives inland indigenous communities the potential to become producers in the oil palm industry. This research offers a new perspective on how smallholders manage their businesses well by working with other leading actors through RSPO certification.

Keywords Sarawak · Oil palm · Plantations · Smallholders · Certification system · Roundtable on Sustainable Palm Oil

---

Y. Kato (✉)
Center for Arts and Sciences, Fukui Prefectural University, Eiheiji, Japan

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_16

16.1 Introduction

Borneo has become the last frontier of oil palm cultivation; it is a new area of surplus land for Malaysia and Indonesia (McCarthy and Cramb 2009). Indonesia, Malaysia and Thailand are currently the top three oil palm producers in the world. Annual production of oil palm fruit in 2016 was 160 million tonnes in Indonesia, 86 million tonnes in Malaysia and 12 million tonnes in Thailand (FAOSTAT 2016). Oil palm cultivation flourished in peninsular Malaysia in the 1970s and 1980s. However, available land in that part of the country has declined due to population growth and industrial development, and sufficiently large swaths of land are no longer available (Ministry of Agriculture Malaysia 1998; Sasaki 1999; Hon and Shibata 2013). The Malaysian state of Sabah was the centre of oil palm production after 1990, while Sarawak had replaced it by the second half of the 1990s. Similarly, oil palm cultivation in Indonesia advanced mainly on Sumatra (Kajisa 1996) though Borneo drew attention as an alternative site for new development due to the difficulty of draining the peat swamplands of Sumatra (Feintrenie et al. 2010).

As Fig. 16.1 illustrates, the area dedicated to oil palm cultivation in Sarawak has increased drastically over the past 20 years. Oil palm plantations covered about 77,142 ha in 1992 and reached 414,260 ha by 2002. By 2012 this area had increased to 1,076,238 ha, and, according to the latest data, the oil palm planted area at

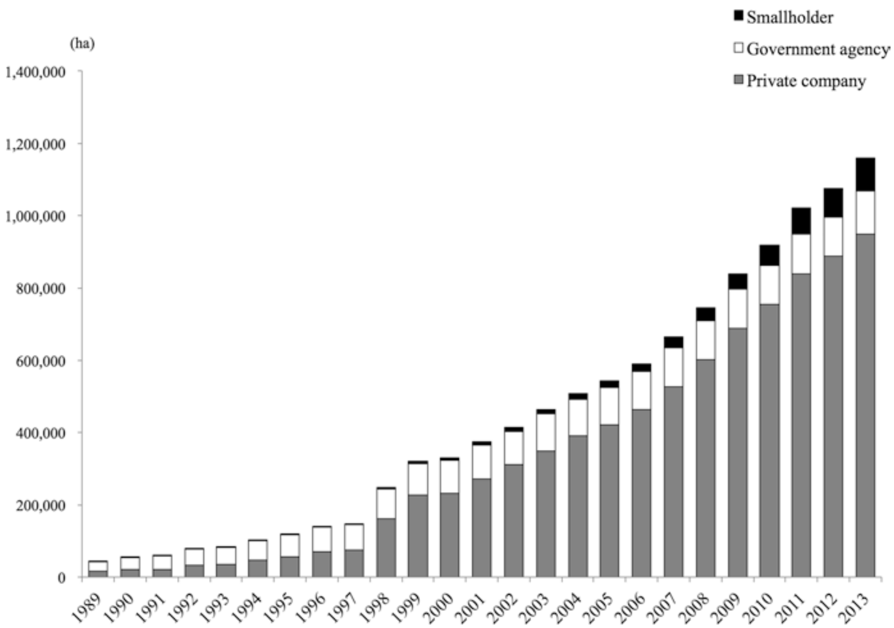


Fig. 16.1 Estimated land area in Sarawak utilised for oil palm cultivation, 1989–2013
Source: Department of Statistics Malaysia, Sarawak Branch (1989–2013)

December 2017 was 1,555,828 ha (Department of Statistics Malaysia, Sarawak Branch 1993, 2003, 2013; MPOB 2017).

The primary stakeholders in the oil palm industry in Sarawak have gradually changed. The government led plantation development until 1995 and then private companies took control after the introduction of *konsep baru* (new concept) in the mid-1990s. *Konsep baru* promoted the effective use of indigenous land by operating joint ventures between private companies and villagers. In this system, private companies lease indigenous people's land for 60 years to develop oil palm and the companies promise to give landowners 30% of the profits in return (Ngidang 2002). Private enterprises flourished using the growing inflow of external sources of capital. In Sarawak, the growth rate of smallholdings since the mid-2000s has been relatively high. The total area covered by oil palm smallholdings in Sarawak increased from 165,625 ha in 2010 to 241,280 ha in 2014, due in part to improved access to oil mills and road development (Department of Statistics Malaysia, Sarawak Branch 2015). The recent astounding expansion means that even large plantation companies cannot ignore conflicts and negotiations with smallholders any longer (Cramb and Sujang 2013).

Initially, oil palm plantations in Sarawak were primarily developed along the coast. However, cultivation by smallholders is currently spreading throughout the inland hill zones on vast post-swidden areas (Kato and Soda 2012). Smallholders are becoming significant actors in the growth of Sarawak's oil palm industry because this inland fallow ground covers an extremely large expanse.

Plantations were historically considered superior to smallholdings due to their economies of scale, road infrastructure, institutional financing and technical advantages during the processing stages. However, smallholdings are the best way for indigenous landowners to earn the greatest profit from oil palm cultivation. Koji Tanaka (1990) pointed out that although rubber plantations were the initial leaders, in Southeast Asia smallholdings have gradually gained an advantage in rubber cultivation too.

Along with the increasing presence of smallholders, it is necessary to examine the capability and profitability of oil palm smallholdings in a context where large-scale plantations are expanding. To do so, this chapter focuses on one plantation and its surrounding smallholders who obtained Roundtable on Sustainable Palm Oil (RSPO) certification. The international community has high expectations for RSPO certification as a system that can promote sustainable oil palm cultivation while also considering environmental degradation and native people's land rights. To examine the efficiency of RSPO certification for oil palm smallholdings, the discussion in this chapter focuses on three elements.

First, it examines the importance of oil palm smallholdings in the agricultural transitions of local communities. Oil palm cultivation is flourishing in Sarawak, exceeding swidden agriculture on which conventional research about local subsistence activities has typically centred (Freeman 1955; Chin 1985; Dove 1985). Only a few studies mention the significance of commercial crops such as rubber, cocoa, coffee and pepper, despite the fact that these crops have provided a new means of livelihood in the region (Cramb 1990, 2007). To address this point, this study discusses the potential and capability of oil palm smallholdings in the context of local people's livelihood portfolios. In addition, it examines how people operate their oil palm smallholdings flexibly by combining them with other economic activities.

Second, this study analyses the efficiency of RSPO certification on oil palm smallholdings. Previously, government agencies such as the Department of Agriculture Sarawak, the Farmers' Organisation Authority (FOA) and the Malaysian Palm Oil Board (MPOB) provided aid and subsidies to smallholders. Support from private companies has not been previously reported. In the case study illustrated here, the plantation company has shown initiative in maintaining a mutually beneficial relationship with the smallholders. The plantation provided a variety of resources while helping smallholders maintain their independence, autonomy and options. Previous research classified smallholders into three categories: independent smallholders, supported ones and managed ones (Cramb 2011). These studies compared managed smallholders' profits (12% of all smallholders) with those of joint ventures (Cramb and Ferraro 2012). However, RSPO-certified smallholders have been largely ignored. Therefore, this research includes an analysis of the possibilities for collaboration between smallholders and certification-holding companies.

Third, the study reconsiders the dichotomy and conflict between plantations and smallholders. In order to delineate the struggle for land resources, previous research has tended to divide oil palm industry stakeholders into government agencies, plantation companies and local communities. These studies often report land conflicts (Okamoto 2002; Barney 2004). However, research is starting to appear that explores the significance of smallholders who collaborate with plantation companies and smallholders' strategic and fluid manoeuvres in generating revenue (Cramb and Sujang 2011, 2013; Cramb and Curry 2012). This chapter aims to move beyond the dichotomy between the lessees and lessors, or buyers and sellers, of land. It investigates the potential of smallholders to become major players in the oil palm industry.

16.2 Study Area and Methodology

This research was conducted in Bintulu Division of Sarawak, Malaysia. With a population of 219,526 in 2010 (Department of Statistics Malaysia, Sarawak Branch 2013), Bintulu is the third most populous division in the state. The division covers Sarawak's middle coasts and is divided into two geographic areas. The first is the plains, which stretch along the coastline, and the second is the hilly inland zone. Industrial complexes, including oil palm processing mills, are located along the coast. The inland part is characterised by huge undulating hills with villages (typically longhouse communities) scattered throughout.

The number of oil palm smallholders is largest in Sarawak's Miri Division because the government has prioritised oil palm plantation development there since the 1980s. Miri Division boasts the most registered smallholders in Sarawak, with 10,518 smallholders out of a total of 30,072 smallholders (MPOB 2018a). However,

Table 16.1 Estimated cultivated area by oil palm smallholders in Sarawak, 2002, 2012 and 2018

Division	Cultivated area (ha)			Percentage increase in cultivated area, 2002–2018
	2002	2012	2018	
Betong	642	3786	12,157	1893.6
Bintulu	186	7638	17,329	9316.7
Kapit	1	1567	4041	404100.0
Kuching	161	3983	10,061	6249.1
Limbang	95	1992	4214	4435.8
Miri	7992	32,751	63,246	791.4
Mukah	426	2655	8371	1965.0
Samarahan	541	6375	21,365	3949.2
Sarikei	130	3234	10,064	7741.5
Sibu	54	3711	9733	18024.1
Sri Aman	637	3700	8600	1350.1
Total	10,864	71,391	169,181	

Sources: MPOB (2012, 2018a) and Department of Agriculture Sarawak (2002)

Bintulu Division has grown remarkably in terms of oil palm cultivation since the 1990s. Currently, 2968 smallholders are registered in Bintulu Division, which is the second largest number following that of the Miri Division. Over the past 10 years, the area of oil palm cultivation by smallholders in Bintulu Division has increased rapidly, third only to the Kapit and Sibu divisions (MPOB 2018a) (see Table 16.1).

The advanced road networks found in the flat coastal areas of Bintulu Division were part of the impetus for the initial development of oil palm plantations in the region. The area is also suitable for broad-scale land grading for planting and transporting harvested fresh fruit bunches to the oil mill within 24 h of being picked.[1] In the past, coastal areas had the advantage of adequate infrastructure because many oil mills were already in place and there were ports for exporting the refined palm oil. Recently, however, oil palm cultivation has spread throughout the inland zone because coastal land has become scarce and inland roads have been increasingly developed. Oil palm smallholders are now found in almost every village in the division (Kato and Soda 2012). The study area for this research is Tubau which is a frontier for oil palm cultivation located along the main inland road (Fig. 16.2). The plantation company in this case study (company K) and the related smallholders are located in this frontier zone.

Company K established an oil palm plantation in 1997 and had approximately 6000 ha of cultivated land. This area is small compared to other plantations which tend to have plantations sites of more than 20,000 ha. The company produces about 120,000 tonnes of fresh fruit bunches annually. More than 10 employees work in the field offices and about 600 field labourers (mostly Indonesians) work on the plantation. A subsidiary company built an oil mill on the plantation in April 2007. In 2011 about 55% of the total fresh fruit bunches processed in the mill was harvested from

[1] Fresh fruit bunches oxidise quickly after harvesting and thus must be transported to the oil mills as soon as possible to prevent losses in the yield and quality of the extracted palm oil.

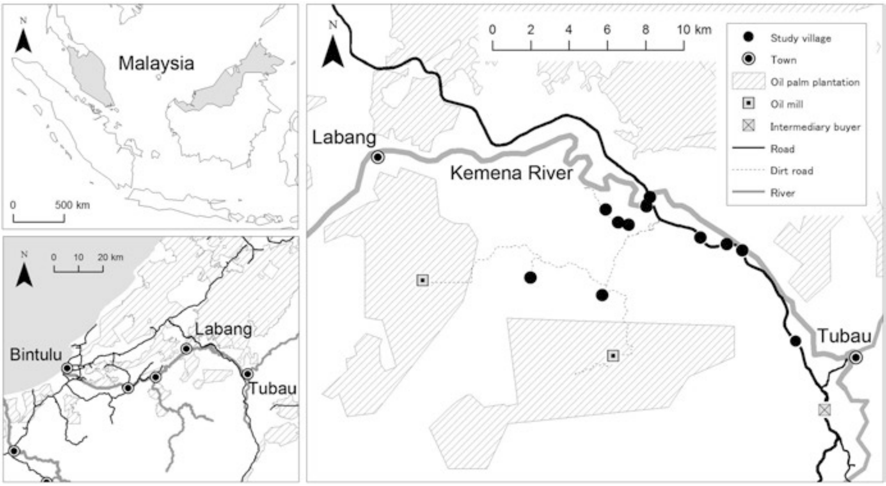


Fig. 16.2 Location of villages and oil palm plantations
Source: Kato and Soda (2012) and authors' field research
Note: Smallholders' farms are not included in this map

their own plantation sites, about 40% came from other companies' plantations and 5% was bought from smallholders. Although the percentage of total fresh fruit bunches bought from smallholders is low, it is in fact an extremely large amount of annual production. The company's manager stated that smallholders make a substantial contribution to the mill's stable operations.

The stakeholders recognised by company K include staff from the MPOB, agricultural material suppliers, contractors and government agencies such as the Bintulu District Office, police stations, fire stations, the Immigration Department of Malaysia, Sarawak, the Department of Labour Sarawak, clinics, primary schools and 11 villages around the plantation. The stakeholder villages include all villages located within a 10-km radius of company K's plantation. The majority population of these villages are Iban.

We conducted interviews with company K and 11 stakeholder villages in August 2011 and March and August 2012. We visited company K twice and interviewed management-level staff about how they run the plantation and the mill and the specifics of enforcing RSPO certification. Regarding the 11 villages, we spoke with chiefs and households in each one. Of the 11 villages, we decided to focus on MA and AN villages in particular. In addition to speaking with all individual households, both group interviews and discussions were used. We also spoke with elderly residents about the history of both villages. Interviews included questions regarding the villages' previous and current agricultural activities, the conditions of oil palm cultivation and smallholdings, their relationships with large-scale plantations, their involvement with the RSPO system and its impact, their relationships with and evaluation of company K and its subsidiaries, and the transition that the subsistence economy has gone through over the past 60 years.

16.3 Results

16.3.1 Company K and 11 Stakeholder Villages

Company K is one of 37 oil palm plantation companies operating in Bintulu Division. The company is a private Sarawakian enterprise managed by an influential Iban of the region. Company K is unique because it has been RSPO certified. The RSPO is a non-profit association comprising palm oil processors and traders, retailers, banks, environmental non-governmental organisations and other players in the commodity chain. The certification aims to transform markets to make sustainable palm oil the norm. The RSPO was formally established in 2004 and has developed a set of environmental and social criteria that companies must comply with to produce palm oil that is certified as sustainable.

To become RSPO certified, company K has met numerous requirements including environmental considerations, contributions to employees' welfare and regard for the surrounding stakeholders in the area. For example, the company created buffer zones along the river banks and deposits factory refuse in a waste reservoir to reduce its environmental impact. The company conducts safety training for its workers who participate in herbicide spraying and harvesting. In addition, the company provides workers with full accommodation. The workers' quarters are high-quality concrete structures with free water and natural gas. Clinics, sports fields, assembly halls and religious facilities (a mosque and a church) are located near the quarters. Among the events held every year for the employees' benefit are the annual Gawai festival, Christmas, Indonesian independence day, religious festivals for Muslims and the annual company dinner.

Taking local communities into consideration is an important RSPO principle for plantation companies. Company K organises numerous activities for the surrounding villages. For example, the company offers short educational courses on methods for cultivating oil palm and arranges discussions with village headmen three or four times a year.

Most of the people in the villages began cultivating oil palm between 2000 and 2008. For example, the people in NU village began planting in 2000 and have sold fresh fruit bunches since the mid-2000s. On the other hand, people from SA village started planting in 2008 and began to sell their fresh fruit bunches in the early 2010s.

As shown in Table 16.2, the number of households engaged in oil palm cultivation differs from village to village. All households in MA, AN, NU and BA villages have oil palm gardens. In contrast, only about 30% of the households in MB, JA, EM and SA villages farm oil palm. The number of cultivated palms per household varies widely with some households growing more than 4000 palms while others plant no more than 100–200 palms.

MA and AN villages are unique among the stakeholder villages. Both are located on the periphery of company K's plantation and sold a portion of their land when the company first opened the plantation. The villages received free oil palm seedlings from company K in 2003. In particular, MA village has benefited from numerous

Table 16.2 Study villages and the range of oil palm cultivation per household

Study village	Number of households	Number of households that plant oil palm	Households that plant oil palm (%)	Average number of planted oil palms per household
MA	26	26	100	846
AN	19	19	100	595
NU	23	23	100	397
BA	17	17	100	1047
SL	13	6	46	1028
EM	8	3	38	367
SA	23	9	39	1700
MB	23	8	35	925
LI	17	15	88	612
JA	9	3	33	633
CH	11	ND	ND	ND
Total	189	129	–	–
Average	17.2	12.9	67.9	815.0

training programmes, such as special lectures for smallholders to become RSPO certified, agricultural advice and fertiliser assistance schemes. In contrast, most people in AN village recently began training to become certified as RSPO smallholders. Below, the significance of oil palm cultivation in these two villages is examined.

16.3.2 The Agricultural Transition to Oil Palm Smallholdings

People in MA and AN villages engaged in many economic activities before oil palm was introduced. According to elders in both villages, the residents moved from Sri Aman in the western part of Sarawak in about 1950. When they first arrived at their new location they mostly subsisted by growing dry and wet rice. While working diligently to farm rice, they also earned some income by selling vegetables, corn and wild boar meat at the nearby Labang market. In the second half of the 1950s they planted rubber trees and sold the harvested latex during the 1960s and 1970s.

During the 1980s, under the guidance of the Department of Agriculture Sarawak, the two villages cultivated commercial crops apart from rice such as cocoa and coffee. However, neither of these crops became stable sources of income. Fortunately, the villages produced black pepper to supplement their harvest which they sold at the Bintulu and Pandan markets until the early 1990s. From the 1990s to the early 2000s most of the villages engaged in logging in the riparian forests during the rainy season in order to sell timber to downriver traders (see Soda et al., Chap. 15).

In addition to these economic activities, villagers have worked away from farms since the 1980s. The headmen of MA and AN villages said some villagers worked for a nearby logging company in the 1980s and 1990s. Other villagers have worked in Bintulu or for company K since the 1990s. In recent years, residents of AN village have worked for company SP (in addition to working for company K) which is another nearby oil palm plantation. Thus far people have held jobs away from farms and all households now cultivate oil palm. The salient fact garnered from these interviews is that before the residents started to farm oil palm they grew many cash crops and conducted other economic activities with these undertakings being chosen according to the crops' market prices and each household's resources. This mirrors the 'fluid' economic manoeuvring mentioned in other chapters (Ishikawa and Ishikawa, Chap. 6; Soda et al., Chap. 15).

16.3.3 Current Oil Palm Smallholdings in MA and AN Villages

The residents of MA and AN villages began planting oil palm in 2003 because company K gave them free seedlings. This was relatively early compared to most other villages. All households in MA village applied for seedlings and began planting after they had deliberated over the matter at a community meeting. Each household received between about 500 and 1000 palms. The headman of MA village requested and planted 700 palms. In contrast, the headman of AN village requested and planted fewer palms (400). Other AN residents were suspicious during the first phase (in 2003) and did not apply for free seedlings. However, after having witnessed the success of their own headman and the MA villagers a few years later, most residents then began planting seedlings.

Afterwards, the MA and AN villagers expanded their oil palm cultivation by purchasing their own seedlings and seeds, based on each household's financial resources. The number of palms a family grows currently ranges from a few hundred to 2000 (see Table 16.3).

After they planted seedlings, the villagers began to use fertiliser and herbicide, with the types used varying according to the extent of their manpower and funds (Kato and Soda 2012). The villagers selected different types of fertiliser and herbicide based on their own personal experiences and what they had learned in the lectures given by company K. Most of the villagers usually buy low-cost fertiliser from company K. Others buy different kinds of fertiliser to use along with those provided by the company, depending on the condition of their palms. The types of herbicide vary according to their targets; some are more effective on weeds and grass while others prevent the growth of invasive trees. Villagers buy herbicides and fertilisers in Bintulu, choosing the kinds that meet their families' farming needs as well as their budgetary constraints.

Oil palm fruits can be harvested gradually, normally starting in the third year of cultivation. Most villagers sell their harvest to company K's mill because its purchasing price is higher than many other mills. Payment occurs via bank transfers. A

Table 16.3 Number of oil palms planted by each household in MA and AN villages

MA village			AN village		
Household number	Number of planted palms	Number of mature palms	Household number	Number of planted palms	Number of mature palms
1	1000	500	1	300	0
2	1000	500	2	1500	1500
3	1000	500	3	200	200
4	500	500	4	400	400
5	1000	500	5	600	600
6	1000	1000	6	600	600
7	1000	1000	7	600	600
8	1000	1000	8	2000	2000
9	1000	1000	9	700	700
10	500	500	10	300	300
11	1000	1000	11	500	500
12	1000	1000	12	200	200
13	300	300	13	1000	200
14	500	500	14	600	600
15	1000	1000	15	300	300
16	800	500	16	300	0
17, 18[a]	2000	2000	17	200	0
			18	400	0
19	1000	1000	19	600	600
20	1000	1000			
21	1600	1200			
22	1000	500			
23	200	0			
24	400	400			
25	1000	500			
26	300	300			

Note
[a]In MA village, the heads of households 17 and 18 are siblings who jointly manage their oil palm farms

few villagers with relatively few financial resources tend to sell their product to intermediary buyers so they can immediately get cash in hand, even when the price offered for their fresh fruit bunches is lower than that of company K. Three-tonne lorries and pick-up trucks transport the harvested fresh fruit bunches. MA village has six suitable vehicles and AN village has one. Residents without trucks rent them from those who own them and pay a transportation fee of RM30 per round trip.[2] Those who grow 2000 palms or more harvest their palms twice a month.

According to the group interview, villagers said it is possible to farm 200 to 400 palms along with rice, rubber and other kinds of agriculture. Oil palm cultivation is

[2] In 2013, US$1 was equivalent to RM3.06.

thus incorporated into a diversified livelihood portfolio. After a household plants about 500 palms, oil palm cultivation tends to become the family's main economic activity. Both the income generated and workload required increase to a point where the family does not need further earnings and additional workers are not available. When the number of oil palms farmed is about 1000 or more a farmer can become a dedicated oil palm smallholder. Many households that farm 500 or more oil palms soon abandon rice cultivation as the combination of farming both rice and oil palm becomes too difficult to sustain when the only available manpower comes from within the household. Only one household in MA village and seven households in AN village grew rice in 2011–2012. Thus the shift from cultivating rice to oil palm is accelerating in the region.

16.3.4 The Profitability of Oil Palm Smallholdings

Oil palm smallholdings are significant for a farming economy. In this section, the profitability of oil palm smallholdings based on the examples of the headmen in MA and AN villages is considered. A breakdown of yearly revenue and expenditure is shown in Table 16.4. Paying for seeds and seedlings is a necessary expenditure as an initial investment. The headman of MA village received 700 free seedlings from company K. He bought an additional 700 seedlings in Bintulu town at a total cost of RM1,469. The headman of AN village received 400 free seedlings from the company and also bought additional seedlings for RM12,800. Fortunately, buying seeds or seedlings is a one-time investment cost.

The largest expense is fertiliser. It is generally applied four times a year with 100 g of fertiliser used per application per palm in the first to third years. After the fourth year, each palm is sprayed with 2.5 kg of fertiliser three times a year. Most of the villagers usually buy low-cost fertiliser from company K that costs the villagers between RM65 to RM70 per 50 kg bag. Both headmen each fertilise their 2000 palms three times a year at an annual cost of RM19,500 for the headman of MA village and RM15,600 for the headman of AN village.

In comparison, herbicide is relatively inexpensive. Both headmen sprayed herbicide once every 3–4 months during the palms' first to third years. After the fourth year, the headmen sprayed herbicide once every 4–6 months. According to them, a 20-litre bottle of herbicide is the proper amount for a one-time application on approximately 2000 oil palms. Depending on the type and brand, the price of herbicide ranges from RM95 to RM130 per bottle. In total, the yearly herbicide costs are RM240 and RM360 for the headman of MA village and the headman of AN village, respectively.

In addition to these costs, the next largest investment is workers' wages. The headman of MA village has one employee (at an annual cost of RM9,600), while the headman of AN village has two full-time workers (at an annual cost of RM18,720). The headman of MA village said that one full-time worker is enough to manage 2000 palms because he and his wife also contribute manpower. The

Table 16.4 Annual estimated costs and returns for a typical smallholder in the survey

		Mr MA	Mr AN
	Estimated plantation area	12.5 ha[a]	11.1 ha[b]
	Number of palms	2000	2000
	Fresh fruit bunches sold annually	144 t	144 t
Annual gross revenue		RM86,400[c]	RM86,400
Annual expenditure	Fertiliser	RM19,500[d]	RM15,600[e]
	Herbicide	RM240[f]	RM360[g]
	Labour	RM13,200[h]	RM18,720[i]
	Truck loan repayments[j]	RM14,400	RM11,880
	Total	RM47,340	RM46,560
Annual net revenue		RM39,060	RM39,840

Note

[a]2000 palms ÷ 160 palms planted per ha = 12.5 ha
[b]2000 palms ÷ 180 palms planted per ha = 11.1 ha
[c]1 tonne is sold for roughly RM600
[d]300 bags (1.5 tonnes total) × RM65 per bag = RM19,500
[e]240 bags (1.2 tonnes total) × RM65 per bag = RM15,600
[f]1 bottle at RM120 × 2 applications per year = RM240
[g]1 bottle at RM120 × 3 applications per year = RM360
[h]Fixed salary: 1 person × RM800 per month × 12 months = RM9,600
Additional cost for harvesting: 2 persons × 3 days × RM25 per day × 24 times = RM3,600
Total labour cost: RM9,600 + RM3,600 = RM13,200
[i]Fixed salary of 2 persons × RM600 per month × 12 months = RM14,400
Incentive for harvesting: 12 tonnes per month × RM30 per tonne × 12 months = RM4,320
Total labour cost: RM14,400 + RM4,320 = RM18,720
[j]Return payments of loans that were taken out to purchase trucks for FFB transportation

headman of MA village hires people to harvest on a daily basis only when necessary. For example, suppose that the additional work for cultivating 2000 palms requires two people working for 3 days and that a day's wages are RM25 per person; given that harvesting occurs twice a month, the headman of MA village must therefore spend RM3,600 annually to cover these additional wages for harvesting. However, when family members exchange labour with other households in a flexible manner, the additional wages for harvesting do not cost the headman anything (see Soda and Kato, Sect. 17.4.3). Another large expenditure is transportation, most often in the form of loan repayments for lorries or pick-up trucks. The headman of MA village pays RM14,400 a year in vehicle loans and the headman of AN village pays RM11,880. Thus the annual expenditure of the headman of MA village is approximately RM47,340 and is about RM46,560 for the headman of AN village.

As for revenue, both headmen harvest about 12 tonnes of fresh fruit bunches per month. The income from this amounts to approximately RM86,400 annually as long as company K maintains an average purchasing price of RM600 per tonne. The average purchasing price between February 2011 and February 2013 was RM629 per tonne. After subtracting the necessary expenses, the headmen of MA and AN villages make a monthly net profit of about RM3,255 and RM3,320 respectively. This profit is high compared to any of the previous cash crops and provides a better income than working in the city. Considering that unskilled labourers in the government sector earn less than RM1000 a month, this is a high income for an agricultural household in the inland area. Villagers said they could make a decent living with 500 palms, live comfortably with 1000 and obtain a large profit with 2000. A smallholding of 1000 oil palms should lead to a large enough profit to ensure that farming rice is unnecessary, in which case there would be insufficient time and labour to tend to the rice.

Thus even on a plot of land as small as 1 ha or 2 ha oil palm smallholdings can benefit local people provided that the threshold levels of initial investment funds are affordable and there are road networks, transport systems, multiple buyers and appropriate agricultural training in place.

16.3.5 Subsidies and Support from Company K

The support that company K provides to neighbouring smallholders consists of three categories: (1) compensation for land and trees; (2) subsidies and aid; and (3) lectures and courses to become RSPO certified.

Regarding compensation for land, villagers receive RM700 per ha. They also receive RM100 per productive tree (such as rubber, cacao, durian and mango). RM700 per ha is low compared to the few thousand ringgit that other companies usually pay. However, many villagers have said company K have not forced communities or individuals to engage in development without their own consent, unlike other logging or plantation companies. The surrounding villages value this aspect of company K.

Company K has maintained roads in some neighbouring stakeholder villages and donated building materials and cash when AN village burned down after a fire. When weddings, funerals and traditional festivals are held in the surrounding villages, the company provides food, drinks and cash donations. These are conventional forms of social support that many logging and plantation companies undertake. Moreover, company K also provides free seedlings and low-cost fertiliser as mentioned earlier. Fertiliser (which can cost about RM120 per bag in Bintulu) can be bought for RM65 to RM70 from the company. To make it even easier, the company has implemented an instalment system in which fertiliser costs are deducted when villagers sell their fresh fruit bunches to the mill. Villagers said this system benefits smallholders who lack capital so they can regularly fertilise their oil palms without a considerable cash flow.

Considering that MA village was the first smallholding village in Sarawak to become RSPO certified, the unique quality of the company's support is its initiative to provide smallholders with the special training needed for certification. Company K provides both indoor and on-site technical lectures and advises villagers on appropriate oil palm cultivation. This programme has already taken place for AN and BA villages. The villagers have high expectations because MA village took part in special courses and its residents have been RSPO certified since 2010. As stated previously, company K organises meetings and offers short courses on methods for farming oil palm. According to people in other villages, many of these courses are open to both stakeholder villages and non-stakeholder villages.

16.4 Discussion

16.4.1 The Potential of Smallholders as Oil Palm Producers

During the group interviews, many villagers believed that oil palm cultivation is a more consistent form of agriculture in comparison with their previously cultivated cash crops such as rubber, cacao, coffee and pepper. MA and AN villagers engaged in rubber cultivation from the 1950s to the 1970s, but many residents complained that rubber tapping requires hard work before dawn and production drops sharply during the rainy season. They also grew cacao and coffee in the 1980s, neither of which lasted for long due to pests and unstable market prices. Although pepper cultivation brought some households considerable income in the 1980s, villagers pointed out that it is a relatively high-risk crop since it is harvested just once a year and is easily affected by both weather conditions and crop diseases. They engaged in logging riparian forests in the 1990s and early 2000s though it was difficult to earn a stable income because they could transport timber downriver for trading during the rainy season (see Soda et al., Chap. 15).

In contrast, oil palms can be harvested twice a month at a consistent pace throughout the year. In recent years, oil palm prices have fluctuated between RM380 and RM770 per tonne (MPOB 2018b). Most informants said an oil palm smallholding was a reliable form of agriculture with the potential for large profits. This perceived stability has boosted the number of oil palm smallholdings.

Since the 1990s researchers have often pointed out that rice cultivation in rural Sarawak has declined, whereas off-farm employment in urban areas and depopulation in rural villages have both increased (Morrison 1993; Parnwell and King 1998; Kedit and Chang 2005). Oil palm cultivation has become an attractive economic activity that can generate considerable income, even in rural villages.

The residents of MA and AN villages understand the vulnerability of monocropping in terms of diseases and price fluctuations. When asked about the threshold price of fresh fruit bunches, many villagers said a net loss would result if their price dropped to below RM300 per tonne. Afraid that the price of fresh fruit bunches would fall, all MA and AN villagers and some people in surrounding villages began to plant new species of rubber trees in anticipation of a future decrease in price.

They said they could respond flexibly to future risk by combining oil palm cultivation with off-farm employment and other agricultural work using their remaining fallow land. Thus the villagers do not see the introduction of oil palm as a drastic or irreversible change in their subsistence. From a long-term perspective, the current boom in oil palm cultivation is only one phase in the villagers' 60-year history of subsistence economy.

16.4.2 The Effect of RSPO Certification on Oil Palm Smallholdings

Compared to managed, supported and independent smallholders, the smallholders surrounding the plantation in this study are unique. Managed smallholders notably lack the freedom to determine how they use their land. The Sarawak Land Consolidation and Rehabilitation Authority (SALCRA) introduced the managed system in the 1970s with the goal of developing native land to aid the socioeconomic development of rural communities (Sanggin and Mersat 2013). The government provided smallholders with 1000–5000 ha of land that was divided into small plots. In the managed system, smallholders can borrow money to cover initial start-up costs and this is later deducted from their fresh fruit bunch sales. Hence, they must sell their harvest to an appointed mill. After 1990 many oil palm plot owners in the SALCRA scheme stopped farming themselves and began employing Indonesian labourers to maintain the plots instead. These landowners then worked in other jobs in urban areas. In many cases, they operated smallholdings only for a secondary or supplementary income (Cramb and Sujang 2013).

Supported smallholders farm oil palms under the programmes implemented by government-related agencies such as the Department of Agriculture Sarawak, farmers' organisations and the MPOB. Most of these projects only provide initial supplies, either sporadically or on a one-off or short-term basis. For example, buying groups could be a successful project as this would enable smallholders to pool their resources. In this instance, fertiliser is provided and smallholders are limited because they must send their fresh fruit bunches to appointed mills. The cost of fertiliser is deducted from a participant's sales. Their profits and incomes increase partly because they also receive technical advice (Cramb and Sujang 2013).

Although company K provides low-cost fertiliser and enforces a deduction system from fresh fruit bunch sales, smallholders are allowed to freely sell their products to other mills as well. In addition, they can take advantage of technical support, lectures and courses that the company frequently provides. Non-stakeholder villages can also receive most of this aid if they choose to.

The company–smallholder relationships in this research are unique because the smallholders are able to decide how to use their land and choose the mills to which they sell their harvest. Continual support by the company differs substantially from the short-term subsidies offered in previous models.

In this case study, a private company provided support while most conventional programmes were government-based. This special feature (which previous studies have not observed) can be attributed to the fact that company K is the first RSPO-certified company in Sarawak. According to a company K employee, becoming certified was a strategy to develop their corporate social responsibility and build the company's positive image in the region. To maintain the certificate through periodic audits, it is necessary to provide stakeholder villages with continual assistance. By being aware of the company's business strategies, surrounding smallholders have been taking advantage of support programmes to develop their own small-scale oil palm farms.

During the initial process of creating the plantation, some landowners in NU and JA villages rejected the land transactions with company K; they were dissatisfied with the selling price the company offered, which was considerably lower than that offered by other companies. Even after the plantation was established, a few residents of AN village remained sceptical of the company. They planted oil palms on their own land that was adjacent to the plantation to secure land rights and prevent potential encroachment.

Although the company and surrounding villagers continue to have some strained relations, conflicts over the area's indigenous lands have not occurred. Many of our informants attached a high value to the fact that they have not experienced any land grabbing, which previous studies have highlighted. An employee of the oil mill said the company regards surrounding smallholders as important fresh fruit bunch suppliers for stable factory management. In this sense, it is important for company K to educate smallholders on producing RSPO-certified fresh fruit bunches. As long as smallholders consistently provide the mill with high-quality fresh fruit bunches, the company does not necessarily require excessive land exploitation to expand the plantation. The relations between the company and smallholders present a new model that differs from the previously observed dichotomy.

16.5 Concluding Remarks

The boost in oil palm smallholdings is a unique phase in rural Sarawak's changing agricultural economy and is not an irreversible shift in villagers' subsistence traditions. Though farm sizes and methods are diverse, smallholders can reap substantial profits by cultivating oil palm. The number of palms needed to start a smallholding is flexible and depends on household size and financial constraints. A household with a smaller initial budget and insufficient manpower can only plant a few hundred oil palms on post-swidden land. Each household can gradually purchase additional seeds and seedlings, as needed and when they can afford to. Families can combine oil palm with numerous other economic activities such as rice cultivation, rubber tapping and working in other jobs off the farm; thus, each household can strategically respond to market fluctuations. Those who earn a considerable income from specialising in oil palm are not necessarily optimistic about long-term profitability and began to plant new rubber trees in anticipation of a future drop in the price of oil palm. It is important to remember that villagers cannot respond flexibly to market fluctuations without being able to decide how to use their land.

In this respect, RSPO certification has the potential to ensure that local smallholders retain a high degree of autonomy. Company K's support (based on the RSPO certification system)—such as initial investment subsidies, free seedlings, technical support and low-cost fertiliser—was key to making it easy for these smallholders to enter the oil palm industry. Surrounding smallholders have enjoyed the company's support and they attach a higher value to the company because it has not forced them to sell their land or build plantations. They also have considerable discretion when it comes to buying fertiliser from other retailers and selling their fresh fruit bunches to other mills or agents, again allowing them to maintain their independence and autonomy. Although there is some degree of tension over land rights, the case study shows the relatively positive aspects of oil palm smallholding when supported by an RSPO-certified company. In this context, the evaluation of RSPO certification's environmental effectiveness and its socioeconomic impacts on smallholding at the local level should be explored further.

This case study also shows that the connections between the company and surrounding smallholders are considerably different from conventional relationships. Most plantation companies (aided by the state's pro-plantation policy) have focused purely on acquiring land from rural indigenous communities to build plantations. These plantation companies consider the only contribution these rural communities can make to agricultural development is by selling or leasing their land to them.

In contrast to this conventional view of rural indigenous communities, company K has focused on helping local villagers to become sustainable oil palm smallholders by providing both material and technical support. This means the company sees the rural population as emerging oil palm-producing actors and not mere suppliers of potential plantation land. This case study suggests a new model of company–smallholder relationships, whereas previous research mainly focused on land conflicts with a sharp dichotomy. Future research should explore the development of relationships between diverse oil palm producers at different levels of scale.

Acknowledgements This research was partly supported by a Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science (nos. 22221010 and 24520896) and a Grant-in-Aid for Japan Society for the Promotion of Science Fellows (no. 22-1346). We are grateful to company K's staff and the people in the villages who helped make this field research possible. We would like to thank Universiti Malaysia Sarawak for their support. We would also like to thank Dr Hiromitsu Samejima for his support in editing a map. An early version of this paper was presented at the ninth conference of the Borneo Research Council, 26 June 2012, and at a special international seminar titled 'Human-Nature Interactions of the Riverine Societies in Sarawak: A Trans-Disciplinary Approach', Kuching, 29 June 2012.

References

Barney, Keith. 2004. Re-encountering resistance: Plantation activism and smallholder production in Thailand and Sarawak, Malaysia. *Asia Pacific Viewpoint* 45 (3): 325–339.

Chin See Chung. 1985. Agriculture and resource utilization in a lowland rainforest Kenyah community. *Sarawak Museum Journal* 35 (56) (Special Monograph No. 4): 1–322.

Cramb, Rob A. 1990. The role of smallholder agriculture in the development of Sarawak: 1963–88. In *Socio-economic development in Sarawak: Policies and strategies for the 1990s*, ed. Abdul Majid Mat Salleh, Hatta Solhee, and Mohd. Yusof Kasim, 83–110. Kuching: Angkatan Zaman Mansang.

———. 2007. *Land and longhouse: Agrarian transformation in the uplands of Sarawak*, Monograph series no. 110. Copenhagen: NIAS Press.

———. 2011. Re-inventing dualism: Policy narratives and modes of oil palm expansion in Sarawak, Malaysia. *Journal of Development Studies* 47 (2): 274–293.

Cramb, Rob A., and George N. Curry. 2012. Oil palm and rural livelihoods in the Asia–Pacific region: An overview. *Asia Pacific Viewpoint* 53 (3): 223–342.

Cramb, Rob A., and Deanna Ferraro. 2012. Custom and capital: A financial appraisal of alternative arrangements for large-scale oil palm development on customary land in Sarawak, Malaysia. *Malaysian Journal of Economic Studies* 49 (1): 49–69.

Cramb, Rob A., and Patrick S. Sujang. 2011. 'Shifting ground': Renegotiating land rights and rural livelihoods in Sarawak, Malaysia. *Asia Pacific Viewpoint* 52 (2): 136–147.

———. 2013. The mouse deer and the crocodile: Oil palm smallholders and livelihood strategies in Sarawak, Malaysia. *Journal of Peasant Studies* 40 (1): 129–154.

Department of Agriculture Sarawak. 2002. *Agricultural statistics of Sarawak 2002*. Kuching: Department of Agriculture Sarawak, Planning Division.

Department of Statistics Malaysia, Sarawak Branch. 1990. *Yearbook of statistics Sarawak 1989*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1991. *Yearbook of statistics Sarawak 1990*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1992. *Yearbook of statistics Sarawak 1991*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1993. *Yearbook of statistics Sarawak 1992*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1994. *Yearbook of statistics Sarawak 1993*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1995. *Yearbook of statistics Sarawak 1994*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1996. *Yearbook of statistics Sarawak 1995*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1997. *Yearbook of statistics Sarawak 1996*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1998. *Yearbook of statistics Sarawak 1997*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 1999. *Yearbook of statistics Sarawak 1998*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 2000. *Yearbook of statistics Sarawak 1999*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 2001. *Yearbook of statistics Sarawak 2000*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 2002. *Yearbook of statistics Sarawak 2001*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 2003. *Yearbook of statistics Sarawak 2002*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

———. 2004. *Yearbook of statistics Sarawak 2003*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2005. *Yearbook of statistics Sarawak 2004*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2006. *Yearbook of statistics Sarawak 2005*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2007. *Yearbook of statistics Sarawak 2006*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2008. *Yearbook of statistics Sarawak 2007*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2009. *Yearbook of statistics Sarawak 2008*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2010. *Yearbook of statistics Sarawak 2009*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2011. *Yearbook of statistics Sarawak 2010*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2012. *Yearbook of statistics Sarawak 2011*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2013. *Yearbook of statistics Sarawak 2012*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2014. *Yearbook of statistics Sarawak 2013*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
———. 2015. *Yearbook of statistics Sarawak 2014*. Kuching: Department of Statistics Malaysia, Sarawak Branch.
Dove, Michael Roger. 1985. *Swidden agriculture in Indonesia: The subsistence strategies of the Kalimantan Kantu*. New York: Mouton.
FAOSTAT. 2016. Countries by commodity. Food and Agriculture Organisation of the United Nations. http://www.fao.org/faostat/en/#rankings/countries_by_commodity. Accessed 16 July 2018.
Feintrenie, Laurène, Wan Kian Chong, and Patrice Levang. 2010. Why do farmers prefer oil palm? Lessons learnt from Bungo district, Indonesia. *Small-Scale Forestry* 9 (3): 379–396.
Freeman, John Derek. 1955. *Iban agriculture: A report on the shifting cultivation of hill rice by the Iban of Sarawak*. London: Her Majesty's Stationery Office, Colonial Office Research Study 19.
Hon, Jason, and Shozo Shibata. 2013. A review on land use in the Malaysian state of Sarawak, Borneo and recommendations for wildlife conservation inside production forest environment. *Borneo Journal of Resource Science and Technology* 3 (2): 22–35.
Kajisa, Kei. 1996. Yojou no hakeguchi' riron no saikou to hantou Mareishia heno tekiou [Re-evaluating 'vent surplus' theory and its application to peninsular Malaysia]. *Ajia Keizai* [Asian Economies] 37 (1): 2–21.
Kato, Yumi, and Ryoji Soda. 2012. Mareishia Sarawaku shu ni okeru shounou aburayashi saibai no doukou [Emerging trends in oil palm smallholdings in Sarawak, Malaysia]. *Chirigaku Ronshu* [Geographical Studies] 87 (2): 26–35.
Kedit, Peter Mulok, and William Chang Wei Say. 2005. *The peoples of the planted forest in Sarawak*. Kuching: Forest Department Sarawak.
Malaysian Palm Oil Board [MPOB]. 2012. Senarai pekebun kecil mengikut daerah, mukim—Sarawak 2012. Malaysian Oil Palm Board. http://www.eqcmpob.com.my/e-lesenpk-reports/sarawak.php. Accessed 10 July 2018.
———. 2017. Oil palm planted area 2017. Malaysian Oil Palm Board. http://bepi.mpob.gov.my/images/area/2017/Area_summary.pdf. Accessed 25 April 2019.
———. 2018a. Senarai pekebun kecil mengikut daerah, mukim—Sarawak 2018. Malaysian Oil Palm Board. http://www.eqcmpob.com.my/e-lesenpk-reports/sarawak.php. Accessed 4 Aug 2018.
———. 2018b. Monthly statistics. Malaysian Palm Oil Board. http://bepi.mpob.gov.my/index.php/en/statistics/price/monthly.html. Accessed 4 Aug 2018.

McCarthy, John F., and Rob A. Cramb. 2009. Policy narratives, landholder engagement, and oil palm expansion on the Malaysian and Indonesian frontiers. *The Geographical Journal* 175 (2): 112–123.

Ministry of Agriculture Malaysia. 1998. *Third National Agricultural Policy, 1988–2010*. Kuala Lumpur: Ministry of Agriculture Malaysia.

Morrison, Phillip S. 1993. Transitions in rural Sarawak: Off-farm employment in the Kemena basin. *Pacific Viewpoint* 34 (1): 45–68.

Ngidang, Dimbab. 2002. Contradictions in land development schemes: The case of joint ventures in Sarawak, Malaysia. *Asia Pacific Viewpoint* 43 (2): 157–180.

Okamoto, Y. 2002. *Aburayashi plantation kaihatsu no kage: Indonesia to Malaysia de naniga okotte iruka* [The shadow of oil palm plantation development: What is happening in Indonesia and Malaysia]. Tokyo: Japan Indonesia NGO Network.

Parnwell, Michael J.G., and Victor T. King. 1998. Environmental changes and population movements: The Iban of Sarawak. In *Environmental challenges in South-East Asia*, ed. Victor T. King, 137–168. New York: Routledge.

Sanggin, Spencer Empading, and Neilson Ilan Mersat. 2013. Landowner's response and adaptation to large scale land development projects in Sarawak, Malaysia. *Macrotheme Review* 2 (6): 146–162.

Sasaki, Hideyuki. 1999. Tenkan-ki ni aru Karimantan: shinrin bassai furontia kara tochi kaihatsu furontia e [Kalimantan: A region in transition—from timber extraction frontier to land development frontier]. *Tropics* 9 (1): 73–82.

Tanaka, Koji. 1990. Plantation nougyou to noumin nougyou [Plantation-based agriculture and smallholder-based agriculture]. In *Tonan Asia no Shizen* [Nature in Southeast Asia], Southeast Asian studies series, vol. 2, ed. T. Takaya, 247–282. Tokyo: Kobundo, Koza Tonan Ajia Gaku.

Chapter 17
The Autonomy and Sustainability of Small-Scale Oil Palm Farming in Sarawak

Ryoji Soda and Yumi Kato

Abstract Although it is true that the vast majority of oil palm is grown on plantations, the participation of the indigenous people of inland Sarawak in the oil palm industry is steadily increasing. This chapter discusses the autonomy and sustainability of farming management by small-scale farmers in the Bintulu region, which has witnessed a significant increase in the number of such farmers. The nature of oil palm farming is different from that of other commercial crops that Sarawak's small-scale farmers have cultivated in the past. This crop involves investing in the land and recovering the returns from such investments—a relatively modern agricultural economic system. This system is believed to place restrictions on time, location and area of the agricultural activities of indigenous communities. In reality, however, people engage in relatively flexible small-scale farming, by following their traditional customs and incorporating aspects of the plantation mode of operation. In addition, the active involvement of urban wage earners in oil palm cultivation is also observed. Such agricultural activities are thus not necessarily confined to the villages. Rather, the cultivation of oil palm has led to a strengthening of social and economic ties within households that are divided between urban centres and rural villages. There is, however, uncertainty concerning the future sustainability of small-scale oil palm farming. A salient issue will be finding a way to enable farmers to shift to another method of earning a livelihood when oil palm cultivation becomes stagnant or unprofitable, while still maintaining secondary fallow forests and rubber fields.

Keywords Sarawak · Indigenous people · Agriculture · Plantations · Oil palm farming · Land use

R. Soda (✉)
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

Y. Kato
Center for Arts and Sciences, Fukui Prefectural University, Eiheiji, Japan

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_17

17.1 The Final Frontier for Oil Palm

Since the 1980s oil palm plantations have expanded rapidly in Southeast Asia. By the late 1990s a state of near saturation had occurred with regard to oil palm plantations in the Malay Peninsula and Sumatra, where plantations had developed earlier (Sasaki 1999). Around this time, Borneo started to attract attention as the final development frontier for oil palm (Soda 2009a; Kato and Soda 2012).

In the Malaysian state of Sarawak, which is located in the northwestern part of Borneo, the development of oil palm plantations has accelerated since the late 1990s (Kato and Soda, Chap. 16). At that time, and under this developmental trend, the future of inland indigenous villagers was often seen as bleak. From the perspective of land use, there were concerns regarding the relative decline of forests available for inland indigenous villagers to use for hunting and gathering, slash-and-burn farming and other agricultural activities. This was due to the fact that the land was being separated into two areas: a development space (used for plantations and commercial timber) and a preserved space (an enclosed space to establish national parks and to promote ecotourism) (Kanazawa 2005).

In terms of the inland labour market, highly educated people from urban areas of Sarawak or peninsular Malaysia occupy managerial and technical positions on plantations and at palm oil mills. In addition, since most on-site workers were Indonesian labourers, not many opportunities were provided for local residents to enter the market. It was thus predicted that inland indigenous villagers would be pushed out of rural areas to towns and cities as a result of losing their foundations of livelihoods, and as polarisation grew both in terms of the landscape and the labour market (Soda 2008).

Among the many restrictions for oil palm cultivation are the indispensability of a transportation infrastructure, the need for over 3000 ha of oil palm crop for the stable operation of an oil mill, and the transport of fresh fruit bunches to oil mills within 24 h of harvesting. Such commercial crops, which rely on economies of scale and require strict timing and swiftness for harvesting and transportation, were perceived to be overwhelmingly dominated by plantations. Thus most people believed that the opportunities for small-scale farmers to enter the oil palm industry were very limited.

However, since the mid-2000s there has been a new movement (Cramb 2011; Cramb and Sujang 2011, 2013; Ichikawa 2011; Cramb and Ferraro 2012; Kato and Soda, Chap. 16). Oil palm cultivation by small-scale farmers has begun to appear on a significant scale in inland Sarawak. Although the overall area ratio and the number of small-scale oil palm farmers are still relatively small, the growth has increased dramatically in the past decade, leading to what can be described as a boom in small-scale oil palm farming.

Under such circumstances, how oil palm cultivation has become established in the inland regions of Sarawak has been presented in detailed operating results for small-scale oil palm farmers (Kato and Soda 2012; Kato and Soda, Chap. 16). Along with the small-scale farming boom of recent years, it is true that numerous indigenous households have abandoned slash-and-burn rice cultivation to specialise in oil palm instead. When this trend has been reported in written papers or in oral presentations various questions and concerns have arisen. The main issue is whether inland indigenous villagers (who had been engaging in hunting, gathering and slash-and-burn farming) would experience ‘peasantisation’, as oil palm cultivation penetrated their society. In this case, peasantisation does not necessarily refer to indigenous inland villagers becoming tenant farmers. Rather, it refers to how the freedom of villagers to choose their livelihoods would be reduced significantly due to the loss of their other livelihood portfolios, resulting from being bound to the land (oil palm farms) and time constraints (continuous agricultural work). In other words, these communities would either become subsumed by the plantation economy or be unable to survive without relying financially on plantations.

Historically, the inland indigenous villagers of Borneo have relied on slash-and-burn farming, hunting and gathering as their main sources of livelihood while engaging in trade of various forest products as well as timber (Ishikawa and Ishikawa, Chap. 6). From the twentieth century onwards, inland indigenous villagers began cultivating a variety of commercial crops and started engaging in timber camps and wage labour in the urban centres. They have been earning a living by flexibly selecting and combining various means of livelihood, depending on the restraints of time and their current circumstances. However, fears that oil palm cultivation would undermine such flexibility have emerged.

This chapter examines farmers’ livelihood strategies to secure resilience, focusing on typical small-scale oil palm farming households whose farm sizes range from several hectares to 20 ha. We evaluate the sustainability of small-scale oil palm farming within the context of the advance of plantation development in Sarawak.

The research was conducted in the Tubau area of Bintulu district. Bintulu is a region in which oil palm cultivation via small-scale farming is expanding rapidly; it can thus be considered one of the frontiers for the small-scale farming of oil palm (Fig. 17.1). The research focused on 11 villages within the Tubau region that are recognised as stakeholder villages by a neighbouring oil palm plantation company. In these villages, smallholders commenced farming oil palm in the early 2000s and have maintained a positive relationship with the plantation company. Although various surrounding villages were visited in the course of this research, this study concentrates on the 11 villages around Tubau unless specified otherwise. This study was conducted intermittently between August 2011 and 2014. The research method mainly comprised interviews conducted in each village as well as the partial inclusion of a collection of reference materials from plantation companies and land-use analysis using satellite images.

The chapter begins by examining how the cultivation of oil palm as a commercial product is significantly different from the traditional livelihood activities of inland indigenous villagers. It then examines how specialisation in oil palm cultivation generates both a new use and different perception of the land, with the local inhabitants now seeing the land as an investment for long-term capital acquisition. The significance of changes to the livelihood structures within the villages is then discussed, giving specific examples of how small-scale oil palm farmers deal with the limitations they face in terms of time and space.

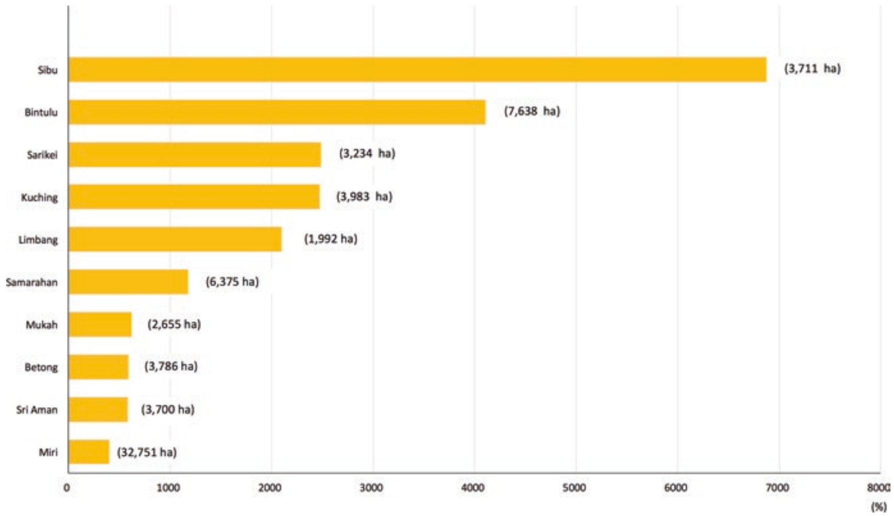


Fig. 17.1 Increase in area of small-scale oil palm cultivation in each division of Sarawak, 2002–2012 (%)
Sources: MPOB 2012; Department of Agriculture Sarawak 2002
Notes: The division of Kapit was not included as the rate of increase was over 15,000%.
The figures in parentheses indicate the total area of small-scale oil palm cultivation as of 2012

17.2 Oil Palm as a New Commercial Crop

This section examines the way in which the cultivation of oil palm as a new commercial crop differs from traditional livelihoods in Sarawak. The majority of indigenous villagers in Sarawak traditionally engaged in slash-and-burn farming, hunting and gathering, and these activities generated their main sources of income. From the twentieth century onwards, they also started cultivating a variety of commercial crops. The informants of this study are no exception. The Iban, who reside in the research area, relocated from the Lubok Antu region around 1950. After receiving permission from colonial administrative officials to settle on the land, they began to engage in hunting, gathering and fishing, while maintaining slash-and-burn rice cultivation as their main livelihood. There were also times when they earned money by selling non-timber forest products. They also began to cultivate commercial crops such as rubber, coffee, cocoa and pepper, depending on their needs and market prices. Some Iban gathered timber from riparian forests which they sold to lumber mills via unofficial routes.[1]

[1] In addition to these livelihood activities, undertaking wage labour at timber-logging camps and in urban centres became another livelihood option from the 1970s onwards.

These ‘traditional’ livelihoods, in which slash-and-burn farming, hunting and gathering dominated, hinged on the extremely rapid revegetation of the tropical rainforest. Such economic activities revolved around the seasonal extraction of ‘harvest goods’ resources. This kind of society can be referred to as a natural or ‘harvest goods economy’. From this perspective, the cultivation of various commercial crops that were introduced from the twentieth century onwards appears to differ significantly from previous livelihood activities, though there is actually a continuity between them. In most cases, the cultivation of pepper and cocoa involved planting seedlings supplied by the Department of Agriculture Sarawak. Even with rubber, many villagers received seedlings supplied by the department or they planted naturally germinated seedlings that came from other people’s farms. Rarely did they need to make any significant investment themselves, whether in terms of finance or labour. In most cases, they only engaged in harvesting when the value of the commercial crops was stable and they would cease harvesting immediately if the crop’s value decreased. The cultivation of such commercial crops thus constituted temporary and opportunistic economic activities. The attitude of expecting benefits without investing substantial costs could be considered to be an extension of the harvest goods economy.

It was during the early 2000s that oil palm cultivation was introduced to the region. What makes oil palm different from the traditional natural economy or from the cultivation of other commercial crops is that oil palm requires considerable capital (seedlings, fertiliser and agricultural chemicals) and workforce investments. The act of investing in the land is built upon the premise of being able to successfully retrieve such capital. In previous research, we referred to indigenous societies that have relied on abundant forestry resources and the extraction of harvest goods as ‘flow societies’ (Soda 2009b; Ishikawa 2010). With the introduction of oil palm cultivation, the inland regions of Sarawak have transformed into a place where relatively significant financial and labour investments are made in the land and then the retrieval of such investments is sought via generating revenue from harvesting oil palm. This can be considered a higher-order use of land.

Although there have been great fluctuations in oil palm prices from the late 2000s onwards, the crop has maintained a high overall value. As such, oil palm came to be acknowledged among indigenous villagers as a commercial crop that could lead to increased revenues in proportion to the amount of money invested. The inland villages have thus become agricultural economic spaces in which villagers can expect earnings in return from making monetary and workforce investments in the land, rather than places for temporary and opportunistic livelihood activities comprising extraction of resources as was done the past. In sum, people who once relied on the harvest goods economy have become strongly aware of the relationship between input and output and between cost and benefit; they have come to emphasise ‘stock’ rather than ‘flow’. This transition in the understanding of land use is thought to be a highly significant (even unprecedented) change within inland farming village societies.

17.3 The Bidirectional Relationship Between Urban and Rural Economy

As explained above, rural farming villages have started to appear as places for investment and earning with the introduction of oil palm cultivation. Such economic revitalisation in rural areas is a phenomenon that has rarely been observed in Sarawak. This section examines the societal change in farming villages from the perspective of the relationship between urban and rural residents.

From the 1990s onwards the proportion of (former) inland indigenous villagers becoming urban residents has been increasing, leading to such phenomena as depopulation and the hollowing out of longhouse communities in interior Sarawak (Soda 2007). Longhouses in inland indigenous villages are very long buildings in which 10–50 households—even more, in some cases—cohabit living spaces. In practice, however, only half the households (or fewer) reside at the longhouse at any given time and it is common for many rooms (*bilik*) to be vacant. As noted previously, it had been predicted that the expansion of oil palm plantations into inland areas would further advance the hollowing out of such longhouse communities. However, with the introduction of small-scale oil palm farming managed by longhouse residents, urban residents have begun returning to villages and thus revitalising village communities in various regions (Ichikawa 2011).

In the Tubau area surveyed for this research, many cases were observed in which young people working outside villages returned to longhouses. There was even one young man who left a steady job with a monthly salary of RM2000 to return to his native village (NU village). In SA village, there has been a drastic population outflow to urban centres, and slash-and-burn rice cultivation became difficult with the remaining number of households so it was abandoned for a while. However, rice farming resumed from 2012 when a number of families began returning to their former longhouses to participate in oil palm cultivation.[2]

Figures 17.2 and 17.3 provide case examples of households that live separately on the edge of a village (one household each in NU and MA villages). In the case example of NU village, the parents of the household started cultivating oil palm in 2000 and started selling their harvested fresh fruit bunches in 2004.[3] They pur-

[2] When slash-and-burn upland rice cultivation is conducted by just one or two households, it is often the case that they are barely able to harvest any rice due to the damage that sparrows cause to the crop. Thinking that damage from birds could be prevented by conducting slash-and-burn farming on land where various households are adjacent, rice farming was initially recommenced in SA village as an experiment. In a labour-saving attempt, the early phase of oil palm cultivation by slash-and-burn farmers frequently uses land immediately after rice has been harvested as it eliminates the need for felling secondary fallow forests. In other words, the recommencement of rice farming in SA village could be considered to be a preparatory task for planting oil palm. Additionally, during the few years in which they did not engage in rice farming, the households that remained at the longhouse earned a living by engaging in irregular wage labour (rubber tapping), working in neighbouring settlements or from remittances sent by relatives working in urban areas.

[3] NU village is a longhouse located alongside the Bakun road, approximately 90 km from Bintulu or one and a half hours' drive away. In 2012, 23 households were cohabiting the longhouse in NU

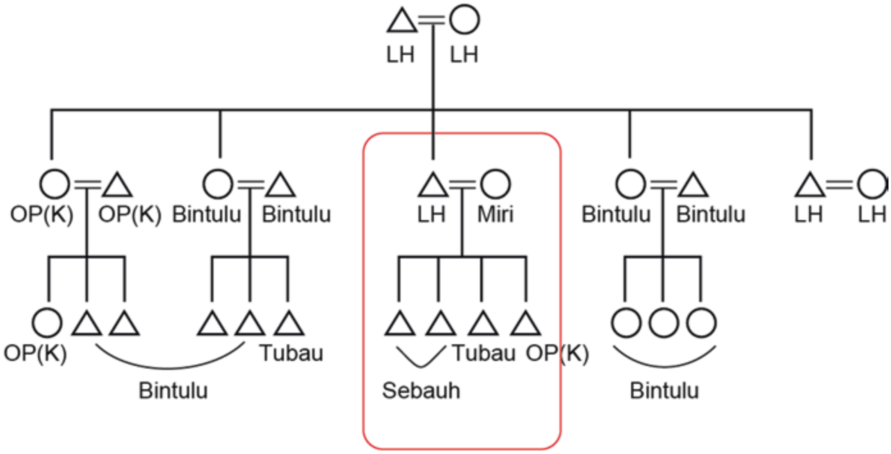


Fig. 17.2 Case example of a small-scale oil palm farming household in NU village
Note: The box indicates the family discussed in which eldest son returned to the longhouse
LH Longhouse, OP Oil palm plantation, (K) Company K

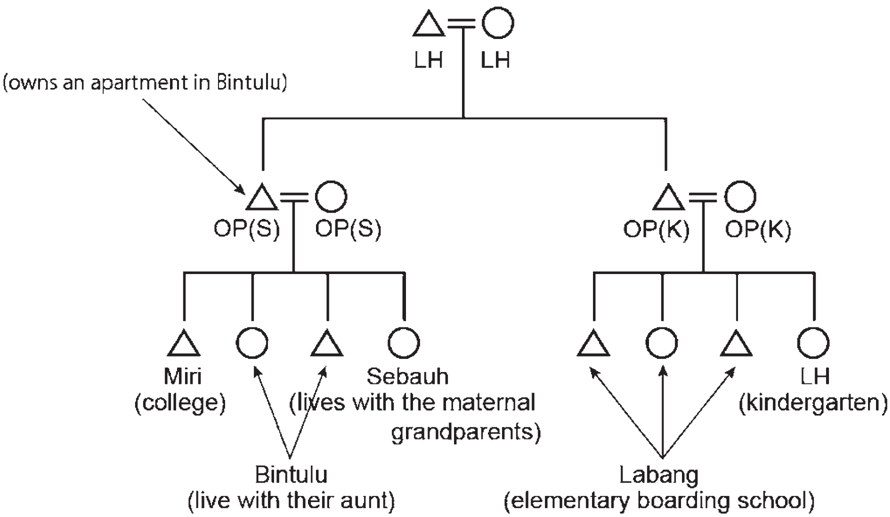


Fig. 17.3 Case example of a small-scale oil palm farming household in MA village
LH Longhouse, OP Oil palm plantation, (K) Company K, (S) Company S

chased a lorry with instalment payments in 2008 when they started earning a profit after recouping enough income from their initial investments. They were thus able

village and they were all engaged in oil palm cultivation. Of these, eight households (35%) were selling fresh fruit bunches while the oil palm belonging to the rest of the residents had not yet borne any fruit.

to make a relatively stable living from oil palm cultivation. In 2011 the eldest son (who had been working in Miri) returned to the village and started engaging in oil palm cultivation with his parents.[4] His wife, however, did not follow him as she had permanent employment at a supermarket in Miri; instead, he travelled frequently between Tubau and Miri. Furthermore, this couple had four sons but since the wife could not look after the children sufficiently due to her job, the two eldest sons were enrolled in a junior high boarding school in Sebauh and the third son was enrolled in a primary boarding school in Tubau.[5] The youngest son was looked after by his sister and her husband who worked at company K's oil palm plantation. In this way, close relatives do not necessarily live in the same living quarters within a longhouse. In cases where a household is split between a village and a town, and family members travel frequently between the two spaces, it is difficult to determine to what extent the household can be deemed a single household.

Here, we discuss a case example from MA village (Fig. 17.3).[6] Although both the eldest and younger sons' households commenced oil palm cultivation in 2003, the eldest son and his wife also managed a general store within the workers' lodgings on plantation S, while the younger son also worked as an administrative clerk on plantation K.[7] Both households normally lived in the plantations' lodgings. The oil palm farms belonging to these brothers were thus usually looked after by their parents and by Indonesian labourers, with the brothers going to the farm only on their days off. The eldest brother's household has purchased an apartment in Bintulu town, using the earnings from the general store and from oil palm cultivation. The eldest son's sister-in-law, his daughter and his second son live in the apartment. The eldest son and his wife frequently travel between company S's plantation, the longhouse and Bintulu to look after their children who live in Bintulu, to procure products for their general store and to manage the oil palm farms.

In this sense, there are many examples in which it is difficult to determine whether a person resides at a longhouse and/or whether they are a villager or a town dweller. The scope of the term 'household' in relation to a longhouse is becoming unclear. Such a situation could be described as the 'spatial expansion' of a household. Although similar case examples have been examined in the past (Soda 2007), what is important here is that the capital brought by workers from outside the village or urban dwellers is frequently used to cover the initial costs of oil palm cultivation

---

[4] Miri is the second largest city in Sarawak and is located approximately 200 km northeast of Tubau.

[5] Sebuah is a market town alongside Kemena River located approximately 90 km from Tubau. It takes about 2 h by car to reach Sebauh from Tubau.

[6] MA is located approximately 95 km from Bintulu, a journey that takes a little over 2 h by car via a public highway and an unpaved plantation road. As of 2011, 28 households were living at the longhouse in MA, with all the households being engaged in oil palm cultivation. Of these, 23 households (89%) were selling fresh fruit bunches, with the crops of the rest of households not yet bearing fruit.

[7] The workers' lodgings are located approximately 10 km from the longhouse (a journey that takes a little over 30 min by car via a plantation road).

in the village.[8] It is evident that no earnings can be made during the two to three years between the oil palm being planted and the first fresh fruit bunches being harvested. It is therefore not unusual for urban workers to bear the purchasing costs for fertiliser and agricultural chemicals. One of the case examples involved the purchase of a pick-up truck from the revenue earned from selling fresh fruit bunches, with the truck being lent as a passenger car to the son of the small-scale farmer who was living in town. In this case, the son was called back to the village twice a month during harvesting time to help out with fresh fruit bunch transportation. As this case shows, the livelihoods of the farming and urban households are starting to merge due to investment in and revenues from oil palm cultivation.

In 2010 and 2011, when the fresh fruit bunch price reached its peak, many villagers were saying that they 'can buy cars and houses in the city through oil palm cultivation'. Traditionally, it was common for some of the cash earned through working in urban centres to be allocated for sending remittances to parents living in villages or it was used for purchasing consumer items. Recently, however, there have been many cases where such earnings have been used to invest in the land (for oil palm cultivation). The revenues made from the investment are then reinvested to expand the oil palm farms or are used to purchase capital and real estate in urban areas. This means that the flow of cash has shifted from being traditionally unidirectional (from the city to the village) to become bidirectional (flowing between the city and the village). From the perspective of household livelihoods, the farming household used to rely upon, or be subordinate to, the urban economy. However, as the farming villages have become sites for the cultivation of agricultural products that can generate revenue, the fusion and mutual linking of the livelihoods in urban and rural areas have emerged.

When considering such a situation, it is possible to view it as the revitalisation of inland farming villages via oil palm cultivation. However, the permeation of oil palm cultivation in farming villages, which is supported by the investment of workers outside the village and is coupled with the continuous expansion of large-scale plantations, also brings the risk of an irreversible regime shift to indigenous societies, as Noboru Ishikawa (2010) suggests. Therefore, the extent to which small-scale oil palm farming relies upon restrictions in terms of land and time due to the introduction of a new commercial crop must be assessed. In addition, the resilience of the villagers in the face of external factors (that is, a decline in the fresh fruit bunch market price) needs to be considered. By examining these aspects, one can attempt to answer the question of whether the changes that have occurred in the rural space in recent years are leading to inland indigenous villagers being subsumed by the plantation economy.

[8] According to Peter Kedit (the former director of Sarawak Museum who is knowledgeable about the labour migration of the Iban), there has been an increase in the number of Iban working in oil fields in the Middle East and northern Europe in recent years. Earnings made from overseas labour migration have been frequently used for oil palm cultivation.

17.4 Avoidance of Spatial and Temporal Restrictions

As discussed above, the introduction of oil palm has brought about new land use and new economic activities that involve investment in the land. However, this investment is premised upon involvement in other agricultural work or other income streams until revenue from the new crop can be collected. For slash-and-burn farmers, hunters and gatherers, who traditionally speaking have been highly mobile, being tied to the land may become a limiting factor that prevents them from shifting their place of residence in an opportunistic manner and from changing their livelihoods. This may lead to adverse effects such as a decline in their social resilience.

In addition to such restrictions in terms of land, oil palm cultivation also involves time restrictions. The palm-blooming and fruit-bearing cycle does not have any distinct seasonality. Although a certain degree of difference in fruit-bearing speed and harvesting volume is observed during the rainy and dry seasons, oil palm can be harvested throughout the year in principle. There is no differentiation between a busy farming season and an off season. In other words, unlike rice and pepper which are generally harvested once a year, or cacao which bears fruit every 6 months, constant harvesting work is generated by oil palm farms.[9] Furthermore, in addition to harvesting work, other tasks (such as fertiliser and agrochemical applications) are necessary. In sum, it is possible that inland indigenous villagers engaging in such agricultural activities will be bound by time constraints.

How do the inland indigenous villagers deal with these locational and temporal restrictions? The following sections discuss the villagers' responses to such restrictions by examining the concrete work tasks of small-scale oil palm farmers.

17.4.1 The Phased Expansion of the Oil Palm Farm

As of November 2013, when the 44 oil palm cultivating households from MA and AN villages were examined, the average number of oil palm farms per household was 4.77 (minimum: 1, maximum: 11), with the average area of a farm being 1.84 ha (minimum: 0.06 ha, maximum 11.00 ha). In the 11 villages in the research area of Tubau, most people did not plant large volumes of oil palm at once. Instead, they planted in phases with several hundred oil palms covering a few hectares being planted every phase. Moreover, the oil palm farms are located in patches in various different areas of the villages (Soda et al. 2015).

Table 17.1 shows the expansion of oil palm over a period of several years for various households within MA village with expansion even occurring multiple

[9] Although rubber, which had been widely cultivated in the inland region of Sarawak, can also be harvested throughout the year, there is no need for repeated fertiliser and agrochemical applications once it has been planted. In addition, even if rubber is left for a long period without being extracted (in the event that its price drops, for instance), the collection of the crop can still be resumed at any point.

Table 17.1 The expansion process for oil palm farms belonging to households within MA

Household					
LE		UN		MA	
Year	Planting area (ha)	Year	Planting area (ha)	Year	Planting area (ha)
2005	2.51	2007	0.59	2004	0.35
2009	2.57	2008	0.51	2004	1.39
2010	1.83	2008	2.01	2004	1.88
2010	3.22	2008	2.51	2004	2.27
		2010	1.62	2007	0.67
		2011	2.92	2008	0.14
				2008	1.67

times within a single year. Such phased expansion of oil palm farms is strongly connected with the relationship between the villagers' financial circumstances and their traditional livelihoods (slash-and-burn upland rice farming). Most households do not have the funds to purchase large quantities of oil palm seedlings, and even if they are able to obtain the requisite amount it is still difficult for them to procure the labour force needed to plant the seedlings. This is because a substantial amount of labour and physical risk is associated with the clearing of secondary fallow forests for cultivation preceding the planting of oil palms. Therefore, in the initial stage of oil palm cultivation, villagers frequently use either the swidden land that becomes available immediately following a rice harvest or a young secondary forest that has been fallow for 1–2 years.

In all the villages in the research area, most households had expanded their oil palm farms gradually in this manner. This phased expansion, made in accordance with the capital and labour power available, results in the avoidance of unmanageable cultivation or excessive investment. Oil palm becomes harvestable in less than 3 years after it is planted. One of the reasons why oil palm cultivation has been well received by inland indigenous villagers is because the pay-out period is short when compared with that of rubber. After the point at which the initial investment is recouped, the villagers usually decide to clear more land for a new oil palm field. This phased expansion every few years suits the management strategy for small-scale farming.

Most of the villages have expanded their oil palm cultivation over the last 10 years or so. That being said, they have left a wide area of secondary fallow forest untouched within the villages. Furthermore, several households in the villages also own rubber farms. When questioned, the villagers stated that even if the price of oil palm dropped suddenly they would still be able to maintain their livelihoods by cultivating rice through clearing fallow forests, resuming the extraction of rubber or finding wage labour outside their villages. The villagers continuously made small-scale investments in accordance with their individual financial power, based on the premise of a relatively short cycle of investment and return. Even if the value of oil palm suddenly drops greatly they will not incur any major losses. The idea of abandoning oil palm and switching to other sources of income is seen as a procedure that could be conducted with relative ease and without the risk of any significant financial or psychological burden. In other words, for the villagers, oil palm cultivation is one of a number of livelihoods upon which they rely. Rather than perceiving that an irreversible shift in village livelihoods is taking place, it is more valid to consider this as a phase that can be compared with episodes of livelihood selection that occurred in the past.

17.4.2 Agricultural Work on an Oil Palm Farm

The people in the research area stated that 1000–2000 oil palms can be managed by just two people (that is, a married couple). Although there are differences that depend on circumstances such as location, soil and climate as well as growing conditions and the age of the oil palm, farmers generally applied fertilisers three times a year and herbicide four times a year. For 2000 oil palms, approximately 200 kg of fertiliser are used during each application.[10] If two people were to perform this, it would take around 3 days to accomplish. Approximately 20 l of herbicide are used per application, after being diluted in water. If this task were conducted by two people, it would normally take between three to four days. In total, approximately 20–25 days per year are required for applying fertiliser and herbicide.

In the event that funds for purchasing herbicide are lacking, there are times when villagers cut weeds by hand using knives. It is believed that such manual work takes two or three times longer than applying herbicide. If insect damage is present then insecticide is also applied as required. However, it was said that outbreaks of insect damage were extremely rare within the research area. In addition, there are other minor tasks, such as pruning and stacking fronds, but they do not take up much time.[11]

The task that consumes the most time is the harvesting and transportation of fresh fruit bunches. If several tens or hundreds of thousands of oil palms have been planted—for example, on a company plantation—then there will be some palms in bloom or bearing fruit every single day. In such cases the task of harvesting never ceases. On a farm where a small-scale farmer plants a few thousand oil palms, however, harvesting twice a month is usually sufficient. In this sense, very small-scale oil palm cultivation of inland Sarawak has not reached a point where it places strong temporal restrictions on the villagers.

---

[10] The villagers often identify and express the size of oil palm farm using the number of seedlings planted rather than the area. Although the area greatly differs depending on the planting interval (7–9 m), planting 2000 seedlings can be estimated to be an area of about 11–18 ha.

[11] The details of tasks at oil palm farms in the observed example in the Malay Peninsula have been listed by R.H.V. Corley and P.B. Tinker (2003). According to this data, weed removal constitutes 10% of the volume of labour while fertiliser application constitutes 5%; harvesting constitutes 79% of labour and fresh fruit bunches transport constitutes 6%. In terms of the financial costs incurred during oil palm cultivation, Fumikazu Ubukata and Yucho Sadamichi (Chap. 24) have compared the costs of small-scale farming to those on a plantation.

What becomes an issue here is that the hard labour that takes up most time is concentrated during the bimonthly harvesting task period. Harvesting includes such tasks as pruning and stacking fronds. Additionally, since the oxidising velocity of fresh fruit bunches after harvesting is rapid, their quality will deteriorate quickly, leading to a loss in the value of the product if it is not transported to factories within 24 h of harvesting. Furthermore, a minimum amount of fresh fruit bunches needs to be harvested within a short period of time in order to offset the costs and time involved in arranging the deployment of pick-up trucks and lorries for transportation. Therefore, it is not possible for two people alone to harvest little by little over a number of days.

On a farm of 2000 oil palms, the harvesting task can be completed within 2 days if five to eight people are working. The amount of fresh fruit bunches that can be collected from 2000 oil palms during a single harvesting task is about 12 tonnes (although there are slight variations depending on the season). This is a harvesting volume that can be transported to an oil mill by making four round trips with a three-tonne truck. As a single round trip can take up to 2–3 h, including the loading and unloading of fresh fruit bunches, it is appropriate to transport such an amount over the course of 2 days. The next section examines how the tasks concentrated in this bimonthly harvesting period are distributed.

17.4.3 The Concentration and Distribution of Labour

A factor that was observed in all 11 villages that were surveyed was the temporary employment of labourers. When engaging in such tasks as harvesting and the application of fertiliser, acquaintances within or outside the village are employed temporarily. When more labour becomes necessary at a particular time, families residing in urban centres frequently return to the villages to participate in agricultural activities. In Sarawak's indigenous communities, in which movement between cities and villages occurs frequently, the workforce within a household can change greatly over time. It is thus not possible to make general statements about how much employment is generated from oil palm farming in relation to specific details such as the scale of cultivation, household size and workload.

A system that is commonly observed in many villages in the research area is a labour exchange system known as *beduruk* in Iban. This system was traditionally utilised when a large quantity of labour was needed during the paddy-planting season; for example, tree cutting, field burning and planting. Of the 11 villages researched, *beduruk* was employed in at least six of them during fresh fruit bunch harvesting tasks. In the *beduruk* system, a group of relatives or three or four close households collaborate and exchange labour. In this way, if one to three workers are provided from each household, a group of about seven to 10 workers can be formed. If this group is engaged in a series of harvesting tasks—for example, A's farm on the first day, B's farm on the second day and C's farm on the third day—the harvesting can be carried out by a sufficient number of people on each farm. As such, the entire harvest for all the households can be finished within three to five days. Although the number of days that each person spends on farms increases due to this system, the labour burden is more evenly distributed, thus reducing it in relative terms. There have been cases in which such a *beduruk* system was employed in such a way that several households synchronised their times for tasks like fertiliser application, agrichemical application and new planting and not just for harvesting periods. If the number of workers is still too few, even after incorporating such a labour exchange programme, the villagers sometimes employ more labourers for greater manpower.

On the other hand, there are people who avoid such labour exchange activities. If only 300–400 oil palms are being cultivated, the harvesting task can be completed within a day using the labour force of a single household. In this instance, if a villager participates in labour exchange with other households, then his own farm's harvesting will be completed within half a day; but the work at other people's farms may last for several days. Some households that plant over 2000 palms commonly choose to employ workers rather than adopting the *beduruk* system, if the household has the financial capability to do so.

Although it is limited to a few cases, there is also a method known as a proxy request. It is said that the inland indigenous villagers have high mobility. They frequently leave their villages and go to urban areas or other villages. The lengths of their stays can range from a few weeks to a year. As mentioned above, with small-scale oil palm cultivation of a few thousand palms, the time restrictions caused by continual harvesting are not thought to be that onerous. Even in such a case, however, harvesting twice a month is indispensable. If a farmer decides to leave the village for a long period, he may pay other households in advance to take over his harvesting tasks. One villager said, 'Since the people at the longhouse are like family or relatives as a whole, I can trust them sufficiently. There are plenty of people I can ask.'

Another method that has been used increasingly in recent years is the employment of Indonesian workers. In many households that have over 2000 oil palms, Indonesian labourers are employed on a permanent basis. The wage structure is varied. For fertiliser or agrichemical application, wages may be set per bag or per gallon applied. For harvesting, wages per tonne might be given. As such, there are cases in which all labour is paid for via a commission system. In other instances, a monthly fixed wage might be set with commission (based on the work volume) added on top during harvesting periods.

As noted, harvesting on a small-scale farm does not involve collecting daily by constantly changing location, as one does on a plantation. As a result, there may not be farm work available at all times and permanently employed Indonesian workers might find that they have some free time on their hands. In fact, when interviewed, Indonesian workers said that working at small-scale farms was better than working at plantations because it was easier. There are also cases where a number of households employ a single Indonesian worker on rotation to efficiently utilise the worker's time. Alternatively, there was a case in which an Indonesian worker was employed by the village chief, with the worker being shared by the entire village. This worker engaged in various chores within the village and not just oil palm cultivation. Temporarily 'borrowing' workers hired by others is also a common practice. For example, a farmer might request that an employer lend him a worker for 2 days during harvesting time. That farmer can then pay the worker directly around RM35 per day for their time.

Thus, the indigenous villagers of inland Sarawak have introduced oil palm cultivation in the form of sustaining the land usage/tenure system based on slash-and-burn upland rice farming. Additionally, each household has expanded its oil palm cultivation in a successive manner every few years by considering both its financial and human labour capacities. This strategy avoids excessive investment which can make capital recovery difficult. It also helps to ease the extent to which villagers are bound to the land.

On the other hand, the work on oil palm farms, including harvesting, is dealt with using various measures, such as the utilisation of a traditional labour exchange system, the temporary employment of wage labourers from outside the villages and asking for help from other households. Furthermore, the flexible use of human resources has been deployed by the introduction of a plantation-like system in which Indonesian workers are employed and shared by several households or by an entire village. All these measures possess cultural and institutional continuity, similar to the previous livelihood activities of these indigenous communities and the traditional land-use systems as well as preserving residence formats and social compositions in longhouses. In this sense, the longhouse community has become a foundation or resource for the efficient and smooth running of small-scale oil palm farming.

17.5 Conclusion

Although oil palm cultivation had been thought to be overwhelmingly dominated by plantations, the participation of indigenous people in the oil palm industry is steadily increasing. The villagers surveyed in this research have been expanding their small-scale oil palm farms, which range from a few hundred to several thousand oil palms, in a successive manner. During such developments, the villagers have reutilised the land, and the human and social resources of the longhouse communities. At times, they have also introduced facets of the plantation system, such as employing Indonesian workers. Through such measures, the inland indigenous villagers have kept the temporal and locational restrictions of oil palm cultivation to a minimum.

Such flexible handling has even generated a trend of 'weekend farming'. This involves working in the city during weekdays and returning to villages to engage in oil palm cultivation only on weekends for farms that comprise a few hundred recently planted oil palms. Even if a villager has a farm of a few thousand palms, it can be managed on a daily basis by parents or relatives who have stayed in the village or by employing one to two Indonesian workers. Through such measures, the fusion of urban and village households will develop further by strengthening the social and financial links between cities and rural areas. Small-scale oil palm farming could be considered a livelihood strategy that offers a more practical and sustainable option than relying on plantations alone.[12]

The gradual expansion of small-scale oil palm farming can be attributed partly to the institutional and historical background of land use in Sarawak. Legal systems have been implemented for commercial use and seizure of indigenous people's land. The reason why oil palm plantation development has expanded rapidly in the past 20 years—despite eliciting land disputes between corporations and residents in various locations—can be attributed to such institutional foundations that were already in existence. In general, the government's policies to promote the oil palm industry have prioritised the development of corporate plantations and have not been focused on small-scale farming. In this sense, small-scale farmers have been largely ignored as the national oil palm industry has been promoted and endorsed by the government. This situation, in turn, could be said to have prevented the establishment of systems in which either prices for small-scale farmers' crops are kept extremely low or their production activities are incorporated into plantation profits. This is an indicator that concepts such as the exploitation of produced goods and that of labour have not surfaced. Therefore, the inland indigenous villagers were able to enter the oil palm industry while the exploitation of small-scale farmers was not yet a reality. This can be said to constitute an institutional factor owing to which small-scale farmers have been able to maintain a certain level of autonomous management without being subsumed by plantations.

Observing the small-scale farmers in the research area creates the impression that at present a certain balance has been established between plantations and small-scale farming. However, it is uncertain how long this balance will be maintained due to the extremely fluctuating state in which both the expansion of plantation areas and the vigorous growth of small-scale farming continue simultaneously. In addition, there is no clear indication of the threshold (limit in terms of area) for ensuring the sustainability of small-scale oil palm farming at this time. As explained in other chapters (Soda et al., Chap. 15; Kato and Soda, Chap. 16), the reasons for inland indigenous villagers planting oil palm are varied. In some cases, villagers have planted oil palms to claim the exclusive right to their land, being wary of plantation companies attempting to seize their land. On the other hand, excessive planting that surpasses the scale of small-scale farming not only creates risks for farmers in terms of investment return but might also result in a loss of land available for reuse for slash-and-burn upland rice farming or rubber tapping should the villagers face difficulties, such as a sharp drop in fresh fruit bunch prices.

The villages have a mosaic land-use format at present, in which oil palm farms, secondary fallow forests, fruit farms, rubber farms and swidden agriculture are

---

[12] Needless to say, there are various elements where the villagers are forced to rely on plantations. One such aspect is with regard to the sales of fresh fruit bunches. In recent years, however, the number of intermediate buyers has grown rapidly, with more sales methods for fresh fruit bunches and increasing opportunities to sell for small-scale farmers. This is a topic we intend to discuss further in a future publication.

mixed. At a micro level, such mosaic landscapes serve as collateral against the future risks associated with oil palm cultivation as well as providing foundations for the reconstruction of multi-livelihood spaces. The issues of the extent to which villagers should guard collateral to mitigate risks and the extent to which they should expand their oil palm farms are two-sided. In the future, the maintenance of balanced land use through careful consideration of the government's agricultural policies and developments in plantation corporations will become even more significant.

References

Corley, R.H.V., and P.B. Tinker. 2003. *The oil palm*. 4th ed. Oxford: Blackwell.

Cramb, Rob A. 2011. Re-inventing dualism: Policy narratives and modes of oil palm expansion in Sarawak, Malaysia. *Journal of Development Studies* 47 (2): 274–293.

Cramb, Rob A., and Deanna Ferraro. 2012. Custom and capital: A financial appraisal of alternative arrangements for large-scale oil palm development on customary land in Sarawak, Malaysia. *Malaysian Journal of Economic Studies* 49 (1): 49–69.

Cramb, Rob A., and Patrick S. Sujang. 2011. 'Shifting ground': Renegotiating land rights and rural livelihoods in Sarawak, Malaysia. *Asia Pacific Viewpoint* 52 (2): 136–147.

———. 2013. The mouse deer and the crocodile: Oil palm smallholders and livelihood strategies in Sarawak, Malaysia. *Journal of Peasant Studies* 40 (1): 129–154.

Department of Agriculture Sarawak. 2002. *Agricultural statistics of Sarawak 2002*. Kuching: Department of Agriculture Sarawak, Planning Division.

Ichikawa, Masahiro. 2011. Factors behind differences in depopulation between rural villages in Sarawak. *Borneo Research Bulletin* 42: 275–288.

Ishikawa, Noboru. 2010. Rekishi no naka no baiomasu shakai—nettai ryūiki shakai no dansei to isō ten'i [Tropical biomass society in history: resilience and transformation of riverine communities]. In *Chikyū-ken seimei-ken ningen-ken: jizoku-tekina seizon kiban o motomete* [Geosphere/biosphere/humanosphere: Seeking a sustainable and survival base], ed. Kaoru Sugihara, Shuichi Kawai, Yasuyuki Kōno, and Akio Tanabe, 251–280. Kyoto: Kyoto University Academic Press.

Kanazawa, Kentaro. 2005. Sarawaku no shinrin to senjuumin Punan no genzai [Commercial logging and the Penan in Sarawak]. In *Nettai Ajia no mori notami: shinrin shigen riyou no jinruigaku* [People in forests in tropical Asia: Environmental anthropology of resource utilisation], ed. Kazunobu Ikeya, 273–301. Kyoto: Jibun Shoin.

Kato, Yumi, and Ryoji Soda. 2012. Mareishia Sarawaku shu ni okeru shounou aburayashi saibai no doukou [Emerging trends in oil palm smallholdings in Sarawak, Malaysia]. *Chirigaku Ronshu* [Geographical Studies] 87 (2): 26–34.

Malaysian Oil Palm Board [MPOB]. 2012. Senarai pekebun kecil mengikut daerah, mukim—Sarawak 2012. http://www.eqcmpob.com.my/e-lesenpk-reports/sarawak.php. Accessed 1 Aug 2018.

Sasaki, Hideyuki. 1999. Tenkan-ki ni aru Karimantan: shinrin bassai furontia kara tochi kaihatsu furontia e [Kalimantan: A region in transition—from timber extraction frontier to land development frontier]. *Tropics* 9 (1): 73–82.

Soda, Ryoji. 2007. Mover-oriented approach to understand rural-urban interaction: A case from Sarawak, Malaysia. *Journal of the Graduate School of Letters* 2: 47–58.

———. 2008. Sarawaku ni okeru purantēshon no kakudai [Expanding plantations in Sarawak, Malaysia]. In *Tonan Ajia no morini naniga okotte iruka: Nettai urin to monsūn rin karano houkoku* [What is happening in the forests in Southeast Asia: Reports from the tropical and monsoon forests], ed. Tomoya Akimichi and Masahiro Ichikawa, 223–251. Kyoto: Jinbun Shoin.

———. 2009a. Mareishia Sarawaku shu ni okeru kankyō kaihen to 'kankyō mondai' [Environmental changes and 'environmental problems' in Sarawak, Malaysia]. *Shirin* 92 (1): 130–160.

———. 2009b. Sutokku no shakai, furō no shakai—nomaddo no shigen riyō [Stock societies and flow societies: Resource use of nomadic people]. In *Ningen katsudō-ka no seitaikei nettowāku no hōkai to saisei—Heisei 20-nendo FR 1 kenkyū purojekuto hōkoku* [Collapse and restoration of ecosystem networks with human activity: Fiscal report on FR 1 Research Project, 2008], ed. Shoko Sakai, Reiichiro Ishii, and Norio Yamamura, 98–99. Kyoto: Research Institute for Humanity and Nature.

Soda, Ryoji, Yumi Kato, and Jason Hon. 2015. The diversity of small-scale oil palm cultivation in Sarawak, Malaysia. *The Geographical Journal* 182 (4): 353–363.

Part IV
Commodification and Local Processes

Chapter 18
The Birds' Nest Commodity Chain Between Sarawak and China

Daniel Chew, Yu Xin, Ryoji Soda, Tetsu Ichikawa, and Noboru Ishikawa

Abstract This chapter explores the commodity chain in edible birds' nests between Sarawak and China. The nests are a highly sought and prized culinary product believed to have health and therapeutic benefits. The framework of the commodity chain is analysed through relationships and networks that have historical roots, and are embedded in economic, social and cultural contexts. Birds' nests are collected in Sarawak, and traded and consumed in China, including Hong Kong, and wherever the Chinese diaspora resides. These economic transactions have social underpinnings in addition to the birds' nests cultural value and status for ethnic Chinese. Due to the high monetary stakes involved in trading, political implications involving governments have come to the fore, which have both positive and negative impacts on the commodity chain.

Keywords Sarawak · Birds' nests · Commodity chain · China · Hong Kong · Trade

D. Chew (✉)
Independent Researcher, Kota Samarahan, Australia

Yu Xin
Institute for Advanced Studies in Humanities and Social Science, Chongqing University, Chongqing, China
e-mail: yuxin2017@cqu.edu.cn

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

T. Ichikawa
Nagoya City University, Nagoya, Japan
e-mail: tetsu-i@kb3.so-net.ne.jp

N. Ishikawa
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_18

18.1 Introduction

Edible birds' nests in Sarawak, which are moulded from the saliva of the white nest swiftlet (*Aerodramus fuciphagus*) and black nest swiftlet (*Aerodramus maximus*), are a highly prized culinary food product reputed to have various health and therapeutic gains. The uniqueness of the appeal of the nests, particular to ethnic Chinese, is its association with China's dynastic past as a special food for royals and the wealthy. It is an appeal that carries on to this day as an expensive and prestigious food product for ethnic Chinese wherever they live. The process of collecting the nests in Southeast Asia for consumption in China and by the global Chinese diaspora fits into the framework of a commodity chain. The concept of the commodity chain was used by Terence K. Hopkins and Immanuel Wallerstein (1982) to depict the flow of trade and capital movements in the global economy before 1800 (see also Wallerstein 2008). The framework of commodity chains has been applied in studies of global networks and movements of products and services. In a review essay, Jennifer Bair (2005) identified two distinct types of commodity chains: the global value chain and the global commodity chain. Global value chains look at the range of activities in the process of bringing a product or service to its final destination as a consumed product or service; global commodity chains examine power relations and the roles of producers and consumers in a product chain. In this chapter, we include the perspective of relationships and networks, which are historical and have embedded cultural, ecological, economic and social contexts—a framework that may not be adequately covered by the global value chain and global commodity chain approaches.

The network of producers and consumers in a product chain is broad, a point recognised by Wallerstein (2008: 4) when he argued that the commodity chain

> is a total phenomenon that we cannot see no matter what we do. The point is to figure out how this total phenomenon operates, what are its rules, what are its trends, what are its coming and inevitable disequilibria and bifurcations. It requires imagination and audacity along with rigor and patience. The only thing we have to fear is looking too narrowly.

Taking on this suggestion of attempting to find out how the commodity chain works, we examine the ramifications of the many diverse aspects which embed birds' nests as a multilayered commodity chain process. As birds' nests are a unique natural commodity, there are ecological considerations in the human–bird species nexus which influence its supply and demand, with ramifications for both humans and swiftlets. As a commodity of high value transregional trade, political ramifications in the commodity chain surface, with implications for production and consumption when policymakers take an interest in birds' nests. With these broad sweeps of historical, economic, sociocultural, ecological and political factors in mind, the case study here of birds' nests in Sarawak is linked to China, both historically and presently the world's biggest market for birds' nests.

18.2 Historical Background

The Kemena and Tatau river catchments in central Sarawak are a procurement zone for jungle products, including both timber and non-timber resources, the latter including gums, resins, rattan (see Takeuchi et al., Chap. 22), beeswax, bezoar stones (see Okuno and Ichikawa, Chap. 23), sago and *engkabang* nuts. The biodiversity and natural riches of the Kemena and Tatau basins attracted the attention of the Brooke family, who wrested control of the river catchments of Sarawak from Brunei in 1861. A primary motive for Brooke intervention and control of Sarawak was the trade in jungle resources. However, birds' nests were not included in the commodities that were reported as being traded in Bintulu, the coastal centre for the Kemena and Tatau basins, in the early 1870s: 'Exports besides *gutta* and raw sago, consist of camphor, India-rubber, bezoar stones and various sorts of canes. Belian wood grows abundantly on the banks' (*Sarawak Gazette* 1871). A decade later, Tatau, the riverine trading centre for the Tatau catchment, still did not list birds' nests in its traded commodities: 'Commodities traded at Tatau were *gutta,* rattan, sago, camphor and timber' (*Sarawak Gazette* 1882, 1883). However, from present-day interviews conducted in Bintulu and Tatau, Kapitan Sim Mong Hui in Bintulu remembered bags of black birds' nests coming into Bintulu from Niah, and informants in Tatau recalled birds' nests brought to the bazaar from the upper Tatau River in Bukit Sarang.

Notwithstanding the lack of recognition of the past contribution of birds' nests to the harnessing of the biodiverse natural resources in the Kemena and Tatau basins, it may be more useful to consider the gathering and trade in birds' nests in this area against the wider context and backdrop of the commodity chain between Sarawak and East Asia, primarily China. While birds' nests may not have been mentioned during the time of Brooke rule (1841–1941) due to the abundance of gums, resins, rattan and timber in the Kemena and Tatau riverine catchments, birds' nests have today become a recognised niche product due to their high economic value. What is happening today at the local level in the upper Tatau River, where cave nests are collected in Bukit Sarang, and from swiftlet buildings in Bintulu, places the locale within the wider framework of Sarawak where the nests are sent to the capital city Kuching and then outwards to the international markets of Hong Kong and China.

The historical backdrop of the birds' nest commodity chain is grounded in the *longue durée* of economic relations between maritime Southeast Asia and China. Lim Chan Koon and the Earl of Cranbrook (2002: 62) and Bien Chiang (2011: 410–411) have highlighted the search for birds' nests in the caves of maritime Southeast Asia for the imperial court of sixteenth-century Ming China. Chiang (2011) makes reference to the therapeutic value of birds' nests in old Chinese medicinal texts from the Ming (1368–1644) and Qing (1644–1911) dynasties as evidence of the high value placed on them. The presence of birds' nests and other commodities in Southeast Asia bound the region to China.

Southeast Asia is a region of high tropical biodiversity that is environmentally rich in natural products. Sarawak has caves from Bau in the west to the Tatau basin and Niah, and the Baram River in the northeast; in all these caves, swiftlets can be found constructing their black-and-white nests on cave walls. A vivid description of Niah caves in northeastern Sarawak in the nineteenth century details how birds' nests were collected by indigenous people under precarious conditions. The nests were recognised as having monetary value, with a distinction made between the more valuable white nests and the cheaper black nests.

> We commenced our exploration of the cave by walking up a gentle incline, a soft flooring of dry scentless guano under foot. We were met by thousands of bats and swallows, the later are the manufacturer of the edible nest; they resemble the common swallow in appearance, but are only half as large. We found ourselves in an immense amphitheatre … the roof of the cave one hundred and twenty fathoms high. Thousands of nests were to be seen clinging on to the pillar like sides and roof. The most flimsy looking stages of bamboo tied together by rattans, shewed [*sic*] us the simple means employed by the natives in collecting them from their seemingly [precarious] position… Some idea of the extent of the caves may be formed from the fact that they yield over 30 piculs or nearly two tons of edible nests at one gathering; unfortunately for the owner the nests are black, and of an inferior quality, worth only $100 per picul, whereas the white nests of first quality realize $2000 per picul.[1] (*Sarawak Gazette* 1873)

The collection of and trade in birds' nests intensified during the high noon of European colonialism in Southeast Asia during the nineteenth century. Traders in Singapore recognised the demand for birds' nests in China.

> The Chinese gentry are passionately fond of birds' nests. This fancy for birds' nests obtains all over China, but can be followed up only by the wealthiest classes. Such is the extraordinary demand for this description of food that its cost is enormous: and to say a man eats birds' nest is equivalent to saying that he is a grandee or a person of great opulence… [Nests] are assorted for the Chinese market into three kinds according to their qualities. The common prices for birds' nests at Canton are, for the first sort, no less than 3,500 Spanish dollars for the picul, … for the second 2,800 Spanish dollars the picul; and for the third 1600 Spanish dollars. From these prices, it is sufficiently evident that the birds' nests, are no more than an article of expensive luxury. They are consumed by only the great; and, indeed, the best part is sent to the capital for the consumption of the court. (*Singapore Chronicle and Commercial Register* 1833)

Trading in birds' nests rested in the hands of ethnic Chinese, with the work of procuring the nests on cave cliffs the speciality of indigenous cave owners and collectors. Chinese traders established themselves in rural riverine Sarawak for the purposes of trading in the nests and other commodities. After the nests were collected in Sarawak, the nodes of the commodity chain extended to Singapore in the nineteenth century right through to the twentieth century. Singapore functioned as an island entrepot that tapped into the regional trade of Southeast Asia. Birds' nests were one of the commodities traded.

> In Singapore, an extensive trade is carried on in these nests, the best and most expensive coming from Borneo, followed by others from Banjermasin, the Rhio Archipelago, Karimon island and several other places in the Dutch East Indies as well as the islands off the east coast of the Malay peninsula. (*Singapore Free Press and Mercantile Advertiser* 1933)

[1] A reference to Niah caves in Sarawak.

The entrepot trade in Singapore linked up with Hong Kong and Canton (Guangzhou), British trading ports in the mid-nineteenth century capitalising on trade between China and Southeast Asia. Birds' nests were a product with low volume and high economic value that could be collected and transported from the caves of Southeast Asia across the seas for the Chinese market.

This commodity chain continues to the present day with Hong Kong as the world's leading centre for the trade in birds' nests for both local consumption as well as export to China and the global ethnic Chinese diaspora in places such as North America. 'Where there are Chinese, there will be exports there. Hong Kong exports globally, to mainland China, Taiwan, Australia, United States of America,' proclaimed V.C. Yew, chairman of the Hong Kong Bird's Nest Association (Yew 2012). Lim and Cranbrook (2002: 97) described the 1980s as a peak period for birds' nest prices, with the prosperity of Hong Kong having a big impact on the industry between 1980 and 1989; imports amounted to 81,000–160,000 kg of nests annually with a value of HK$40–300 million. Most of these nests were locally consumed in Hong Kong with smaller quantities re-exported to the Chinese diasporic communities in the United States, Canada, Japan and Taiwan. In recent years, growing affluence in China has created an additional demand for birds' nests, a development that impacts on the supply chain. 'After 2003, there is wealth in China. There is gift presenting. It is good to send gifts of nests,' remarked Winnie Hon of the Hong Kong Bird's Nest Association (Hon 2012). There is a consensus that the growing market in China has increased the demand. Wilson Ng (2012) of Hing Kee Java Edible Bird's Nest made this observation on the Chinese market:

> A lot of people come from China to Hong Kong for shopping for the past few years. Last year 24 million people from China visit Hong Kong. Most customers in the past were local. Last few years from China. Increase in customers depends on China market. For Hong Kong for the past many years, mature enough, just a little growth. Last few years, demand from China is great.

This phenomenal growth in demand means that the Chinese mainland has become a critical node in the commodity chain and this has had implications for Hong Kong and the sources of supply in places such as Sarawak, which in turn have responded to the demand.

18.3 The Human–Swiftlet Nexus

The caves in Sarawak that supply the nests have faced declining yields over the years due to overharvesting. It was inevitable that the supply of nests would diminish unless swiftlet populations were allowed to rebound unhindered by human actions. The main issue was the relentless harvesting of nests, and with it the indiscriminate destruction of eggs, which prevented enough birds from reproducing successfully. Lim and Cranbrook have identified the fluctuations in the production cycles in Sarawak. The 1930s were the peak years, followed by an interruption during the Japanese occupation, a return to prewar harvest levels in the 1950s, and then a progressive decline in the 1960s and 1970s. Following the opening up of China to global trade after decades of self-imposed communist isolation, the demand rose around the end of the twentieth century and in the early years of the twenty-first century. This caused a surge in interest in increasing the production of birds' nests.

A fortuitous discovery that swiftlets could build nests in buildings and spaces other than caves led to enterprising traders turning man-made structures into nesting havens for the birds. An industry based on swiftlet 'ranching' or 'farming' in buildings first appeared in Java in the early twentieth century, spread to peninsular Malaysia by the end of the century and then to Sarawak. With natural cave nests suffering from declining quantities, the birds' nest industry in Sarawak, and indeed in the rest of Malaysia and neighbouring Indonesia, turned to buildings (both specially designed or converted from existing ones) in order to entice swiftlets to build nests.

Swiftlets in farming buildings and in caves are from different species, with the white nest swiftlet (*Aerodramus fuciphagus*) living mainly in buildings producing the more valuable white nests, while the black nest swiftlets (*Aerodramus maximus*) in the caves produce the more feathered black nests which are less valuable. Both varieties of nests can be found in the caves of Sarawak; black nests are found in the caves in Bau and Niah, while the white nests are found in the Baram area. During the nineteenth century and the first three-quarters of the twentieth century, Sarawak was known in the Hong Kong market as the production site for black nests and it was not until the past two decades when a farming industry developed in Sarawak that white nests began to be noticed.

The supply end of the nest product chain, where existing and new buildings accommodate the swiftlets, has become a capital-intensive industry that requires high financial investments (Lim 2012). A knowledge industry has developed with information on how to attract swiftlets with taped music of swiftlet sounds and other tips in building construction being sold and with trade secrets being well guarded. Experts and those professing to be experts organise seminar circuits in Malaysia and Indonesia, promising hefty returns on investments. Tan Jak Kuang of Daro, Sarawak, who converted a shophouse into a swiftlet farm, attended paid seminars on the subject in Jakarta.

When the branches of the local commodity chain are examined, the different layers of connectivity may take on the shape of a commodity web with spokes radiating out instead of being like a chain. Kalimantan and Sarawak are two separate states but both are connected like commodity webs. According to traders in Kuching, birds' nests are sent to Kalimantan for cleaning and processing where labour costs are both cheaper and more readily available than in Sarawak. Sarawakian investors build swiftlet houses in Kalimantan as well.

In Sarawak, the nodes of the commodity chain spread out laterally for swiftlet farms. There are architects who draw up building plans for the swiftlet houses, and builders and suppliers who construct the structures according to specifications. Some more expensive and elaborate buildings look like fortresses, while at the other end of the scale are much simpler-looking structures similar to *kampung* houses in

Daro (Figs. 18.1 and 18.2). In towns, shophouses are converted into swiftlet farms. With an estimated 4500–5000 buildings in Sarawak devoted to swiftlet farming, it is quickly developing as an industry, though the majority of such buildings in urban and built-up areas are not authorised to be swiftlet buildings (Wong 2011; Cheng 2016). Where such buildings are in towns and built-up areas, there are public concerns over noise pollution from swiftlet sounds played continuously to attract the

Fig. 18.1 Swiftlet house in Daro. (Photograph: Daniel Chew 2012)

Fig. 18.2 Large fortress-like swiftlet house in Daro. (Photograph: Daniel Chew 2012)

Fig. 18.3 Swiftlets in the sky over Daro bazaar. (Photograph: Daniel Chew 2012)

birds as well as health concerns given the number of swiftlets in the area (Fig. 18.3). When the land on which the swiftlet houses are built is owned by indigenous people, investors (mostly ethnic Chinese) make arrangements to either buy or lease the land or form partnerships with the owners. A planned government venture in Balingian is a swiftlet farming centre, consisting of three-storey buildings designed for swiftlets to nest (Wong 2011).

When the buildings are completed in the hope that the swiftlets will be enticed to build their nests, guards (usually local indigenous people) are employed to look after the valuable nests to prevent theft. Workers are then needed to collect and clean the nests. The work of cleaning the nests makes it possible for housewives to undertake the work from home. For example, in Siniawan some traders in shops employ local women to do the painstaking work of cleaning the nests (Fig. 18.4). The involvement of a range of people from traders to investors and local communities in the industry also extends to indigenous groups who claim customary land ownership in caves where the swiftlets build their nests, for example in Bau, the Tatau basin in Bintulu Division and in Niah and along the Baram River in Miri Division.

The interlinked roles of indigenous land/cave owners and Chinese traders in the product chain at a local micro level can be illustrated by a case study of nest collecting in the upper Tatau River (Figs. 18.5 and 18.6). At Bukit Sarang in the upper Tatau basin, a co-management model was initiated between Chinese traders and Punan Bah cave owners. In this model, both stakeholders share responsibilities in the management and collection of nests and focus on long-term sustainability rather than short-term gains. The Bukit Sarang cave complex is owned through native customary rights by some Punan Bah families, a situation that has caused disputes over poaching, further accentuated by lack of attention to the sustainability of nest

Fig. 18.4 Manual cleaning of nests in Siniawan. (Photograph: Daniel Chew 2012)

collection. A financial backer, a *towkay*[2] (shopkeeper) in Bintulu, persuaded the cave owners to let him manage the collection and conservation of birds' nests on a profit-sharing basis with a third of the profits given to the cave owners and two-thirds given to the *towkay*. The scheme was initiated by the swiftlet expert Lim Chan Koon who advised Ah Kong, the manager working for the *towkay*. A conservation measure of keeping a percentage of eggs untouched to allow breeding was introduced and accepted by Ah Kong with the support of his *towkay*. Ah Kong (2011) explained the arrangements to leave a portion of nests for conservation and breeding:

> How many per cent for breeding I have to tell my *towkay*. We sign an agreement with cave owners every five years to share profits but we manage the caves and take care of expenses and labour. In the beginning leave 40% of nests for breeding. In the fourth year, 25% of nests left behind. At first, output was 27–28 kg of nests per month. Then after saving nests, output went up to 40 kg a month. I started managing the caves in 1999 and I have worked for 12 years now.

The conservation strategies had the intended effect of increasing the output of nests, and the stakeholders, the cave owners and the *towkay* were happy (Ah Kong 2011; Lim 2011). Ah Kong heads downriver to deliver the cave nests to his Bintulu *towkay*. From Bintulu, the nests are sent to Kuching and then onward to the regional markets. Ah Kong revealed an insight into this kind of financing and management:

---

[2] *Towkay* means shopkeeper or trader in Hokkien. It is also a term of endearment or respect for such people.

Fig. 18.5 Daniel Chew (left) with Albertus, a visiting researcher at Universiti Malaysia Sarawak, at the foot of Gunung Staat, Siniawan, where black cave nests are collected. (Photograph: Albertus 2012)

his *towkay* was wont to lend hundreds of ringgit to the cave owners, not because the *towkay* wanted to but to keep the cave owners indebted to him and to maintain an ongoing economic relationship. According to Ah Kong: 'My *towkay* prefers that they are in debt. He is worried they don't borrow enough.' Debts would be paid back from the collection and sale of the nests. This kind of credit lending or indebtedness was common in Sarawak's rural economic history even though there were risks of debtors not repaying their debts or absconding.

Fig. 18.6 Collecting cave nests by climbing tall bamboo scaffolding inside the cave of Gunung Staat. (Photograph: Albertus 2012)

This mode of procurement and management of nests in Bukit Sarang can be contrasted with efforts by the indigenous communities themselves, such as in Siniawan where two neighbouring *kampung* took yearly turns to harvest nests. We observed this in operation in Siniawan where a local Bidayuh community in Kampung Kopit was taking its annual turn to harvest birds' nests. Collectors appeared to have no concern with saving some nests to allow for breeding and seemed to be more concerned with harvesting as much as they could before their neighbouring *kampung*'s turn. J.F. Liew, a birds' nest trader in Siniawan, revealed to us that individuals will sell him small cave nests which were not yet fully formed and such harvesting methods do not consider the sustainability of their practices and the potential for significantly reducing the swiftlet population. By whatever arrangements made by entrepreneurs, cave owners, collectors and buyers, the harvesting of nests has consequences for the swiftlet population.

The survival and sustainability of swiftlets in their natural and constructed environment are tied to and depend on human actions which are more often guided by non-altruistic motives of benefiting and profiting from the commodity rather than environmental and sustainability concerns. The nexus of connections between humans, bird species and the environment could not be any starker than in the construction of swiftlet ranches to meet the insatiable demand for this prized commodity. Human intervention in the building of the swiftlet nests and an unceasing demand for the product could lead to a drastic decline in swiftlet populations if the birds are not given the opportunity to reproduce. The construction of swiftlet farms may also inadvertently lead the investors to think ecologically for the sake of their investments. The development of this industry seems to have forced local communities to better understand bird behaviour, their preferred habitats, sources of food supply, how human actions can attract or repel the birds to nest, and undertake appropriate harvesting measures.

Swiftlet farmers in urban areas have reported decreasing harvests of nests. This could be due to overharvesting and not allowing the swiftlets to reproduce. According to Andy Tiang, treasurer of the Sarawak Bird's Nest Suppliers' Association: 'In recent years, there has been a steady decline in the production of birds' nests in certain towns like Sarikei, Tanjung Manis and Belawai. The decline ranges from 50 to 80%' (Cheng 2017). This has forced the entrepreneurs to think of relocating their farms to the rural areas. Tiang added: 'Many swiftlet farmers have discovered that the rural areas provide a more conducive environment for the swiftlets where food may be found more readily for these birds. Farmers are now moving their farms out to the rural areas on their own initiatives' (Cheng 2017). Just as cave nests have faced declining yields due to overharvesting, so too with farmed house nests. Keeping up with the supply of nests led us to examine the demand chain of birds' nests in Hong Kong, the global trading hub of the product.

18.4 Commodity Chain Between Sarawak and Hong Kong

> My father's elder brother was living in Hong Kong. We were sending jungle products and birds' nests to him and we asked him to deal with our imports from Sarawak. (Loh Tiaw Kui, birds' nest trader, Kuching, Sarawak, 12 March 2012)

> Hong Kong people often buy birds' nests, once they finish, they buy again. Hong Kong people eat birds' nests all year round. (V.C. Yew, chairman of the Hong Kong Bird's Nest Association, Hong Kong, March 2012)

Before the birds' nests are shipped out from Kuching to Hong Kong, they are collected locally in places like Bintulu. Bintulu is a coastal city where swiftlets build their nests in the top floors of shophouses and in specially constructed buildings along the river banks outside of the city centre.[3] In the evenings, swiftlets can be seen hovering over the city skyline. Tajang Laing, a Kayan *maren* (aristocrat) from the Bakun dam resettlement scheme in Sungai Asap, has a shophouse in Bintulu dedicated to attracting swiftlets to build nests. He collects 5–10 kg of nests every one to two months which he sells to Loh Tiaw Kui. Tajang Laing (2011) explained how he got into swiftlet farming:

> I saw how people were collecting birds' nests from the top floor of shophouses and I got interested, and started asking around, even going to peninsular Malaysia to try to learn. A friend showed me how and what to do in my shophouse in Bintulu. Slowly, I learned. Birds started to come and make nests, and I collect the nests. At first I don't know where to sell the nests. Then I remember a *towkay* in Kuching whom I used to sell *gaharu*. Loh [father of Loh Tiaw Kui] is a good friend from many years back. I bring my nests down to Kuching to sell to my *towkay* Loh every one to two months.

The above quotes of Loh and Yew highlight the links between Sarawak and Hong Kong in the collection and trade in birds' nests. Birds' nest consumption in Hong Kong is culturally rooted, and taken for health and therapeutic reasons. Relationships and networks like in the example of the Loh family underpin the commodity chains linking Sarawak with other nodes of the commodity chain, including Singapore, Hong Kong and China. The Loh family in Kuching, comprising Loh Tiaw Kui and his father, is a two-generation family trading in birds' nests. They began with the collection of and trade in cave nests and are now concentrating on and even investing in the construction of buildings to accommodate swiftlets, which include a processing factory to clean nests. Before the Second World War, Loh Tiaw Kui's father established a shop at Kuching's main bazaar dealing with jungle produce such as dammar (resin), gutta-percha (percha latex) and birds' nests from caves. These jungle products are rare nowadays and cave nests have become scarce too, being replaced by house nests. There are other traders like Liu Thian Leong in Kuching (also president of the Sarawak Bird's Nest Import and Export Association as of 2017) who has switched from cave to house nests by constructing buildings as swiftlet farms. According to Liu (2011): 'We export to Hong Kong, Singapore. Over the years, because of heavy taxes and uncertainties, traders export more to Hong Kong, Singapore. Then up to Hong Kong people to export to China.'

Winnie Hon, a wholesale birds' nests trader in Hong Kong, is a personal friend of Liu Thian Leong in Kuching. When we visited Hon's office in March 2012 in Sheung Wan, Hong Kong, she related her personal connections with swiftlet ranch farmers in peninsular Malaysia and Indonesia, making regular trips to Southeast Asia to inspect swiftlet buildings and to meet her suppliers. Hon said: 'We have

[3] For reasons of personal safety, we were advised not to pursue our research with traders and owners of swiftlet buildings in Bintulu, some of whom were said to be members of gangs or secret societies who might not take kindly to our queries. Kuching was regarded as a safer location to conduct our research.

relationships with suppliers in Indonesia. We trade with them. I only get from big factories. They collect goods from everywhere and they choose the good ones.' She is very much aware of the supply and market conditions in Indonesia and Malaysia such as the costs of producing the nests, the quality of the nests, and knows where to go for what she wants.

Another wholesale trader in Hong Kong, Hing Kee Java Edible Bird's Nest, which has its own processing facilities, has a network of suppliers and exporters in Indonesia and Malaysia, including Sarawak. The company staff regularly visit Southeast Asia to ensure the continuity and quality of the supply of birds' nests. The company has a Chinese Indonesian woman on its staff who speaks Indonesian, which is useful for communicating with their suppliers. Communication is important as birds' nest companies such as these must source the nests from several different countries in the region. Wilson Ng (2012) commented on the countries that supply Hing Kee Java Edible Bird's Nest:

> Malaysia is one of the region's birds' nests industry. Indonesia is another one. Indonesia is 70%, Malaysia 20%, Thailand, Vietnam, 10%. Our company has 90% of nests from Indonesia. For the past ten years, we established long-term relationships with the suppliers. Now all over Indonesia, Medan, Surabaya, Jakarta. We always need high quality products, so we need high quality suppliers…We mostly visit our suppliers in Indonesia, then Malaysia, some suppliers in Sarawak.

These networks, personal and built up over time, facilitate dealings across the region to ensure a steady and continuous supply of nests to meet demand. These personal relationships in facilitating commercial transactions are known as *guanxi* in Chinese.[4] The ethnic Chinese element in *guanxi* can be illustrated by this example in China Street, Kuching, a heavily ethnic Teochew quarter where there are traditional Chinese medicine practitioners who sell birds' nests as an ancillary product. A hidden and unnoticed part of the product chain are the itinerant travellers, tourists and traders from China who come to Sarawak and the region to buy nests in both individual or commercial quantities. Teochew travellers from Shantou often make a beeline for China Street and the adjacent Carpenter Street, where the local Teochew are found, to look for birds' nests to buy (Figs. 18.7 and 18.8). According to our informants in Kuching, Chinese visitors would buy several kilograms of nests to bring home, before the imposition of restrictions. Teo Teo Khoon runs a traditional Chinese medicine shop in China Street and is not a fully fledged birds' nest trader, stocking a limited number of birds' nests for retail sales. However, as an enterprising trader, Teo sources the nests through his network of contacts when approached by Chinese visitors looking for them. Several other birds' nest traders in Kuching also confirmed that this is the way they meet the requests of would-be buyers, by sending word out and sourcing for more birds' nests if they do not have enough in stock.

[4] The concept of *guanxi* refers to the interpersonal dynamic between two parties, particularly in a business arrangement, where the exchange of personal favours and the maintenance of a relationship are highly valued.

Fig. 18.7 Unprocessed birds' nests in a retail shop in Kuching. (Photograph: Daniel Chew 2012)

The Chinese government has attempted to stem this kind of trading by disallowing Chinese travellers going overseas from bringing back commercial quantities of birds' nests. After the ban was implemented in 2012, which forbade any amount of raw birds' nests to be brought back by tourists from outside China due to food security issues, technically no amount of birds' nests could be brought into the country without going through a series of inspections by the Chinese State Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and customs officials, which entails time-consuming procedures without any guarantee of successful importation. However, it is easy for Chinese travellers to take home small packages of birds' nests which they can claim are for individual consumption, or for parcels to be sent by post which may go undetected. It may also be possible to bribe officers at customs checkpoints to illegally allow birds' nests to pass through without issue. Another concern for China is the extraofficial or extralegal channels for the import of nests across the Hong Kong–Shenzhen border, which may be regarded as illicit trade. Among the Hong Kong traders interviewed, several alluded to these illegal trade networks, but were not prepared to divulge any more details for obvious reasons. This could be 'a phenomenon we cannot see, no matter what we do' (Wallerstein 2008: 4).

There is a robust transborder trade between Hong Kong and China in birds' nests. As noted previously, Hong Kong traders attributed the size and growth of the industry in recent years to demand from travellers and traders. Hong Kong traders are wary of Chinese policy changes which could have negative consequences for the industry.

Fig. 18.8 Processed birds' nests in a retail shop in Kuching. (Photograph: Daniel Chew 2012)

From our research visit to Hong Kong, what was apparent was the sheer scale of the industry. What was brought to our attention was how and why Hong Kong came to this pre-eminent position as a world centre for birds' nest trading: Hong Kong is a free port, has efficient banking services and has vast experience in dealing with the China market, the Chinese diaspora and with suppliers throughout Southeast Asia. Research and development are undertaken with regard to quality assurance, as well as the safeguarding of ethical business practices in not adulterating or counterfeiting products. The chairman of the Hong Kong Bird's Nest Association claimed that there are about 10,000 establishments supporting a workforce of around 80,000 people in the industry. The Sheung Wan district in Hong Kong is the hub of wholesale

Fig. 18.9 Row of birds' nests shops in Sheung Wan, Hong Kong. (Photograph: Daniel Chew 2012)

and retail trading in birds' nests with rows of streets specialising in the sale of the commodity (Fig. 18.9). Some shops look like emporiums and are elaborately fitted out with displays of glass jars of neatly cupped birds' nests on the walls and in horizontal glass display panels (Fig. 18.10); other shops are smaller but use similar glass jar displays too. During a research trip to Sheung Wan in March 2012, the normal hustle and bustle of businesses usually associated with Hong Kong were noticeably subdued. The reason was due to a consumer confidence crisis in birds' nests.

18.5 The Chinese Government's Response to the Birds' Nest Trade

With birds' nests associated with both opulent consumption and food safety scandals, the Chinese government was forced to act by imposing controls on the lucrative trade in the commodity. Confidence in the safe consumption of birds' nests took a big hit in August 2011 when routine inspections carried out on samples of birds' nests in markets in Zhejiang province uncovered high portions of nitrite, exceeding the acceptable World Health Organisation limits.

> The quality watchdog in east China's Zhejiang province has found excessive amounts of chemical nitrite in cubilose, or edible birds' nest, once again raising concerns over food safety in China. However, the poisonous food was not locally produced, but imported from Malaysia. The Zhejiang Provincial Administration for Industry and Commerce said at a

Fig. 18.10 Birds' nests shop in Sheung Wan, Hong Kong. (Photograph: Daniel Chew 2012)

> press conference on Monday that the amount of nitrite in the blood-red cubilose, a rare type of edible birds' nests, from 491 dealers in Zhejiang have shown nitrite levels average 4,400 mg per kg, far above the allowed cap of 70 mg per kg. An Agriculture vice minister of Malaysia, Chua Tee Yong, was earlier cited by a local Chinese newspaper, *Sin Chew Daily*, as saying that all the so-called 'blood-red cubilose' on the market is fake. A video footage obtained by the administration shows several dealers have admitted that almost all the blood-red cubilose on the market are ordinary birds' nest that have been dyed, resulting in excessive nitrites. (*Xinhua* 2010)

Media publicity of these tests created public alarm, concluding that the birds' nests were fake products and that the consumption of nitrite-tainted nests could cause food poisoning and even death. To allay these public concerns, the Chinese State Administration for Industry and Commerce issued new regulations on 'inspecting the circulation of nests' and policies were announced to prohibit the importation of birds' nests from all countries and regions to China.

A crisis of confidence swung through the entire industry from the demand to the supply chain. With prohibitions on imports and a lack of consumer confidence, sales slumped in the Chinese market by as much as 70%. The suppliers and traders of the nests were just as badly hit as Malaysia was publicly identified as the source of nitrite-tainted nests. Policy changes on import prohibitions and consumer perceptions in China caused panic in the region, including in Sarawak, especially among entrepreneurs who had invested in swiftlet farming. Within a period of just 4 months, the price for unprocessed white birds' nests dropped by a third. Colin Wong Chung Onn of the Sarawak Bird's Nest Suppliers' Association noted: 'The average prices have dropped to around RM3000 per kg as compared with RM4500 before the ban. The prices are under pressure' (Wong 2011). Over a period of many months, there was high-level government intervention from Malaysia, with visits by government ministers and senior officials to China to plead for the lifting of import restrictions.

> Agriculture and Agro-based Minister Datuk Seri Noh Omar was reported to have said last month that a working committee set up by Malaysia and China to determine the permissible nitrite in birds' nest products was expected to resolve the issue before the Chinese New Year. The committee was formed following a meeting between Health Minister Datuk Seri Liow Tiong Lai and his Chinese counterpart Chen Zhu in Beijing. Its members include food specialists and experts. Liow said that China would lift the import ban after determining the allowed level of nitrite. (Wong 2011)

When our research team was in Hong Kong in March 2012 to talk to birds' nests traders, we experienced first-hand the fallout from these trade concerns between China and Malaysia. Hong Kong traders were quick to distance themselves from nests originating from Malaysia and everyone we talked to said that they now only imported nests from Indonesia. Nests from Malaysia had earned a bad reputation and therefore had to be avoided. Previously, when there were bird flu outbreaks in Indonesia and nest exports to China were stopped from there, the industry in Indonesia suffered. From information in the Hong Kong archives (*Ta Kung Pao* 1949), Indonesia has always been the first supplier of birds' nests in Hong Kong; this could be the reason why Indonesia continues to be a point of reference for nest supplies for Hong Kong traders, rather than peninsular Malaysia and Sarawak. Up to the 1990s Sarawak was known only as the supplier of black nests in Hong Kong. It was not until after the 1990s that a birds' nest farming industry began to develop in Sarawak and farmed white nests from the state began to enter the Hong Kong market in small quantities. Hong Kong, as a Special Administrative Region of China, was exempted from the Chinese government bans, but what happened in China had a spillover effect on Hong Kong. Hong Kong birds' nest traders depend on Chinese buyers, and if they stop or reduce buying nests because of the bans then the Hong Kong traders would be affected.

We held a discussion with committee members and wholesalers of the Hong Kong Bird's Nest Association in Hong Kong on 6 March 2012 when the implications of this crisis on banning imports to China on the commodity chain were clearly spelled out. The subtext of a veiled warning from a Hong Kong wholesale trader strongly hinted at Malaysia bearing responsibility in creating the crisis and that it would suffer the most from the consequences of falling prices:

> We would like you to pass this message on. If birds' nests from Hong Kong continue to be prohibited from import into China, then prices will drop. This affects those in Malaysia too. The birds' nests industry will suffer. It is not only the Hong Kong people who will suffer. It is not a problem for Hong Kong people. If the price drops, we sell at a lower price. That's all. The industry as a whole will suffer. The hardest hit will be those who supply the birds' nests.

When a preliminary paper on this subject was presented to local experts and stakeholders at a seminar in Kuching in July 2012, there was a suggestion from the swiftlet specialist Charles Leh that this commodity chain study, which extended beyond Sarawak's shores, should confine itself to the local birds' nest industry in Sarawak. Though this may be a valid comment, commodities like birds' nests have far-reaching impacts at multiple sites in the commodity chain. Such research is interdisciplinary too, as shown by Motoko Fujita and Charles Leh (Chap. 19) and Haruka Suzuki et al. (Chap. 20) in this volume. In their publication, Lim and Cranbrook (2002) also provided historical data alongside ecological information for their research on swiftlets in the region and their nests. Wallerstein's suggestion cited at the start of this chapter is a reminder that a phenomenon such as birds' nests must be studied with a wider frame of reference, and the entire commodity chain should be examined.

With regard to the stark message given to us in Hong Kong, the Hong Kong traders we spoke to were anxious and critical of the approaches of the Malaysian authorities in making a high governmental intervention that was publicised in the media. The birds' nest sellers in Hong Kong had fears that if Malaysian producers had a foothold in China by exporting directly to the country, their own trading role would be affected. The anxiety would be even greater if Indonesia, the largest supplier, had followed in Malaysia's footsteps; this would have even affected their middleman trading functions.

Winnie Hon, while critical of the Malaysian approach, contrasted it with the softer and subtler Hong Kong *guanxi* way of doing things.

> Now the issue is open, complicated. So high profile does not help at all. When you put the problem high profile, it becomes a big problem. Malaysians don't understand the Chinese. Hong Kong people are more skilled. Hong Kong people deal with the problem subtly. By holding banquets, having wine, sitting with them. Not too direct. Find out their views. Find out who is the decision maker in this issue. And then approach in a proper way. Not too rushed. (Hon 2012)

Chinese government restrictions, after intense lobbying from Malaysia and after negotiations between government representatives from both countries, were eventually lifted on 25 December 2013. The AQSIQ lifted the ban on birds' nest imports with new requirements to trace the origin of nests, and where they were collected and processed. Processing plants or buildings for cleaning and packaging the nests had to be approved by the Chinese authorities. Due to these new regulations and requirements, production costs went up, and retail prices increased as well. Certification and the approval given to three plants in Sarawak to export the birds' nests have given a fresh lease of life and hope to investors in the industry. The main benefit of certification was to confer an impression of quality, given that the nests had traceable origins and met assurance standards even though costs of production inevitably increased. The eventual lifting of restrictions on the export of birds' nests, followed by stringent import requirements in China regarding certification of processing plants and registered radio frequency to trace the origin of birds' nests in December 2013, restored a sense of normality. Prices of the nests then rose, to the delight of suppliers in Sarawak. Notwithstanding the stricter import requirements, a newspaper report suggested that compliance was not always forthcoming (Cheng 2016). Out of an estimated 4500–5000 swiftlet farms only 514 were licensed and 1036 have registered a radio frequency. The bureaucratic obstacles and costs of compliance were turning suppliers away. As Liu Thian Leong was to admit:

> There are so many limitations for exporting and processing such as nitrate levels, radio frequency for traceability and so on … all this is making it hard for the local industry. Most would stick to the old ways of exporting through Hong Kong or directly to China through middlemen to avoid red tape and save trouble. (Cheng 2016)

The implications of Liu's remarks were that the tried-and-tested processes of networks and relationships in the commodity chain were useful in circumventing official requirements and restrictions. The digital age and the advent of instantaneous communications have given a fillip to the commodity chain. Telephone applications like WhatsApp and WeChat rapidly connect suppliers, buyers and middlemen and these channels may even evade bureaucratic obstacles and import and export restrictions. Traders in Kuching and Hong Kong hinted at these hidden pathways in the commodity chain and are cagey in not talking or revealing any details to researchers. This is the underside of the commodity chain that still remains largely hidden.

18.6 Conclusion

The interrelated processes in the birds' nest commodity chain are multifaceted and complex. The historical backdrop, and the economic, social, cultural, ecological and political contexts in which the product is procured, traded and consumed, extends the idea of a commodity chain into a web. The modifications to the chain that occur with the advent of swiftlet farming give new meaning to the relationship between humans and birds. The *Aerodramus* swiftlets that construct their nests with saliva on the crevices of cave walls and in buildings would not have realised that their completed nests, when handled, procured and consumed by humans, take on a different life with many interconnected processes.

In this chapter, we aimed to explore the commodity chain of birds' nests as a 'total phenomenon' in light of Wallerstein's suggestion. Historically, birds' nests are part of the culinary and medicinal history of China's imperial past. Birds' nests are a culturally unique food consumed by ethnic Chinese in China as well as Hong Kong and locations with Chinese diasporic communities. The reasons for this uniqueness are cultural beliefs in the health benefits and high social status associated with birds' nests. Embedded social relations within nest-producing zones in Sarawak and the sites of trading and consumption in Hong Kong and China connect production with consumption. The Chinese concept of relationship building or *guanxi* underpins social and economic relations at various stages in commodity chain. Faced with declining yields of cave nests and other ecological considerations, swiftlet farming has gained traction as a capital-intensive industry that attracts local communities. The human–swiftlet nexus makes it crucial for human actors to ensure an adequate supply of the nests through the building of bird farms. The supply of nests may not necessarily increase and may even decline if the human–swiftlet nexus is not well understood, especially with regard to the conservation and reproduction cycles of the swiftlets.

Finally, political intervention in policies and regulations add yet another complex element to the commodity chain with far-reaching effects. There are still phenomena that lie hidden, such as the illicit trading of birds' nests, which are difficult to research as many parties choose to remain silent on these matters. While Wallerstein's suggestion to analyse commodity chains as a 'total phenomenon' is a noble and ambitious one, we acknowledge it may be difficult to achieve this objective, given the gaps in the commodity chain which we may have no access to or knowledge of. The nodes of supply and demand for birds' nests are dynamic and evolving processes, all of which add to the difficulties and complexities of studying it as a 'total phenomenon'.

Personal Interviews

Ah Kong. 2011. Sarikei, November.
Chai Poh Khong. 2011. Kuching, August and September.
Chai Poh Khong. 2012. Kuching, March.
Hon, Winnie. 2012. Hong Kong, March.
Laing, Tajang. 2011. Sungei Asap and Bintulu, August.

Lim Chan Koon. 2011. Kuching, September.
Lim Chan Koon. 2012. Kuching. October.
Liu Thian Leong. 2011. Kuching, August and September.
Liu Thian Leong. 2012. Kuching, March.
Loh Siaw Kuei. 2011. Kuching, August and September.
Loh Siaw Kuei. 2012. Kuching, March.
Ng, Wilson. 2012. Hong Kong, March.
Sim Mong Hui. 2011. Bintulu, August.
Teo Teo Khoon. 2011. Kuching, August and September.
Teo Teo Khoon. 2012. Kuching, March.
Yew, V.C. 2012. Hong Kong, March.

References

Bair, Jennifer. 2005. Global capitalism and commodity chains: Looking back, going forward. *Competition and Change* 9 (2): 153–180.

Cheng, Liang. 2016. Birds' nests trade needs a shot in the pinion. *Borneo Post*, 4 September

———. 2017. Give us 10 years to relocate farms. *Borneo Post*, 23 June.

Chiang, Bien. 2011. Market price, labor input, and relation of production in Sarawak edible birds' nest trade. In *Chinese circulations, capital, commodities and networks in Southeast Asia*, ed. Eric Tagliacozzo and Chang Wen-Chin, 407–431. Durham: Duke University Press.

Hopkins, Terence K., and Immanuel Wallerstein. 1982. *World-systems analysis: Theory and methodology*. London: Sage.

Lim, Chan Koon, and Earl of Cranbrook. 2002. *Swiftlets of Borneo: builders of edible nests*. First ed. Kota Kinabalu: Natural History Publications.

Sarawak Gazette. 1871. Bintulu. 30 March.

———. 1873. The caves of Mount Sobis. 1 July.

———. 1882. Bintulu. 1 July.

———. 1883. Bintulu. 2 April.

Singapore Chronicle and Commercial Register. 1833. Caprices of the human appetite. 28 March.

Singapore Free Press and Mercantile Advertiser. 1933. The edible birds' nest of Pulau Tiuman. 8 September.

Ta Kung Pao. 1949. Birds' nest industry in Hong Kong. 1 March.

Wallerstein, Immanuel. 2008. Protection networks and commodity chains in the capitalist world-economy. In *Frontiers of commodity chain research*, ed. Jennifer Bair, 83–91. Stanford: Stanford University Press.

Wong, Jack (2011) Ban on imports badly affecting demand for white birds' nest in China. *The Star*, 30 December.

Xinhua. 2010. Excessive toxic chemical found in imported edible birds' nests in east China. 15 August.

Chapter 19
The Feeding Ecology of Edible-Nest Swiftlets in a Modified Landscape in Sarawak

Motoko Fujita and Charles Leh

Abstract There has been a dramatic establishment of swiftlet houses throughout the state of Sarawak over the last two decades, largely supplanting traditional sources of sought-after birds' nests. As a result, edible-nest swiftlets have succeeded in expanding their range. This study focused on the feeding ecology of swiftlets in order to clarify their adaptability in a disturbed and modified landscape. Our preliminary survey during the dry season showed that many birds that left their colonies in Bintulu city in the morning flew in the direction of a lower montane area, whereas in the evening they were observed flying back in the direction of their colonies. Swiftlets thus appear to commute between their colonies and their primary feeding grounds that are more than 30 km apart. This is due to high insect availability in the natural forest. Although suburban and rural landscapes may function as secondary feeding areas, our study indicates the importance of natural forests as a primary feeding area. This suggests how edible-nest swiftlets have adapted to the new nesting sites and modified feeding landscapes from the perspective of feeding behaviour.

Keywords Sarawak · Ecology · Land use · Swiftlets · Birds' nests · Feeding patterns

M. Fujita (✉)
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: fujita@cseas.kyoto-u.ac.jp

C. Leh
World of Birdnest Museum, Singapore, Singapore
e-mail: charllmu@sarawak.gov.my

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_19

19.1 Introduction

The consumption of birds' nests is a source of intrigue to most Westerners, but they are a medicinal feast to ethnic Chinese anywhere in the world. Ethnic Chinese see birds' nests as a luxury food item that is rich in nutrients, supposedly offering long life and a cure for a variety of health issues including lung disease, weak bladders and post-maternal illness. They are believed to contain elements capable of improving the immune system and renal functions, enriching the blood, soothing nerves and, not least, boosting virility and fertility. Regardless of whether they provide any medicinal value, birds' nests are known to be high in protein, contain little to no fats and are rich in essential amino acids (Kathan and Weeks 1969; Marcone 2005).

For centuries birds' nests have been harvested and traded in Southeast Asia. The nests are made by swiftlets using their saliva (Fig. 19.1b). Harvesting them from natural marine or limestone caves is a difficult and dangerous activity. Unfortunately, a decline in swiftlet populations has occurred in many places due to overexploitation from uncontrolled harvesting methods with no consideration of the breeding biology of the swiftlets. This situation changed dramatically in the 1990s, after a technique of farming swiftlets was developed in Indonesia during the postwar period. In Sarawak, many existing shophouses in both cities and rural areas have now been converted into swiftlet houses (Fig. 19.1d), while in other cases purpose-

Fig. 19.1 Swiftlet house conditions in Sarawak including (**a**) multistorey concrete house in a coastal area; (**b**) birds' nests harvested from a swiftlet house; (**c**) swiftlet at nesting beneath a speaker in a swiftlet house; and (**d**) swiftlets flying around a swiftlet house located in the top floor of shophouses in Bintulu. (Photographs: Motoko Fujita, (**a**)–(**c**) 2011, (**d**) 2010)

built concrete buildings consisting of several storeys have been constructed (Fig. 19.1a). These houses are fitted with loudspeakers to broadcast the recordings of chick calls in order to attract swiftlets (Fig. 19.1c). Alongside the establishment of swiftlet houses throughout the state, Sarawak's rural landscape has also changed drastically with wide-scale conversions of primary and secondary forests into plantations for the cultivation of oil palm and fast-growing tree species such as acacia. Disturbed landscapes do not provide good food sources for swiftlets, such as flying insects. Despite the drastic changes in their environment, swiftlets seem to have survived and even expanded their range in Sarawak.

In this chapter, we first explore the basic feeding behaviours of several swiftlet species. We then discuss the adaptability of house-farmed edible-nest swiftlets to a modified landscape, reporting our observations of their diurnal foraging trips and foraging strategies.

19.2 Biology and Taxonomy of Swiftlets

19.2.1 Swiftlet Species

Birds' nests are made of the saliva of swiftlets. These small birds have a body weight of 15–28 g and a total length of 12–14 cm. Swiftlets are sometimes confused with swallows, but these two groups are taxonomically completely different. Swallows belong to the Hirundinidae family of the order Passeriformes, whereas swiftlets belong to the Apodidae family of the order Apodiformes. These two families of birds are generally similar in their external appearance and both families feed entirely on small airborne arthropods, but their taxonomical differences are greater than those between crows and swallows.

On the island of Borneo there are three species of genus *Aerodramus*—the edible-nest swiftlet, *Aerodramus fuciphagus*; the black-nest swiftlet, *Aerodramus maximus*; and the mossy-nest swiftlet, *Aerodramus salanganus*—and one species of genus *Collocalia* (the glossy swiftlet, *Collocalia esculenta*) (Fig. 19.2). *Aerodramus* spp. use echolocation to navigate in dark environments that they frequent such as caves, and can nest deep within a cave where there is little or no light. However, the glossy swiftlet lacks this ability and only nests in cave mouths.

19.2.2 Nest Building

During the breeding season, each pair of birds can produce a full nest of saliva, from salivary laminae cement (almost equal to one bird's body weight) in 30–45 days (Lim and Cranbrook 2014). The saliva is produced from a pair of sublingual glands located beneath the bird's tongue and released through ducts to the floor of the

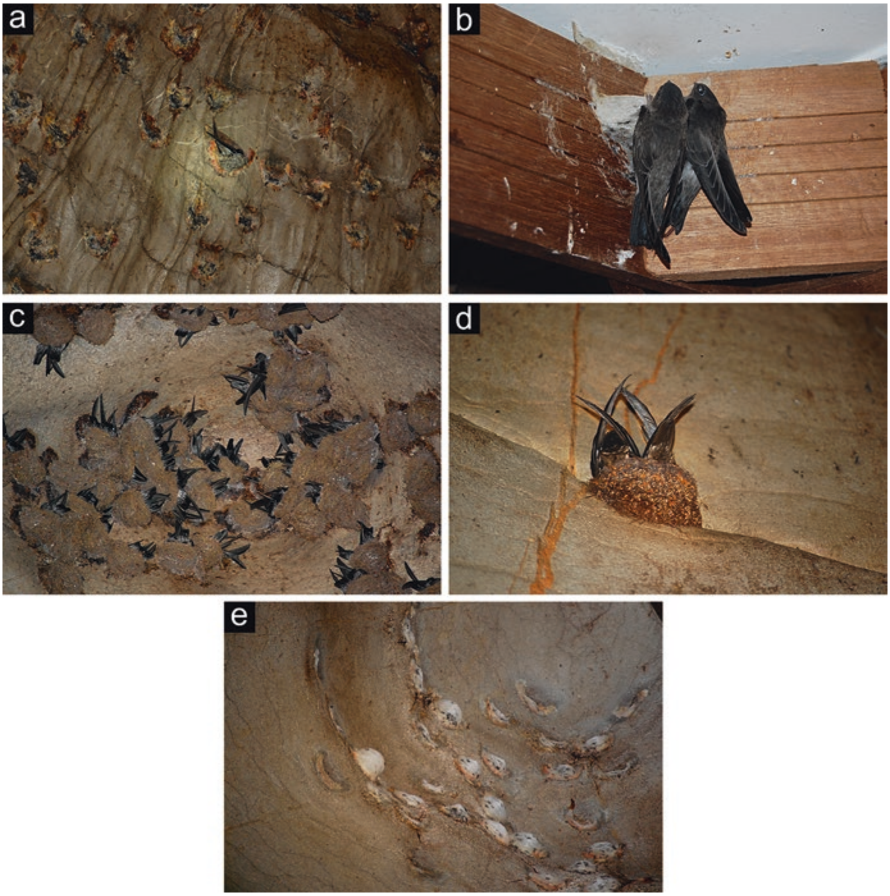


Fig. 19.2 Swiftlet species: (**a**) black-nest swiftlet (*Aerodramus maximus*) in Bukit Sarang, Tatau; (**b**) house-farmed edible-nest swiftlet (*Aerodramus fuciphagus*) in Kuching; (**c**) glossy swiftlets (*Collocalia esculenta*) in the middle Baram; (**d**) mossy-nest swiftlet (*Aerodramus salanganus*) in the middle Baram; and (**e**) nests of *Aerodramus fuciphagus vestitus* in the middle Baram. (Photographs: Motoko Fujita, (**a**), (**b**) 2010, (**c**)–(**e**) 2011)

mouth. Both sexes possess a pair of these glands but, based on our observations, the female bird contributes over two-thirds of the nest-building activity.

The majority of swiftlet species use their saliva as nest cement that is built up in layers but also incorporate other materials, including feathers, clay and organic plant material. Two species (edible-nest swiftlets and black-nest swiftlets) build nests without any organic plant material or clay and thus their nests are the ones that have been traditionally harvested for human consumption. Nests of black-nest swiftlets (Fig. 19.2a) are usually covered with black feathers and hence are called 'black nests', with the quantity of feathers differing with the time of year. Nests of edible-nest swiftlets (Fig. 19.2b, e) contain relatively fewer feathers and are called 'white nests'; these nests are considered more valuable than black nests and thus fetch a higher price on the market. The nests are constructed with a lattice structure that is attached in a horseshoe shape to the wall of the cave or swiftlet house.

19.2.3 Subspecies of Edible-Nest Swiftlets in Borneo

The edible-nest swiftlet (*Aerodramus fuciphagus*) complex is made up of several subspecies whose taxonomy is quite complicated and has been disputed over years due to similarities in their morphological characteristics (Fig. 19.3). Recently, the taxonomy and phylogeny of this group of birds have been reviewed at the morphometric and genetic levels (Cranbrook et al. 2013). It has been shown for the first time that the colonies of edible-nest swiftlets that inhabit swiftlet houses are not all genetically identical and some may represent hybrids of wild species. Since the morphological characteristics of the white nests are not a reliable way to identify the swiftlets at the subspecies level (Lee et al. 1996), genetic evidence is needed for further identification of the farmed colonies.

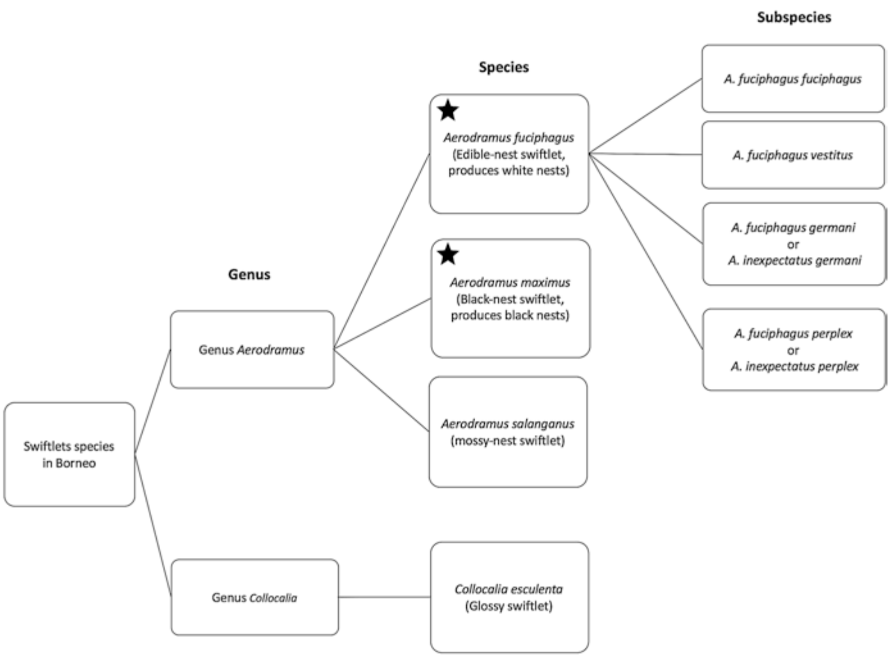


Fig. 19.3 Swiftlet species of Borneo with stars indicating the species that produce birds' nests that are consumed by humans

Four subspecies of swiftlets in Borneo produce wholly white edible birds' nests (Fig. 19.3). In Sarawak, *Aerodramus fuciphagus vestitus*, also known as the brown-rumped swiftlet, is found in the caves in the middle Baram (Fig. 19.2e). This swiftlet is generally blackish-brown on its back, rump and tail. It is also found in the Gomantong caves in Sabah and other inland caves in Kalimantan. *A. fuciphagus germani* (proposed as *A. inexpectatus germani* by Cranbrook et al. 2013), also known as Germain's swiftlet, is believed to have originated in Vietnam; it has a dark back and tail with a grey rump. It is found in western Kalimantan, western Sabah and in the Satang islands, Lakei Island and Tanjung Datu National Park in southwest Sarawak. Riley's swiftlet, *A. fuciphagus perplexus* (proposed as *A. inexpectatus perplexus* by Cranbrook et al. 2013), is very similar to Germain's swiftlet in terms of body colouration and inhabits northeastern Sabah and eastern Kalimantan. The most common white edible-nest swiftlet is *A. fuciphagus fuciphagus*, known as Thunberg's swiftlet. This pale-rumped subspecies is believed to have initially come from Java and it is thus also known as the Javan subspecies.

19.2.4 Subspecies Farmed in Swiftlet Houses in Sarawak

The status of edible-nest swiftlets in Sarawak has changed radically as a result of the swiftlet farming industry that has grown rapidly in the last 20 years. The practice of farming swiftlets in purpose-built houses in Sarawak initially occurred in the coastal town of Miri and its surrounding areas in the mid-1990s, followed by Bintulu in 1997 and Mukah in 2000 (Cranbrook et al. 2013). Photographs of birds from Miri, Sarikei, Saratok and Kuching confirm that all resemble the variable, pale-rumped swiftlets (*A. fuciphagus fuciphagus*) of swiftlet houses in peninsular Malaysia. None of the birds in swiftlet houses resemble any of the wild species in Sarawak (such as the grey-rumped subspecies, *A. fuciphagus germani*, and the brown-rumped subspecies, *A. fuciphagus vestitus*). Owners of swiftlet houses in Sarawak attest that they have not transferred eggs or nestlings into their houses. Therefore, the expansion of the industry is possibly the result of successful inducement of adult swiftlets of a distinctive type to occupy the sites. The original birds of the type now found in swiftlet houses could have flown spontaneously across the South China Sea from the east coast of peninsular Malaysia or flown over the mountain ranges from the Indonesian part of Borneo, and it is probable that such movements are continuing to occur (Cranbrook et al. 2013). The territory of the pale-rumped type raised in swiftlet houses now extends around the coast of Borneo from Sarawak to Sabah. Clearly, swiftlets are highly mobile and capable of colonising suitable habitats. The origin of house swiftlets has yet to be clarified using detailed genetic evidence.

19.3 Feeding Ecology of Swiftlets

19.3.1 Composition of Diet

Swiftlets consume insects from the orders Hymenoptera (ants, wasps and bees), Diptera (flies and mosquitoes), Hemiptera (aphids and plant lice), Ephemeroptera (mayflies), Coleoptera (beetles), Psocoptera (booklice), Lepidoptera (butterflies), Orthoptera (grasshoppers), Trichoptera (caddisflies), Thysanoptera (thrips), Acari (mites and ticks), the suborder Heteroptera (true bugs), the infraorder Isoptera (termites) and the class Arachnida (spiders). Of these, ants and wasps are the most common prey consumed (Langham 1980; Lourie and Tompkins 2000). According to Sara Lourie and Daniel Tompkins (2000), who studied the food boluses of several swiftlet species in the Gomantong caves and Ampang reservoir in Malaysia, there were marked differences in prey items among various species and different landscapes. Black-nest swiftlets had the most selective and specialised diet—89% of the insects they consumed were hymenopterans and of these 97% were flying ants. Edible-nest swiftlets and mossy-nest swiftlets mostly fed on hymenopterans (39% and 46%, respectively) and dipterans (39% and 26%, respectively). Glossy swiftlets were the least selective feeders of all. In rural and urban landscapes, this species feeds on different prey items than it does in the forest landscape, appearing to have adapted to the modified landscape. In contrast, the highly selective black-nest swiftlets are probably restricted to forested areas and have not adapted to the modified landscape.

19.3.2 Foraging Areas and Altitude

Swiftlets feed in natural forests, mangroves, coconut plantations, paddy fields and oil palm plantations in lowland areas. Although few studies have been conducted on their foraging area, swiftlets are believed to have large foraging ranges. For example, Lord Medway (1962) observed *A. maximus* and *A. salanganus* flying more than 24 km from the caves in which they were breeding.

A study in the Andaman and Nicobar Islands clarified that edible-nest swiftlets (*A. fuciphagus* or *A. inexpectatus*, a local subspecies in these islands) were observed to forage at a relatively higher altitude than glossy swiftlets (*C. esculenta*, a local subspecies) (Manchi and Sankaran 2010). Edible-nest swiftlets were also more active in the early morning and late afternoon. As flying insects are considered to move upward with the increasing ambient temperature and warm air currents (Johnson 1969), edible-nest swiftlets probably shift their foraging height at midday, unlike glossy swiftlets, which forage above or below the forest canopy. D.R. Waugh and Chris Hails (1983) also recorded a higher feeding altitude of edible-nest swiftlets, with foraging occurring at 80–100 m during the day. In comparison, glossy swiftlets foraged mostly at 20–40 m with a maximum of 80 m during the daytime. These different preferences for altitude could be the result of resource partitioning.

19.3.3 Diurnal Feeding Behaviour

Edible-nest swiftlets normally leave their nesting and roosting sites from the swiftlet houses in groups at dawn to forage for food, sometimes as early as 05:30. They follow specific flight paths each day and are probably led by several leaders. These free-ranging swiftlets disperse over large areas to feed during the daytime. Edible-nest swiftlets exhibit two main feeding rhythms each day, one occurring in the early morning and one in the late afternoon. From the ground, the swiftlets can be observed to be feeding until about 10:00. As insects rise into the atmosphere due to the rising hot air, the swiftlets probably feed higher in the air and can no longer be observed from the ground. By midday, many of the swiftlets begin to feed over bodies of water and along coastal areas, when winged insects emerge from these areas. In the late afternoon, the swiftlets begin their flight home, stopping occasionally to feed. In the dryer months, swiftlets may return in flocks as late as 19:00 when nightfall is early. In Penang, edible-nest swiftlets entered the colony's nesting site by 19:30 (Langham 1980).

19.3.4 Seasonality in Food Supply and Breeding

Food availability is one of the most important factors that controls the breeding cycle of birds. Unlike temperate areas where seasons are easily defined by temperature and day length, tropical areas have seasons that are largely defined by rainfall patterns. These patterns affect insect abundance and thus also affect the breeding cycle of swiftlets. The feeding ecology of swiftlets reared in swiftlet houses is largely dependent on the weather conditions of the different seasons. From October to February each year, the rain brought by the wet northeast monsoon supports the yearly flowering and fruiting of the dipterocarp forest, causing an increase in insect populations. During the dry season, from May to September each year, swiftlets must fly further inland from their colony base to look for sufficient food sources. They typically leave their nests very early in the morning and return home as late as 20:00. Edible-nest swiftlets often return to roost after sunset, making full use of the remaining light of dusk to capture insects that only emerge in the early evening when temperatures are cooler.

Edible-nest swiftlets (*A. f. vestitus*) in the middle Baram have a long breeding period that lasts from August until the following May, with three peaks in egg laying taking place in September–November, December–February and March–May; the largest peak in egg laying is the first peak (Lim and Cranbrook 2014). This pattern coincides with the northeastern monsoon periods which continue from August until December. Meanwhile, swiftlets in the Gomantong caves in Sabah have their breeding peak in March–April, which coincides with the dry season (Francis 1987). The parents of black-nest swiftlets seldom feed their chicks during the daytime in the dry months; during the wet season, they feed them one to four times per day. These differences in seasonal feeding patterns seem to be due to the changes in foraging ground according to insect availability.

19.4 Range Expansion of Edible-Nest Swiftlets in Response to Swiftlet Farming

Swiftlet species and subspecies that are native to Sarawak, such as *A. fuciphagus vestitus* and *A. maximus*, breed in the natural limestone caves that are abundant in the hills, montane tropical rainforests and a few islands off the coast of the state (Fig. 19.4). Most areas of the coastal plain along the western part of Sarawak, including cities such as Kuching, Sarikei, Sibu, Mukah and Bintulu, lack native swiftlet colonies.

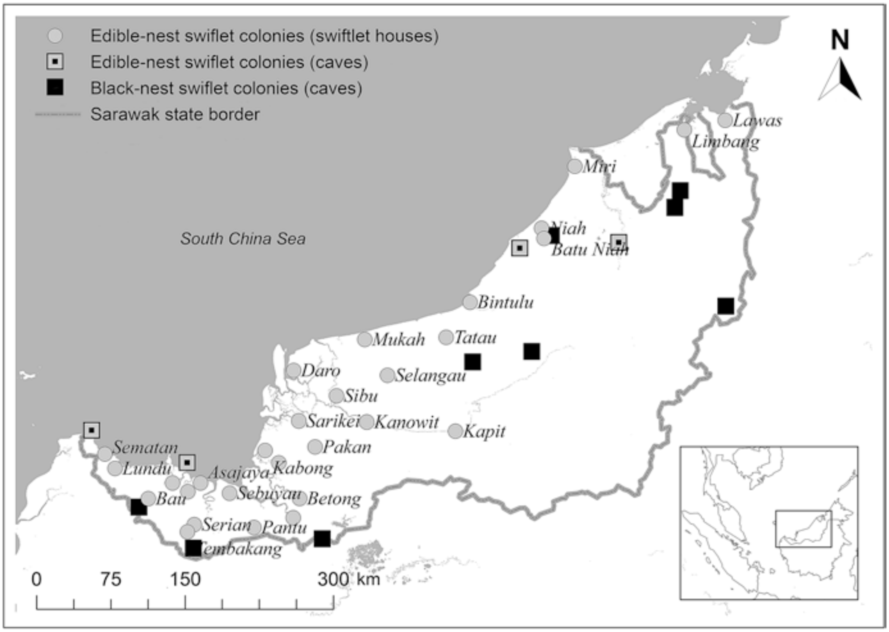


Fig. 19.4 Distribution of swiftlet colonies in Sarawak with the colonies of edible-nest swiftlets in swiftlet houses (grey circles) and caves (grey squares), and the colonies of black-nest swiftlets in caves (black squares)
Note 1: Locations of swiftlet houses are approximate as many locations have multiple swiftlet houses distributed throughout a large area.
Note 2: Data on swiftlet houses was based on observation by the authors (Fujita and Leh) in 2014, while the data on cave colonies is based on Lim and Cranbrook (2014). Only locations with swiftlet houses are named on the map.

It is believed that the Javan subspecies of the edible-nest swiftlet (*A. fuciphagus fuciphagus*) was first successfully farmed in Indonesia and then introduced to the Malay Peninsula, after which it arrived in Sarawak around 2000. Since the introduction of the swiftlet houses and resources on swiftlet-breeding techniques, *A. fuciphagus fuciphagus* has expanded its range through the urban areas of Kuching, Sibu, Bintulu and Miri, where native swiftlets are absent.

It is not surprising that swiftlets thrive in houses in Saratok and Engkilili which are located far inland. Competition for available food resources in the surrounding forests, paddy fields and agricultural plantations drives swiftlets into the interior regions, where there is relatively much less competition. When competition is intense, some colonies of swiftlets may break up into smaller subgroups and move to locations further inland where a larger amount of vegetation and insects are available. In the Mukah and Bintulu divisions, there was a large population of swiftlets that divided into smaller groups in 2005 (Leh, personal observation). Some swiftlets from Bintulu moved to Tatau, while some swiftlets from Sibu travelled to live in houses in Kanowit and Kapit. The hunger drive for more food causes swiftlets to move and expand their habitat inland probably at rates of at least 10 km per year.

Swiftlet farming is expected to expand in the future, as the market price of birds' nests continues to increase. At the present price of RM4200 (US$1000) per kg it is still profitable to enter the industry if one is capable of building a suitable swiftlet house. However, not all swiftlet houses are necessarily successful at any given location. The success of the swiftlet house depends on a multitude of factors such as the general house design, orientation of the house, location, proximity to the next successful swiftlet house, sound system, the swiftlet recordings being played and overall maintenance. If the swiftlet farming industry continues to expand, the expansion of swiftlets into rural areas will occur more rapidly. Nevertheless, the range expansion of the swiftlets will eventually reach a limit due to natural ecological barriers, such as steep mountain ranges and food shortages due to high competition.

19.5 Swiftlet Survival in a Modified Landscape in Sarawak

Swiftlet houses provide a relatively safe environment for swiftlets. In addition to appropriate breeding sites, food availability is an important factor in the survival and proliferation of birds. Since most swiftlet houses are built in cities or in rural areas, swiftlets need to search for appropriate foraging grounds that are either in or close to these areas.

Unlike the lower montane areas, which contain extensive natural forests, the plains along the western coasts are modified landscapes (Fig. 19.5a, b). Suburban areas include plantations of oil palm, rubber, coconuts, bananas and pineapples, whereas rural areas include oil palm plantations, planted acacia forests, shifting cultivation sites and secondary forests. Some patches of natural forest still remain in suburban or rural areas but they are often highly fragmented or have been disturbed

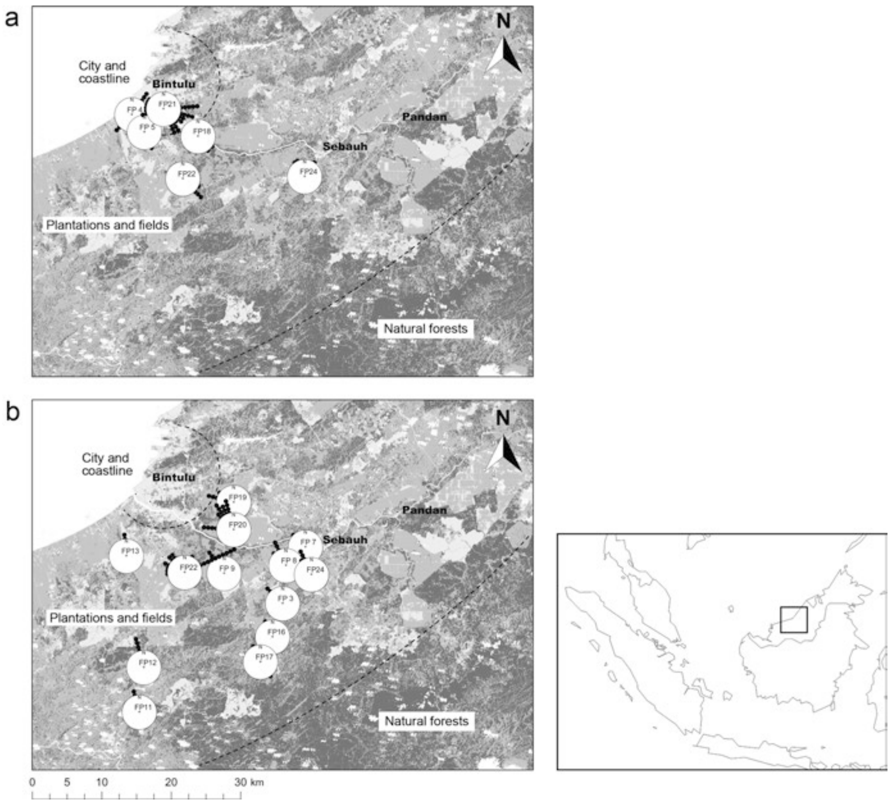


Fig. 19.5 Flying direction of swiftlets (**a**) in the morning; and (**b**) in the evening; with the inset showing the location of the study area

Note: White circles indicate survey points, while black dots around the white circles indicate the mean number of individual swiftlets per one-minute census flying in each direction. A single dot refers to one to 10 individuals; for example, three individuals are shown as one dot, while 22 individuals are shown as three dots.

by logging. The lower montane areas are the only regions where relatively large patches of natural forest still remain in reasonable condition, although these forests could seldom be considered pristine.

The abundance and diversity of many arthropods decrease with increasing anthropogenic disturbances. The abundance of ants and termites has declined in oil palm plantations compared with natural forests (Turner and Foster 2009; Luke et al. 2014). Bee populations have also declined in disturbed forests (Liow et al. 2001). In these studies, insects were trapped and collected near ground level, thus the findings may not directly reflect food availability for swiftlets which feed on flying insects such as winged ants, stingless bees, wasps and termites that are found high above the tree canopy. Nevertheless, these studies do indicate that modified landscapes may not provide as good a source of insect prey for swiftlets as do natural forests.

Many bird species are capable of adapting to artificial environments, sometimes by consuming different diets. The level of behavioural plasticity differs among species, causing variations in sensitivity to habitat change among species. In the case of swiftlets, Lourie and Tompkins (2000) speculated that edible-nest swiftlets might be able to adapt to urban and rural landscapes because their diet seems to be less selective than that of black-nest swiftlets.

As urban, suburban and rural environments do not provide ideal foraging habitats for swiftlets, it is interesting to explore how they are coping with these new modified environments. There is little information available on whether the modified landscapes of planted forests meet their feeding needs, and whether they still require some natural forest for feeding. In the next section, the preliminary results of our field survey are introduced, which aim to clarify the feeding environment of edible-nest swiftlets.

19.6 Feeding Trips of Swiftlets in Bintulu: A Case Study

In Bintulu, most swiftlet houses are in the urban zone or on the coastal plain southwest of the city. Large patches of natural forest remain some 30 km inland from Bintulu city, and the suburban and rural area in between is covered by oil palm plantations, acacia plantations and farmland (Fig. 19.4). In September 2014, the end of the dry season in Sarawak, 17 survey points were placed within 40 km of Bintulu city, and several one-minute censuses were conducted at each point from 06:00 to 08:30 and from 15:30 to 19:00. During each census, the number of swiftlets and the direction in which they were flying were recorded. At one survey point that lay close to the swiftlet houses in Bintulu and was directly on their flight path, one-minute censuses were performed every 3–5 min between 06:15–08:15.

Most swiftlets flew southeast in the morning (Fig. 19.5a) and northwest in the evening (Fig. 19.5b). As this tendency was observed at almost all survey points, it is reasonable to conclude that swiftlets fly over suburban and rural areas in the direction of the lower montane area, where extensive natural forest remains. In order to consume enough insects, they must travel more than 30 km from their colonies in Bintulu city to the lower montane area. Swiftlets' primary feeding area was considered to be the natural forest, rather than the city centre, farmlands or plantations (Fig. 19.6). On rainy days, not many swiftlets were observed flying, so it was concluded that they do not go out to feed during periods of heavy rain.

Most swiftlets seem to make long feeding trips almost every day and typically reach their feeding ground by 08:00. However, some swiftlets were still observed near their respective colony nesting sites even after this time. It is suspected that some individuals do not participate in the long foraging trips and instead remain in closer vicinity to the nesting site. In the evening, tens to hundreds of individuals were occasionally seen flying over plantations or feeding for a short period of time in small patches in urban parks, small fragmented forests or farms. This occasional

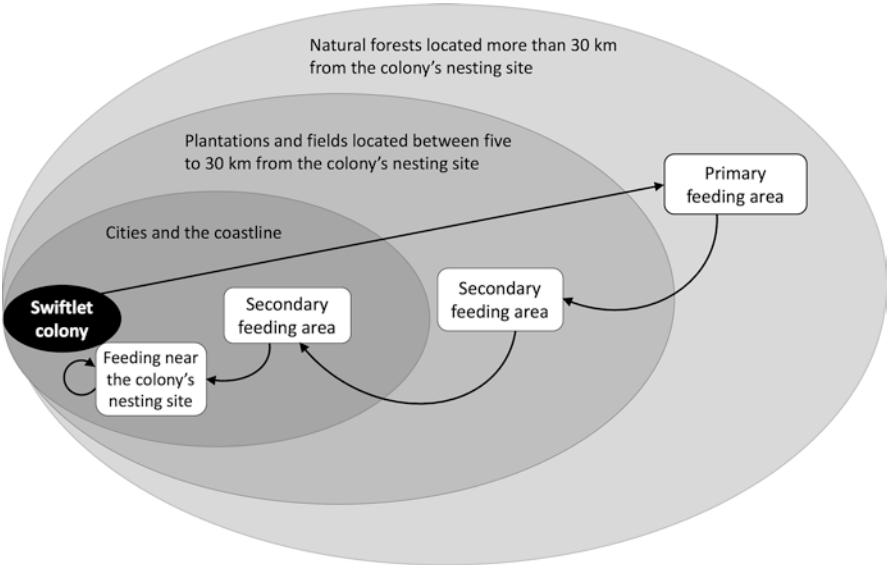


Fig. 19.6 Daily foraging trip of edible-nest swiftlets

feeding behaviour is quite distinctive and has been observed by many, including those involved in the swiftlet farming industry. These modified environments of plantations, cities or farms may function as secondary feeding areas for swiftlets (Fig. 19.6). Urban environments near the colony may provide some insects for birds that lack the physical strength to undertake a long foraging trip. Plantations or farmlands in the suburban and rural areas may also provide some insects, especially in the evening, when the cooler ambient temperatures drive insects that fly at high altitude in the daytime down closer to the vegetation.

During the study period, which was at the end of the dry season, swiftlets were preparing for the forthcoming breeding period. During this time, most of the swiftlets seemed to commute between their colony's nesting sites and their primary foraging ground (the natural forest), most likely due to abundant insect availability in the forest. Along their flying path, they occasionally foraged in suburban and rural environments, stopping at these 'cafes' to feed for several tens of minutes before returning to the colony.

Some researchers have noted that the foraging range of swiftlets may change seasonally according to insect abundance (Francis 1987; Lim and Cranbrook 2014). Typically, swiftlets are considered to fly further during the dry season to search for food, whereas in the wet season many insects are swarming and the swiftlets do not fly very far. Our results strongly support this observation regarding the dry season. To improve the understanding of swiftlets' seasonal behaviour, it is necessary to perform further continuous observations in a more systematic manner.

19.7 Swiftlets in a Modified Landscape

It is highly probable that the population of native swiftlets depends largely on the presence of appropriate nesting sites in caves that are safe from predators and have appropriate rock sites on which to build their nests. The successful breeding of edible-nest swiftlets (*A. fuciphagus fuciphagus*) in swiftlet houses, which has enabled the subspecies to expand its range, is primarily due to these houses being relatively safe and having adequate and appropriate nesting sites. Nevertheless, swiftlets need to rely on the natural environment for their food, as it would be impossible for humans to provide sufficient and suitable food sources. Therefore, the landscape surrounding the colony's nesting site is of great importance for the sustainable propagation of swiftlets.

Unlike edible-nest swiftlets, black-nest swiftlets have not successfully adapted to artificial farmhouses. In places throughout Sarawak such as Bau, many swiftlet houses have been built near caves with existing nesting colonies of black-nest swiftlets, but none of these swiftlet houses has been successful so far in attracting the swiftlet colonies. The reason for this failure is unknown but this species seems to be rather sensitive to its environmental surroundings and does not have high behavioural plasticity compared other swiftlet species. As black-nest swiftlets are highly specialised in their diet that consist mainly of Hymenoptera, they are more dependent on forests for their foraging than edible-nest swiftlets are; thus, it seems unlikely that the black-nest swiftlets will adapt to new modified landscapes. Meanwhile, edible-nest swiftlets have easily adapted to the new nesting sites and the modified feeding landscapes given their high flexibility regarding nest site selection, diet and foraging grounds.

References

Cranbrook, Earl of, Goh Wei Lim, Lim Chan Koon, and Mutsafa Abdul Rahman. 2013. The species of white-nest swiftlets (Apodidae, Collocaliini) of Malaysia and the origins of house-farm birds: morphometric and genetic evidence. *Forktail* 29 (2013): 107–119.

Francis, Charles M. 1987. *The management of edible birds' nest caves in Sabah*. Sandakan: Wildlife Section, Sabah Forest Department.

Johnson, Cecil George. 1969. *Migration and dispersal of insects by flight*. London: Methuen.

Kathan, Ralph H., and Dianna I. Weeks. 1969. Structure studies of *Collocalia* mucoid I. Carbohydrate and amino acid composition. *Archives of Biochemistry and Biophysics* 134 (2): 572–576.

Langham, Nigel. 1980. Breeding biology of the edible-nest swiftlet *Aerodramus fuciphagus*. *Ibis* 122 (4): 447–461.

Lee, Patricia L.M., Dale H. Clayton, Richard Griffiths, and Roderic D.M. Page. 1996. Does behaviour reflect phylogeny in swiftlets (Aves: Apodidae)? A test using cytochrome b mitochondria DNA sequences. *Proceedings of the National Academy of Sciences of the United States of America* 93 (14): 7091–7096.

Lim, Chan Koon, and Earl of Cranbrook. 2014. *Swiftlets of Borneo: Builders of edible nests*. 2nd ed. Kota Kinabalu: Natural History Publications.

Liow, Lee Hsiang, Navjot S. Sodhi, and Thomas Elmqvist. 2001. Bee diversity along a disturbance gradient in tropical lowland forests of South-east Asia. *Journal of Applied Ecology* 38 (1): 180–192.

Lourie, Sara A., and Daniel M. Tompkins. 2000. The diets of Malaysian swiftlets. *Ibis* 142 (4): 596–602.

Luke, Sarah H., Tom M. Fayle, Paul Eggleton, Edgar C. Turner, and Richard G. Davies. 2014. Functional structure of ant and termite assemblages in old growth forest, logged forest and oil palm plantation in Malaysian Borneo. *Biodiversity and Conservation* 23 (11): 2817–2832.

Manchi, Shirish S., and Ravi Sankaran. 2010. Foraging habits and habitat use by edible-nest and glossy swiftlets in the Andaman Islands, India. *Wilson Journal of Ornithology* 122 (2): 259–272.

Marcone, Massimo F. 2005. Characterization of the edible bird's nest the 'Caviar of the East'. *Food Research International* 38 (10): 1125–1134.

Medway, Lord. 1962. The swiftlets (*Collocalia*) of Niah Cave, Sarawak. Part 2: Ecology and regulation of breeding biology. *Ibis* 104 (2): 228–245.

Turner, Edgar C., and William A. Foster. 2009. The impact of forest conversion to oil palm on arthropod abundance and biomass in Sabah, Malaysia. *Journal of Tropical Ecology* 25 (1): 23–30.

Waugh, D.R., and Chris J. Hails. 1983. Foraging ecology of a tropical aerial feeding bird guild. *Ibis* 125 (2): 200–217.

Chapter 20
Swiftlet Farming: New Commodity Chains and Techniques in Sarawak and Beyond

Haruka Suzuki, Tetsu Ichikawa, Logie Seman, and Motoko Fujita

Abstract This chapter analyses the characteristics of the contemporary edible birds' nest trade in Sarawak with special reference to how changing knowledge and new commodity chains and techniques are affecting business trends. The two trends in the trade are: (1) the shift from traditional ecological knowledge and practices to more scientific and economic knowledge and practices; and (2) the move from the collection of nests in caves to swiftlet houses. The introduction of swiftlet farming and the resulting new method for birds' nest collection are transforming people's environmental knowledge and ethnic relationships in Sarawak society. The new farming method includes constructing buildings for nesting swiftlets, but this method does not include breeding and domesticating the swiftlets or using their eggs, meat or feathers. Swiftlet house owners are searching for more scientific knowledge of swiftlet ecology and are using technological equipment to ensure the greatest chance of success in the industry. Traditionally, indigenous people collected birds' nests from caves, local Chinese middlemen bought and distributed them, and people in mainland China and Hong Kong imported, consumed and re-exported them. Since the introduction of swiftlet farming in houses, the Chinese in Sarawak have dominated these new farming methods from upriver to downriver areas.

Keywords Sarawak · Birds' nests · Trade · Farming · Swiftlet houses

H. Suzuki (✉)
Kyoto University of Foreign Studies, Kyoto, Japan
e-mail: h_suzuki@kufs.ac.jp

T. Ichikawa
Nagoya City University, Nagoya, Japan
e-mail: tetsu-i@kb3.so-net.ne.jp

L. Seman
Forest Department Sarawak, Kuching, Sarawak, Malaysia

M. Fujita
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: fujita@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_20

20.1 Introduction

In Southeast Asia, including Borneo, trade networks for tropical resources between the indigenous peoples, coastal Malays and ethnic Chinese have been established for many centuries. Various forest and maritime products prized in such places as China, India, the Middle East and Europe were collected by communities of hunter-gatherers, sea nomads and swidden farmers in insular Southeast Asia, and were then bought and distributed by Chinese and Malay traders. Through the gathering, producing, processing, buying, distributing, selling and consuming of ecological resources and natural forest products, local knowledge of the natural environment was strengthened and relied upon, ethnic relations between upstream and downstream communities were reinforced, and trading networks connecting local societies with the outside world were established. Recent changes in these commodity chains due to global trade have caused dramatic changes in human–nature relations in the region. Analysing the complex trade networks of ecological resources and their transformation helps deepen our understanding of these changing relations.

Edible birds' nests—particularly those of the swiftlet—are a major forest product distributed in the global market. This chapter analyses the characteristics of the contemporary edible birds' nest trade in Sarawak with special reference to how changing knowledge and new commodity chains and techniques are affecting business trends. In the 1990s swiftlet farming was introduced as a new concept into the birds' nest business and it has been transforming ecological knowledge and ethnic relationships ever since. After the construction of specially designed swiftlet houses, swiftlet farmers then attempt to attract swiftlet colonies to nest by playing recordings of swiftlet calls. If the swiftlets nest in the houses, people harvest the abandoned nests after the young birds have fledged. The farmers do not feed, breed or domesticate the colonies and do not use the swiftlets' eggs, meat or feathers. The swiftlet farming industry has particular implications for the livelihoods of local inhabitants, the ecology of the swiftlet populations and the resulting animal–human relationships in a tropical biomass society.

20.2 Southeast Asia: Source of a Popular Chinese Delicacy

Edible birds' nest, known as *yan wo* (燕窝) in Mandarin and *sarang burung* in Malay, is a rare and expensive Chinese food delicacy. Although the Chinese word *yan* means 'swallow', this delicacy is not a swallow's but a swiftlet's nest. The swiftlet is a biologically different species from the swallow. Among the members of the swiftlet's *Aerodramus* genera, only two species, *Aerodramus fuciphagus* (white-nest or edible-nest swiftlets) and *Aerodramus maximus* (black-nest swiftlets) build edible nests by using their saliva. It is commonly believed that swiftlets use seaweed to build their nests, which is why their nests may taste like seaweed to some consumers. Though this is a prevalent belief it is false as the swiftlets use only their saliva to build their nests. These two species commonly build their nests in limestone caves in inland and coastal areas in tropical Asia (Lim and Cranbrook 2002).

While it is unknown when exactly Chinese people began consuming edible birds' nests as a delicacy, it can be dated back to at least the Tang dynasty according to some scholars. It has been a popular part of Chinese cuisine since the Ming dynasty and was used as an important dish for the Manchu Han Imperial Feast (*man han quan xi* [满汉全席]) during the Qing dynasty (1644–1912). It remains a prominent delicacy in Chinese cuisine in mainland China and among overseas Chinese communities today (Figs. 20.1 and 20.2; Lim and Cranbrook 2002; Jordan 2004; Chiang 2011; Zhuan 2011).

Edible birds' nests are rarely produced in China but have been imported from Southeast Asia for centuries (Mohamed Yusoff 2002: 45; Chiang 2011: 409–410). Southeast Asian countries remain the main source of edible birds' nests today (Marcone 2005: 1126). Edible birds' nests are still considered a special product of the Southeast Asian region and are consistently sold to overseas tourists with Chinese backgrounds (see Chew et al., Chap. 18). For example, edible birds' nests are regarded as a typical local product of Thailand and are sold as a local delicacy in Bangkok at international airports and shops, consumed as a dessert in restaurants or bought from street vendors on Yaowarat Road in Chinatown. In Thailand, both local Thai and Chinese residents, as well as foreign tourists, consume edible birds' nests.

As in Thailand, edible birds' nests are also traded in Sarawak. According to one Chinese businessman in Kuching, the main consumers in Sarawak are Chinese people from various parts of East and Southeast Asia, in particular from peninsular Malaysia, Singapore, Hong Kong, Taiwan and the People's Republic of China. Birds' nests in Sarawak are not only sold in retail shops to local customers but are

Fig. 20.1 Packaged edible birds' nests sold in a shop in Kuching with the top birds' nest priced at RM428 and the lower birds' nest priced at RM598. (Photograph: Tetsu Ichikawa 2012)

Fig. 20.2 Edible birds' nest dessert sold in a restaurant in Kuching costing RM50 per serving. (Photograph: Tetsu Ichikawa 2011)

Fig. 20.3 Edible birds' nest shops in Sheung Wan, Hong Kong. (Photograph: Tetsu Ichikawa 2012)

also exported overseas along with shark fin and sea cucumber as speciality products, especially to China and Hong Kong (Fig. 20.3). Edible birds' nests in Sarawak are traded through the so-called Chinese trading network, with sellers playing an important role connecting multiple locations as well as people in and beyond Southeast Asia.

Changes have occurred in recent times in the structure of the edible birds' nest trading network in Southeast Asia, including Sarawak. One of the main reasons for this change is the introduction of a new method for collecting nests. Traditionally, nests were collected from caves located in tropical rainforests or in coastal areas.[1] Chinese merchants faced several difficulties in procuring nests, having to find capable people to reach such natural environments, enter the caves and collect the nests in the darkness. However, since the introduction of the new collection method, it is no longer necessary for Chinese merchants and middlemen to ask indigenous people to collect the nests. Consequently, this new method has changed the conventional ethnic relationships in the area, as well as the pattern of the nest trade itself.

20.3 The New Birds' Nest Commodity Chain

20.3.1 Traditional Edible Birds' Nest Trade in Sarawak

As already noted, indigenous people have collected edible birds' nests in caves in the rainforest for centuries, and the cave usufruct has been historically established among local people. They used ladders, towers and parbuckles to collect the nests, which are built on the roofs and walls of the caves (Figs. 20.4, 20.5, and 20.6). Only skilled indigenous people who knew the geographical location and characteristics of the caves could engage in this work.

The collected nests were bought by other indigenous people or by Chinese middlemen, and then sold to Chinese merchants in the city. Some of the nests brought to the city were consumed locally, but most were exported to countries such as Hong Kong, Taiwan and China, as well as to Chinatown districts in other countries.[2]

This trade network partially overlaps with the traditional trade network in the Borneo interior. As in other parts of Southeast Asia, indigenous people of the region collected jungle products that are highly valued in international markets, such as in China, India, the Middle East and Europe. These products include animal meat and fur, elephant tusks, ironwood (*belian*), rattan (see Takeuchi et al., Chap. 22), aromatic trees, various kinds of resin and bezoar stones (see Okuno and Ichikawa, Chap. 23), with birds' nests being one of the major forest products (Mohamed Yusoff 2002; Chiang 2011). In the meantime, commercial or industrial products—such as processed food, sugar, salt, porcelain, ornaments, clothing, medicine and

[1] For example, in Thailand, seafaring indigenous people (such as the Moken) have collected edible birds' nests from caves in seashore cliffs to sell.

[2] Retail shops for birds' nests can be easily found in Chinatowns in Yokohama, Kobe and New York.

Fig. 20.4 Cave where swiftlets build nests in Kakus. (Photograph: Tetsu Ichikawa 2010)

Fig. 20.5 Swiftlet nests built on the wall of a cave. (Photograph: Tetsu Ichikawa 2010)

Fig. 20.6 Unprocessed black nests taken from a cave. (Photograph: Tetsu Ichikawa 2011)

hardware—have been imported to the interior. Rural communities in Borneo have been connected to the rest of the world for centuries through the trade of these jungle products (Chew 1990; Brosius 1995; Wadley 2005; Ishikawa and Ishikawa, Chap. 6).

The indigenous peoples of Borneo are not known to consume edible birds' nests themselves. Even the Chinese middlemen in Sarawak do not consume the nests as part of their daily diet because of their high economic value. They are usually only consumed on special occasions or purchased as a gift for family, friends or business partners. Some restaurants in Sarawak do serve edible birds' nests as part of their special menus.

20.3.2 Transformation of the Edible Birds' Nest Trade in Sarawak

Although the traditional trading network provided a relatively clear role for each ethnic group the nature of this network has recently changed. In the 1990s a new method for harvesting edible birds' nests was introduced from Indonesia to Sarawak. This involves the construction of buildings that look like warehouses with small openings in their walls. Sarawakians, especially local Chinese, try to attract swiftlets to build their nests inside the buildings. The swiftlet house is called *yan wu* (燕屋) in Mandarin and *gedung walet* in Indonesian.

Although this new technique began in the early 1990s in peninsular Malaysia, it gathered momentum after the Asian financial crisis of 1997–1998, when the

Fig. 20.7 Female workers processing edible birds' nests in a factory in Kuching. (Photograph: Tetsu Ichikawa 2012)

Malaysian economy declined and the country experienced a recession. In other words, the swiftlet house industry emerged when companies and entrepreneurs faced a crisis and were looking for alternative business opportunities. The great migration of swiftlets to Malaysia following vast forest fires in Indonesia in 1997 also contributed to this momentum. It was in this period that the swiftlet house industry began in Sarawak.

The establishment of swiftlet house businesses in Sarawak in the 2000s cut out the need for local Chinese merchants to visit indigenous villages in remote areas to acquire birds' nests. Instead it provided middlemen with an avenue to obtain the nests themselves and in greater amounts than before. However, middlemen do still employ some indigenous workers, including those for the cleaning and processing of birds' nests from swiftlet houses (Fig. 20.7).

Despite the rapid increase in birds' nest supply from Malaysia since the late 1990s, the price of the nests has continued to rise, buoyed by economic growth in mainland China. According to a Chinese businessman in Kuching, the price of raw birds' nest in the 1980s was about RM80 per kg but increased to RM5000 in early 2011, fuelled by the boom in the late 1990s and 2000s.[3]

In the 1990s, when the swiftlet farming industry was new, local people had little or no understanding of the methods needed to attract swiftlet colonies to nest. Many newcomers merely constructed swiftlet houses in their own way and according to their own designs. In most cases, these pioneers failed due to a lack of sufficient knowledge regarding the ecology of swiftlets, their nesting preferences, their flight patterns and other behaviour. It was only in the early 2000s that many in the Sarawakian swiftlet farming industry began to succeed. Now, some

[3] In 2013 the exchange rate was US$1 to about RM3.06, in the 1980s US$1 was about RM2.44.

Fig. 20.8 Swiftlet house created by renovating the top floor of a shophouse to attract the birds. (Photograph: Tetsu Ichikawa 2010)

swiftlet houses are even constructed by converting old buildings, existing bungalows and shophouses (Fig. 20.8).

20.4 New Knowledge and Techniques of Managing and Constructing Swiftlet Houses

In order to attract swiftlets into the houses, it is necessary to obtain sufficient knowledge of the birds' life and their preferred environment and ecological conditions. In this section, the newly acquired knowledge and techniques involved in managing and constructing swiftlet houses are discussed.

20.4.1 The Ecology of Swiftlets in a Swiftlet House

Swiftlets begin to forage outside after dawn or as early as 05:30 or 06:30, subject to good weather. After foraging over a wide range, they return to the nesting site at approximately 15:30 and enter the swiftlet house before dusk. Because they are very agile fliers, they are able to mate in the sky and keep a ball of insects (bolus) in their mouths to feed the chicks inside the swiftlet house.

People who work on the edible birds' nest business state that swiftlets have three flying paths: (1) the primary path; (2) the secondary path; and (3) the deviation path.

In the primary path, a large flock of swiftlets glides together from the same location. The most important sites for building swiftlet houses are around swiftlet foraging locations along the primary path, such as in coastal areas with mangrove forests, vast tracts of paddy fields, near secondary forests and reforestation areas (except for oil palm plantations), where there are plenty of insects. While foraging, swiftlets fly 20–50 m above the ground. The secondary path is used by a smaller flock of swiftlets in pursuit of potential foraging locations but it is not very far off from the primary path. The deviation path is not a fixed gliding location and is used by a very small number of swiftlets for two reasons. First, they may be pursuing aerial insects in another spatial zone, and second, they may need to deviate to keep themselves safe from predators such as eagles and large bats. Due to its unpredictability, the deviation path is not a suitable location for a swiftlet house.

20.4.2 Appropriate Location Conditions for a Swiftlet House

The site location for a swiftlet house is highly critical for a successful business. In Sarawak, most successful swiftlet houses are in coastal areas (Fig. 20.9), such as those between Asajaya (Figs. 20.10 and 20.11) and Sebuyau, Lingga or Maludam, and between Pusa or Kabong, Sarikei or Sibu and Matu Daro. Other good coastal areas are between Mukah and Bintulu, and between Similajau and Bekenu or Miri. Before a swiftlet house is erected, the suitability of the location must be determined by playing swiftlet mating sounds between about 06:30 and 09:00 and 16:00 to 19:00 at least five times a week. The location is suitable if at least 50 swiftlets react

Fig. 20.9 Swiftlet house in the coastal area of Sematan. (Photograph: Tetsu Ichikawa 2011)

Fig. 20.10 The appearance of a swiftlet house in Asajaya is similar to a longhouse. (Photograph: Tetsu Ichikawa 2011)

Fig. 20.11 The entrance of a swiftlet house in Asajaya resembles that of a cave. (Photograph: Tetsu Ichikawa 2011)

to the echolocation by gliding and hovering to the mating sound, flying at above 10 m above ground level (Salekat 2010).

Zero degrees latitude falls exactly at Pontianak, West Kalimantan, Indonesia, while Sarawak is located slightly north of the equator. Hence, to reduce the heat from the sun, the length of the swiftlet house must be orientated from east to west with its ‘monkey house’ and entrance facing the north.[4] More heat must be directed onto the southern side than the northern side. The following is a list of guidelines for reducing the heat from the external environment.

1. The roof must not be fixed directly to the upper beams of the building but approximately 0.5 m above the beams, with the space increased to about 2.0 m above at the apex of the roof. This open space is to accommodate radial ventilation and also functions as an insulator to the building structure.
2. Thin aluminium roofing is effective because it reflects heat from the outer surface but it must be reinforced with an air duct insulator from the inside.
3. The roof of the roving area should be at an approximately 30° angle in order to reduce the afternoon heat from the west.
4. There should be a drain approximately 0.3 m wide and 0.45 m deep; it must touch the ground wall and the foundations in order to fill it with rainwater. At the lower end of the drain, a tap is installed to accommodate monthly cleaning. The main reasons to construct a drain in this manner are to create a cooling system and to keep predators (such as geckos, ants and rats) from entering the swiftlet house.
5. According to AgroMedia (2009), the entrance should be 0.4 m × 1.0 m, but after birds’ nest production starts it should be narrowed to 0.15 m × 1.0 m. This adjustment reduces excess light and heat and discourages predators like owls and bats from entering. The entrance must be located approximately 40 cm below the roof.

20.4.3 Suitable Interior Conditions of Swiftlet Houses

The temperature inside the swiftlet house must be kept at 26–29 °C, with the humidity between 75% and 95%. The ideal light intensity is around 3.0 lux (AgroMedia 2009). The roving area must not be smaller than 3.0 m width × 3.0 m length so that the young chicks can safely learn to fly inside the house. The ventilation for maintaining conductive humidity should be installed using PVC pipes of 0.6–1.2 m in length and placed 1.0–1.5 m apart along each wall, 1 m above the ground. The other should be placed approximately 3 m above the lower ventilation. The floor and walls must be concrete. To enhance humidity, several buckets or jars filled with water should be placed on the floor. The floor must be sprayed with water twice a

[4] ‘Monkey house’ (*rumah munyit*) is a term coined by Indonesians to indicate the ‘roving area’ within the swiftlet house where swiftlets move inside; it is where a small entrance is placed.

week. The ledges at which swiftlets make their nest are best made of meranti (*Shorea* spp.) timber approximately 2 cm width × 15 cm height with two shallow horizontal grooves, which should be placed in lines on all the ceilings of the house. The horizontal distance between each ledge is normally 0.6–0.7 m, and as many lines of ledges are placed according to the size of the ceiling. A swiftlet house should have double doors, with the main door facing south to reduce disturbance to the bird entrance that faces north.

For mating chirps, the main tweeter (high frequency loudspeaker) should be placed at an angle of 60° above the entrance. Speakers with various tweeters for chick chirps are placed inside the roving area, whereas those for breeding chirps should be placed inside the nesting area. A CD player producing swiftlet chirp sounds is used to attract swiftlets (Fig. 20.12). A USB flash drive or memory card are recommended for storing the sounds. Stacks of amplifiers are needed to strengthen the bird chirping sounds. The chirping sound must ideally be played between 06:00 and 10:00 and between 15:30 to 19:30. The necessary electrical appliances such as loudspeakers, sprinklers, humidifiers and surveillance cameras are available for sale in the major towns of Sarawak, namely Kuching, Sibu, Bintulu and Miri (Fig. 20.13).

Books and magazines specialising in the swiftlet house business have been published in Malaysia and Indonesia. Business owners who have succeeded in the business or scholars who have extensive knowledge of the farming industry are well paid for giving lectures on the farming industry. Swiftlet house construction has clearly attracted widespread attention among entrepreneurs and businesspeople in Malaysia, and especially Sarawak.

Fig. 20.12 Equipment used to play recorded swiftlet cries for attracting birds to the swiftlet house. (Photograph: Tetsu Ichikawa 2012)

Fig. 20.13 Security monitor in a swiftlet house. (Photograph: Tetsu Ichikawa 2011)

20.4.4 A Single-Storey Swiftlet House

In Sarawak, businesspeople and companies have initiated the construction of large swiftlet houses of three to four storeys in height, which can cost between RM300,000 and RM400,000. Considering the risk of an unsuccessful investment, it has been difficult for rural indigenous people with limited financial means to participate in the swiftlet house boom. Many initially thought that the flourishing swiftlet house business would be totally dominated by local Chinese. However, many indigenous people are now looking for alternative ways to build budget swiftlet houses.

Figures 20.14, 20.15 and 20.16 show an example of a budget swiftlet house that has a height of 4 m for the breeding area with a roving area that is 6 m high. The width and length are 6 m and 15 m, respectively. This single-storey swiftlet house (including infrastructure and electrical appliances) can be constructed for approximately RM35,000—a much more affordable investment that poses less financial risk. Constructing multiple small swiftlet houses has proven to be more strategically viable in terms of turnover and maintenance in relation to the capital invested, due to owner expertise. Competition with other swiftlet houses is considered a relatively a minor issue as long as the swiftlet house is located in a primary flying path with a large supply of insects.

In the last few years, many low-budget swiftlet houses have been built not only by Chinese merchants but also by rural indigenous people and the urban middle class. However, many of these indigenous swiftlet house owners are still at the trial-and-error stage. In the following section, an example of a low-cost wooden swiftlet house recently constructed by indigenous people in a rural area is illustrated.

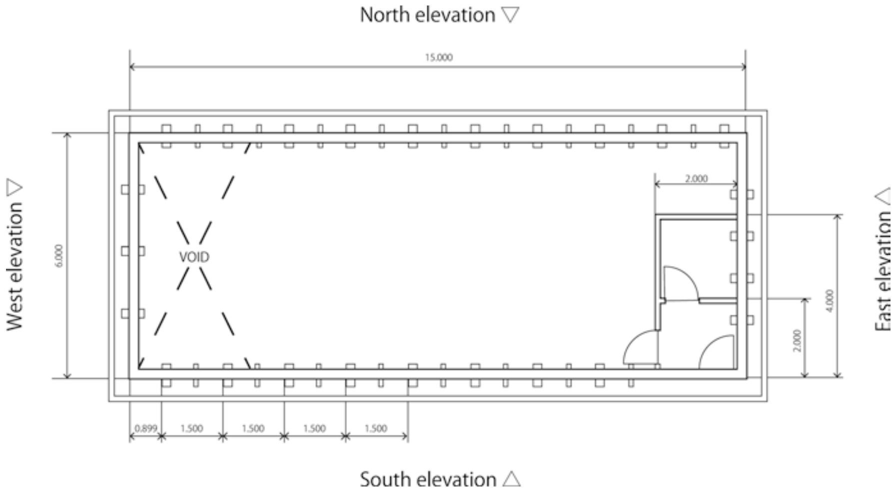


Fig. 20.14 Example of floor plans for a swiftlet house (metres)

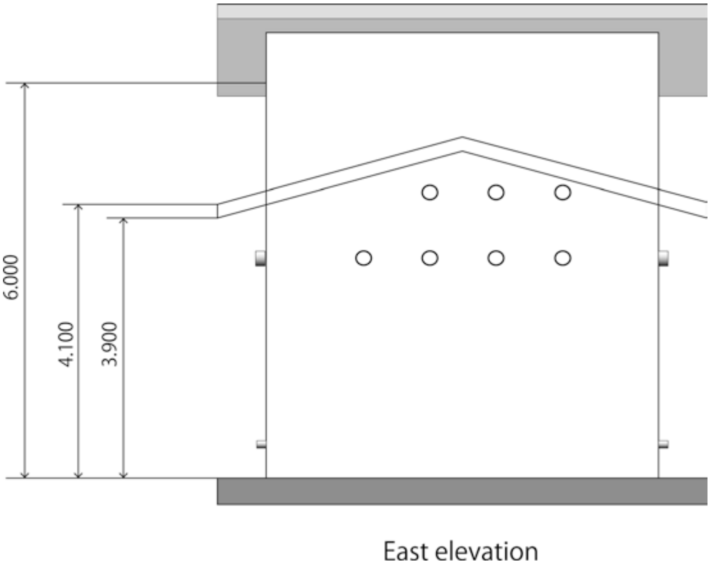


Fig. 20.15 Example of the east elevation for a swiftlet house (metres)

Fig. 20.16 Example of the south elevation for a swiftlet house

20.5 New Techniques for Low-Cost Wooden Swiftlet House Construction

20.5.1 Location

Here, we introduce a unique wooden swiftlet house constructed by a Kayan family, examining its characteristics and the new techniques employed for attracting swiftlets. This swiftlet house was built along a feeder road in the Sebauh area, about half an hour by car from Bintulu.

T, his wife D, his son B and his daughter L were primarily responsible for building and managing the swiftlet house. The house was actually constructed by several residents of Sungai Asap, a region about half a day inland by car from Bintulu and the original home of T and his wife. T's son B lives in Kuching and operates several swiftlet houses in both Kuching and Bintulu. T's daughter L lives in Bintulu where she runs a logging company.

B, who oversaw the construction of the swiftlet house, chose the location in Sebauh because he owns a parcel of land there. He purchased the 4–6 ha of land from an Iban. The land was essentially untouched peatland surrounded by secondary fallow forests and oil palm plantations. In B's view, the large number of the insects on which swiftlets feed in the peatland and the nearby oil palm plantations made this site well suited for a swiftlet house. Many swiftlet houses are located along the road connecting Bintulu and Sebauh, but no other buildings are near T's swiftlet house, which is well ventilated with good views of the surrounding area.

20.5.2 Construction Methods

The most noteworthy characteristic of this swiftlet house is its wooden construction, as most swiftlet houses are built from concrete. Many people probably believe that concrete provides an environment that most closely resembles the caves in which swiftlets normally build their nests. However, wood was used for this swiftlet house in an effort to reduce the cost of construction and a site survey revealed that its cost was indeed lower than if it had been made of concrete.[5]

The exterior dimensions of this swiftlet house are 720 cm wide, 1,800 cm high and 705 cm deep. There are 24 air holes each on the eastern and western sides of the structure, to which PVC tubes are attached. An entrance for swiftlets is located on the top of the northern side. This entrance measures 60 cm × 90 cm. In comparison to the entrances of other swiftlet houses this one is rather large. Openings for workers to enter the small rooms are located on the southern and eastern sides of the house, and there is a control room containing audio equipment on the southern side of the house.

The principal building materials included *belian* (*Eusideroxylon zwageri*) and meranti (*Shorea* spp., *Parashorea* spp.) square timber and boards, as well as plywood. *Belian* was used for the foundations and for the columns between the foundations and the upper portion of the house, both areas that require an especially high level of strength and durability. Meranti was used for other structural parts and plywood was used for the floors, ceilings and walls. The wood was either joined using screws and wedges (for columns and boards) or nails (for plywood).

The carpenters and B's parents together chose the construction methods and design of the swiftlet house. The house was built using a simple framing method. Foundations were laid and a subfloor was built on top of the foundations. The floor and walls of plywood were then nailed in place. The foundations were designed so they would not sink into the loose base provided by the peatland where the swiftlet house is sited. Normal concrete swiftlet houses require a more complex and lengthy process for foundation construction, including the boring of deep holes that are then filled with stone and gravel. By contrast, this swiftlet house's foundations were simply constructed by means of a number of wooden stakes driven vertically into the ground, with horizontal wooden crosspieces then secured to the stakes. According to B, builders in Sungai Asap dig holes in the ground when building foundations, insert stakes of about 2 m in length and secure them in place by backfilling the holes with soil. Then horizontal pieces are attached to the stakes with screws to complete the foundations. Because the soil in Sungai Asap is dry, this approach provides adequate support for most structures. While it is unclear whether this construction method is sufficient in the absence of a careful evaluation of its strength, it can be safely said that since the weight of the wooden house is far less than that of a concrete house the wooden house does not require the same extensive

[5] Construction costs were calculated based on interviews with E, who owns a concrete swiftlet house in Sadong Jaya (about 1 h by car from Kuching) and with B, who was involved in the construction of this swiftlet house.

foundation construction. In general, it seems that they chose the construction method for the foundations of this house, and indeed for the entire house, based on their experience to date with similar constructions.

The house is a three-storey structure with a vaulted opening on the north side. After coming in through the entrance, the swiftlets proceed to the open space within the house, from which they move to the other floors. Each floor has an opening for an entrance or exit on the west side of the house.

20.5.3 Interior Equipment

There are about 20 speakers inside the swiftlet house, including large speakers on both sides of the swiftlet entrance and small speakers on the tops of the columns. These speakers are connected to an MP3 player in the control room that plays a looped recording of swiftlet calls, which are important in attracting swiftlets to the house. The owner of the swiftlet house has tried various speaker types and locations through a process of trial and error and creative modification in order to attract as many swiftlets as possible.

D's detailed description of the audio equipment suggests she has paid enormous attention to this aspect of the design. B explained that he had obtained a good recording of swiftlet calls and that the birds would come to the house immediately if this recording were played. It seems apparent that the house owners enjoy developing ideas and creatively figuring out how to attract swiftlet colonies.

Inside the swiftlet house, an odour that is attractive to swiftlets hangs in the air, potentially masking any other scents in the man-made structure. The floors of each storey are covered with the birds' droppings, dispersing the smell of ammonia throughout the structure. The owners say that this odour is identical to the one that can be found inside caves with swiftlet colonies where guano has built up over several decades. Furthermore, the walls and floors of the house have also been coated with a solution of ammonia and water. The owners explained that swiftlets would not otherwise come to newly constructed houses due to the smell of the timber and paint used in their construction. Figure 20.17 shows an example of the interior structure and placement of speakers that is similar to the wooden swiftlet house in this case study.

20.5.4 Family Networks Involved in Swiftlet House Building

The procurement of materials for and the construction of this house drew on the skills of the family network. The various responsibilities, such as procuring materials and working on the building, were divided among family members. The families of D and T, B's parents, supervised these tasks. D and T live in Sungai Asap, so they organised residents there to carry materials and perform the carpentry. D and T have

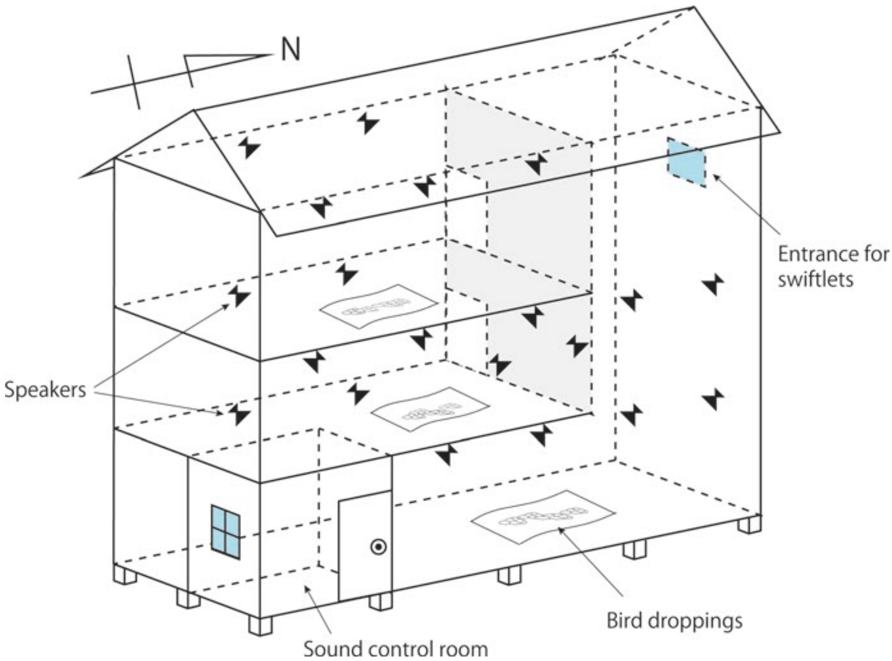


Fig. 20.17 Example of the interior structure and placement of speakers of a wooden swiftlet house

children, including B, who are residents of Bintulu and Kuching and who were responsible for procuring building supplies—such as screws, nails and plywood—as well as the speakers and other audio equipment.

The timber, which is the principal building material, was harvested from a concession near Bakun dam that is owned by the timber company run by L, B's daughter. Punan people living in Bakun harvested and processed the timber, and L transported it from the concession by boat down the river to Bakun and then over logging roads to Sungai Asap. The timber was then transported from Sungai Asap to the construction site. The owners said that loading and unloading the timber, as well as its transportation to the site, were handled primarily by two or three Indonesians living in Sungai Asap. B himself purchased the speakers, amplifier and other audio equipment in Kuching and transported them to the site.

Men from Sungai Asap did all the construction work. Farming is their primary job but they do carpentry work as needed on the side. They take about one week to build a single house, either sleeping at the site or travelling back and forth between the site and Sungai Asap. Five or six carpenters worked in a team, whose composition sometimes changed. Of the Indonesians living in Sungai Asap who transported timber to the construction site, two or three were always at the site and they were responsible solely for that work. The composition of that team was also subject to change as circumstances dictated.

20.5.5 The Success of Wooden Swiftlet Houses

This brief site survey of the construction of this swiftlet house found that although it differs from other swiftlet houses because of its building material, its other characteristics generally compare favourably with other such structures. Arguments can be made both for and against wooden swiftlet houses. One group, exemplified by B, claims that swiftlets will occupy good houses, regardless of whether they are constructed from wood or concrete, and that wooden construction is not problematic. In contrast, Dr Charles Leh of the World of Birdnest Museum, Singapore, who has detailed knowledge of swiftlet ecology and swiftlet houses, has doubted this approach and suggested that the temperature inside a wooden house would rise and prevent swiftlets from occupying the structure. It appears that additional studies will be necessary in the future in order to determine whether the swiftlet house in question will be successful or not.

20.6 Conclusion

The swiftlet house business can be understood as a new way of engaging with the natural environment and a change in the dynamics of multiethnic relationships and commodity chains in Sarawak. As noted earlier, the traditional ethnic relationships and commodity chain can be summarised as follows: indigenous peoples used the caves and collected nests, local Chinese middlemen bought and distributed them, and people in mainland China or Hong Kong imported, consumed and re-exported them. In reality, multiple actors are involved in the trade and the relationships are far more complex. The edible birds' nest trade network should thus be described as a 'commodity web' and not a 'commodity chain' (cf. Chew 2013: 3).

The uniqueness of the new swiftlet farming industry is that the farming of birds' nests is now artificially controlled and managed based on the understanding of the swiftlets' ecological characteristics. Although it is unclear whether the indigenous communities of the region have retained the knowledge involved in traditional nest collection, they may have new knowledge regarding swiftlet ecology and the suitable conditions under which swiftlets choose to breed and build their nests.[6] Before the introduction of this new method, Chinese traders relied on indigenous people to obtain the nests from the jungle (Chiang 2011: 426). The introduction of the swiftlet house enables Chinese traders to obtain edible birds' nests without either going to the caves themselves or requiring indigenous people to do so.

The importance of the landscape for nest collection has also changed. Peat swamps and mangrove forests are believed to be more favourable for constructing

[6] Some scholars have reported on sustainable nest collection as practised by indigenous peoples and Chinese traders in Borneo (Mohamed Yusoff 2002; Chew 2013). However, the overharvesting of nests in caves sometimes results in a decrease of the swiftlet population in some areas (Chiang 2011).

swiftlet houses, which are geographically different from the limestone caves in inland areas, which are the sites of traditional nest collection. Swiftlet house owners are interested in obtaining as much scientific knowledge of swiftlet ecology as possible and are using technological equipment to succeed in this farming industry. Although the traditional system for harvesting birds' nests still exists, the contemporary swiftlet house business is growing rapidly in Sarawak.[7]

The overall trend can thus be described as a departure from traditional techniques of harvesting in naturally occurring settings (caves) with a shift in focus to production and farming of birds' nests instead, using and building upon knowledge of the swiftlets' flight patterns, feeding patterns and ecological preferences in a man-made setting (swiftlet houses). This shift in the birds' nest trade has also been observed in other Southeast Asian countries with interest in building swiftlet houses emerging in the Philippines, Myanmar and Cambodia. This is a useful indicator that more and more local communities in the region are keen to gain a market share of the booming industry.

Of course, the contemporary structure for the edible birds' nest business in Sarawak has many key players, is a multifaceted network and its nature should not be oversimplified. However, the introduction of this new industry for nest collection has transformed ethnic relationships and current environmental knowledge in this high biomass society. Although the Chinese in Sarawak have dominated the edible birds' nest trade since the introduction of the swiftlet farming method, low-cost swiftlet houses have recently emerged in rural Sarawak, largely constructed by inland indigenous people. It remains to be seen whether the swiftlet houses in these rural areas will succeed or fail. This question is the key to understanding whether the native communities of Sarawak have the ability to maintain their foothold in the edible birds' nest business.

References

AgroMedia. 2009. *Buku pintar budidaya bisnis walet*. Jakarta: AgroMedia Pustaka.

Brosius, J. Peter. 1995. Bornean forest trade in historical and regional perspective: The case of Penan hunter-gatherers of Sarawak. In *Society and non-timber forest products in tropical Asia*, Occasional Papers Environment Series, No. 19, ed. Jefferson Fox, 13–26. Honolulu: East-West Center.

Chew, Daniel. 1990. *Chinese pioneers on the Sarawak frontier, 1841–1941*. Singapore: Oxford University Press.

———. 2013. The edible birds' nest commodity chain between Sarawak and East Asia. *Equatorial Biomass Society* 7: 1–6.

[7] However, the government of the People's Republic of China restricted the importation of Malaysian edible birds' nests in 2011 by declaring that the nests exceeded the acceptable levels of nitrite due to adulteration (see Chew et al., Chap. 18). Since then, it has become harder to export Malaysian edible birds' nests to China and Hong Kong, and the prices have dropped though the market has improved of late. As this incident still influences the edible birds' nest trade in Malaysia, the authors are planning further research on the ongoing transformation of the trade in the region.

Chiang, Bien. 2011. Market price, labor input, and relation of production in Sarawak edible birds' nest trade. In *Chinese circulations, capital, commodities and networks in Southeast Asia*, ed. Eric Tagliacozzo and Chang Wen-Chin, 407–431. Durham: Duke University Press.

Jordan, David. 2004. Globalization and birds' nest soup. *International Development Planning Review* 26 (1): 97–110.

Lim, Chan Koon, and Earl of Cranbrook. 2002. *Swiftlets of Borneo: Builders of edible nests*. 1st ed. Kota Kinabalu: Natural History Publications.

Marcone, Massimo F. 2005. Characterization of the edible birds' nest: The 'Caviar of the East'. *Food Research International* 38 (10): 1125–1134.

Mohamed Yusoff, Ismail. 2002. Sacred food from the ancestors: Edible bird nest harvesting among the Idahan. In *The globalization of Chinese food*, ed. David Y.H. Wu and Sidney C.H. Cheung, 43–55. Honolulu: University of Hawai'i Press.

Salekat, Ir.H. Nasir. 2010. *Membangun rumah walet hemat biaya modal 2–40 juta rupiah*. Jakarta: AgroMedia Pustaka.

Wadley, Reed L. 2005. *Histories of the Borneo environment: Economic, political and social dimensions of change and continuity*. Leiden: KITLV Press.

Zhuan, Ye Yan Wo Shang, ed. (2011) *燕窩大全* [Complete work of edible birds' nests]. Hong Kong: Hong Kong Union of Chinese Medicine Shops.

Chapter 21
Current Status and Distribution of Communally Reserved Forests in a Human-Modified Landscape in Bintulu, Sarawak

Yayoi Takeuchi, Ryoji Soda, Hiromitsu Samejima, and Bibian Diway

Abstract In the traditional agricultural land-use pattern of the indigenous peoples of inland Sarawak, there are small areas of primary forests, referred to as a *pulau* or communally reserved forests (CRFs), which are customarily reserved by local communities. Here, we investigate the current condition and geographic distribution of CRFs in the human-modified landscape of the Kemena and Tatau areas of Bintulu, Sarawak. We conducted a field survey of CRFs in the region by visiting villages and interviewing local people regarding the existence and number of CRFs within each village. We also assessed the social background, main use, disturbance condition and current management system of the CRFs, all of which may be affected by development. Then we investigated whether the current development pressure statistically affects the existence of CRFs. We visited 27 villages in the Kemena and Tatau areas and found that 11 out of 27 villages had no CRFs and approximately 40% of villages have only one CRF. Statistical analysis revealed that accessibility of the village affects the numbers of CRFs; that is, less accessible villages tended to contain more CRFs. As expected, the concepts or perceptions regarding CRFs have changed from conventional ideas. This is probably due to socioeconomic reasons as

Y. Takeuchi (✉)
Center for Environmental Biology and Ecosystem Studies, National Institute for Environmental Studies, Tsukuba, Japan
e-mail: takeuchi.yayoi@nies.go.jp

R. Soda
Graduate School of Literature and Human Sciences, Osaka City University, Osaka, Japan
e-mail: soda@lit.osaka-cu.ac.jp

H. Samejima
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

B. Diway
Botanical Research Centre, Sarawak Forestry Corporation, Kuching, Sarawak, Malaysia
e-mail: bibian@sarawakforestry.com

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_21

developmental pressure has been increasing in this region. The connectivity to the urban area of Bintulu promotes social and economic development that affects the traditional land-use patterns in rural areas, as well as people's lifestyles, livelihoods and perceptions. This may reduce the number of CRFs and their level of preservation.

Keywords Sarawak · Communally reserved forest · Traditional land use · Indigenous people · Development

21.1 Introduction

The indigenous communities of Sarawak have traditionally performed shifting cultivation agriculture within large tracts of village territory, which results in a land-use pattern that resembles a complex mosaic (Wadley et al. 1997; de Jong 2002; Takeuchi et al. 2017). Within this land-use pattern there are active agricultural fields, fallows (secondary forests in various stages of recovery) and areas of primary forests. Each remnant expanse of primary forest is referred to as a *pulau* in the Iban language, literally meaning 'island', as *pulau* are usually patchily distributed within an area of shifting cultivation. In the *Encyclopaedia of Iban studies* (Sutlive and Sutlive 2001: 1507), a *pulau* is defined as follows:

> *Pulau*: *pulau ban*, *pulau danan*, *pulau papan*, and *pulau rutan*—islands of wood and canes—or sacred groves, are regarded as essential reserves for each longhouse community. It is from these reserves that members obtain wood for the construction of houses and boats, and prior to the availability of iron nails and other hardware such as hinges, canes were used to bind structures together.

Local communities preserve *pulau* for multiple purposes; for example, inhabitants collect essential building materials such as wood and rattan canes. As *pulau* contain timber trees, they are also regarded as backup reserves for house construction because fires occasionally damage traditional longhouses. Another type of *pulau* is the taboo forest, referred to in the Iban language as *pulau mali*. This is a sacred grove where spiritual beings (including ghosts and dragons) are believed to live; thus, access to these forests is limited. Regardless of the type of *pulau*, they are frequently regarded as sacred places and are supposed to be permanently protected through management by local village communities. In addition, *pulau* harbour many types of useful plants for local inhabitants, including medicinal plants, plants for religious and ceremonial purposes and holy trees such as figs in which local people believe spirits reside (Kaga et al. 2008). This type of forest, where local communities have traditionally managed their own land, are commonly found throughout Asia and are often regarded as sacred groves (Upadhaya et al. 2003) or culturally protected forests (Gao et al. 2013; Ray et al. 2014). Here, we call *pulau* communally reserved forests (CRFs) because *pulau* in the region are forests that are preserved at a community level for the cultural and environmental purposes described above (see also Takeuchi et al. 2017). However, these forests are not always strictly protected by local communities.

From an ecological viewpoint, CRFs play an important role as reservoirs and sources of regional biodiversity, especially in highly deforested areas or fragmented forest landscapes. Previous studies have demonstrated that the genetic diversity of a tree species population in a CRF is equivalent to that of larger primary forests (Takeuchi et al. 2013), with similar results for tree species diversity and species composition (Nakagawa et al. 2013). Timber tree species are abundant in CRFs, especially dipterocarp species such as *Shorea* spp., *Dipterocarpus* spp. and *Dryobalanops* spp. (Kaga et al. 2008; Nakagawa et al. 2013). It has also been reported that CRFs harbour relatively high animal and insect species diversity, including mammals (Nakagawa et al. 2006), scarabs (Kishimoto-Yamada et al. 2011) and army ants (Matsumoto et al. 2009). In addition, surrounding degraded forests (such as fallow fields) can be rehabilitated faster by seed input from species in nearby CRFs compared to areas fully covered by degraded forests. This can improve the overall regional species diversity in a mosaic landscape covered with various stages of degraded forest. Thus, CRFs are crucial in this land-use pattern for both biodiversity conservation and environmental rehabilitation in this region.

However, local communities have recently begun to change the land-use system in their village territories, often due to development pressure. In particular, oil palm plantations in Sarawak have increased in the past two decades since the state government aimed to transform a million hectares of land into oil palm plantations by 2010 (Cooke 2006). By 2015 over 1 million ha of land in Sarawak had been converted into oil palm plantations with the state government looking to increase this area even more (Goh 2015). The current expansion of logging roads also affects the land-use patterns in areas accessible by these roads as access to rural areas is a principal determinant of development and the deforestation rate (Laurance et al. 2014). Development pressures are also causing a change in the livelihoods in local communities with some villages already abolishing shifting cultivation completely in favour of small-scale oil palm farming (Kato and Soda, Chap. 16; Soda and Kato, Chap. 17). Nowadays, these cases are often observed not only in areas neighbouring urban Bintulu but also in relatively rural villages. As such, land-use patterns and systems have been changing drastically and the current state of CRFs is not unaffected by this socioeconomic pressure given that some villages have been under development pressure for at least the last five decades. In line with this pressure, the concepts, perceptions and use of CRFs have similarly undergone significant change. Because local villagers' management systems and thoughts will affect land-use patterns to an even greater extent in the future, understanding the region's context is fundamental if an ecologically and socially sustainable society is to be shaped.

This chapter aims to investigate the current condition and geographic distribution of CRFs in the human-modified landscape in the Kemena and Tatau areas of Bintulu in central Sarawak. We conducted a field survey on CRFs in the region by visiting villages and interviewing local communities regarding the existence and number of CRFs contained within each village. We expected that the current status of CRFs in terms of both their presence or absence and their number would be affected by development pressure. This development pressure was represented here by the accessibility of villages, including road availability, and investigated using a statistical method. Specifically, we addressed the following questions:

1. How many local communities are still home to CRFs?
2. How many CRFs are in each village?
3. Does the accessibility to villages affect the existence of CRFs?
4. What is the main use of and social background surrounding each CRF?
5. What is the disturbance condition of CRFs?
6. What is the management system of CRFs?
7. What reasons motivate local communities to maintain CRFs?

21.2 Materials and Methods

21.2.1 Study Site

This study was conducted in the district of Bintulu in central Sarawak (Fig. 21.1). The indigenous people—the Iban, the Kayan and the Penan—live in longhouses along the Kemena and Tatau rivers, which are two of the largest rivers in this region. In this area, some villagers have already relocated from their previous location

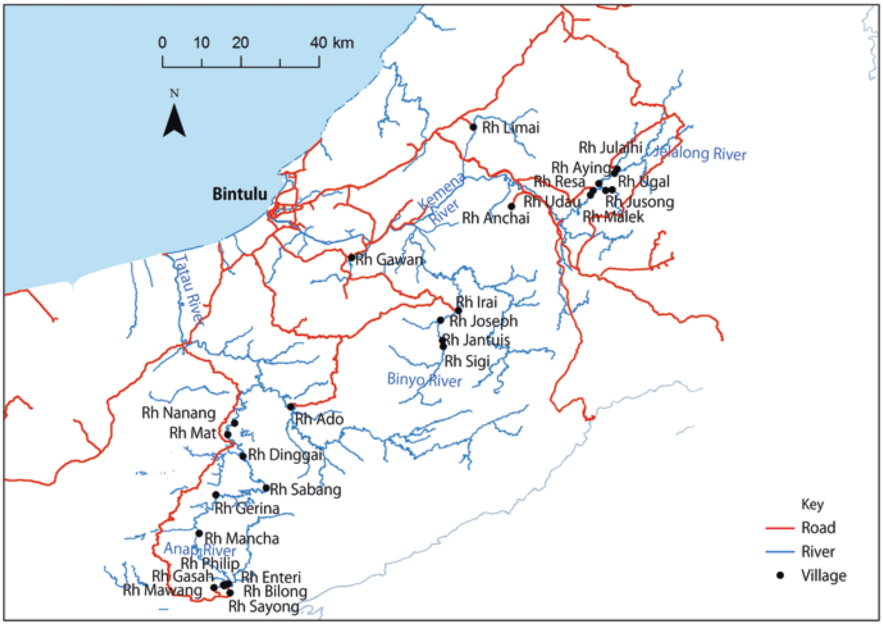


Fig. 21.1 Location of villages in this study

along river banks to new settlements along logging roads in order to plant oil palm and stake their claims to the land (see Soda et al., Chap. 15).

We conducted field surveys in 14 villages along the Kemena River and 13 villages along the Tatau River in May 2013 and February 2014, respectively. The traditional indigenous residence is a longhouse where multiple families live together, called *rumah* (house) in the Iban language. One or several longhouses form a village. We asked local inhabitants if their village owns CRFs and how many they have in total. We also asked about the establishment of CRFs, each village's main purpose of accessing them and how each CRF is managed. Where possible, we also investigated and explored CRFs on foot with the guidance of local villagers in order to determine the disturbance condition and tree species composition of each CRF.

We also investigated whether the accessibility of villages affects the existence or number of CRFs within each local community. From Bintulu town itself, some rural villages cannot be reached solely by road, but require one to transfer to a boat. As difficulties in transportation affect development initiatives we employed two measures related to accessibility. The first was the total travel time from Bintulu town (the nearest major city) to each village in minutes; for example, when we visited a village that required using both a car and a boat to access it, we calculated the time spent as distances divided an average speed (we assumed 60 km/h for a car and 20 km/h for a boat). The second measure was accessibility purely by road, meaning a combination of both cars and boats was not needed. If villages could be accessed purely by roads, including logging roads, they were denoted as 1, and if not as 0. To estimate the correlation between existence of CRFs and development, we used generalised linear mixed models, implemented within a Bayesian Markov chain Monte Carlo (MCMC) framework using by the statistical software R statistical software R (version 3.0.3; R Development Core Team 2014) with the MCMCglmm (MCMC generalised linear mixed model) function. We analysed the status of CRFs not only in terms of abundance (number) but also the presence or absence of CRFs which may provide a more conservative result. This is because abundance data is sometimes highly affected by social circumstances. The full model is expressed thus:

Full model: Number of CRFs or presence/absence of CRFs ~ log (total travel time from Bintulu) + accessibility by road alone

For the number of CRFs, we fitted a Poisson error structure, while for presence or absence of CRFs the category of river (Binyo River, Jelalong River, three branch rivers of the Kemena River, Anap River, Tatau River and one branch river of the Tatau River) was treated as a random effect. For the random effects, we used an inverse Wishart prior specification for variance components with two parameters, $V = 1$ and $nu = 0.002$. We ran the analysis for 3,100,000 iterations with a burn-in of 100,000 and a thinning interval of 1000 to minimise autocorrelations in the chain. Starting from the full model, we performed a stepwise model selection using the deviance information criterion (DIC) and chose the best model with the lowest DIC value. All statistical analyses were implemented using the statistical software R (version 3.0.3; R Development Core Team 2014)

21.3 Results

21.3.1 Current Status of CRFs in the Bintulu Region

We visited 27 villages in the Bintulu region and found that a total of 33 CRFs exist though some of them could be considered degraded. Approximately 20% of villages responded that they do not have a single CRF, including two in the Kemena basin and three in the Tatau basin, although no significant difference was found among the regions (Fisher's exact test, $p > 0.05$). However, although Rumah Gawan, Rumah Dinggai, Rumah Sabang, Rumah Bilong and Rumah Enteri responded that they had CRFs in their village, we treated them as having no CRFs because the forests were too degraded to be defined as such. Eleven villages were thus counted as not having CRFs among the 27 villages in this analysis.

One typical village that used to contain CRFs is Rumah Nanang; however, the forests had been logged by a timber company. The villagers now rely on a secondary forest (known locally as *temuda*) as a water catchment area instead of a CRF, as they do not refer to it as such. Approximately 40% of the villages studied have only one CRF (Fig. 21.2). In most cases, villages used to have more CRFs, but they have already been developed by logging companies or oil palm plantations. The largest number of CRFs contained by a single village was four, which was found in two villages, Rumah Aying and Rumah Malek.

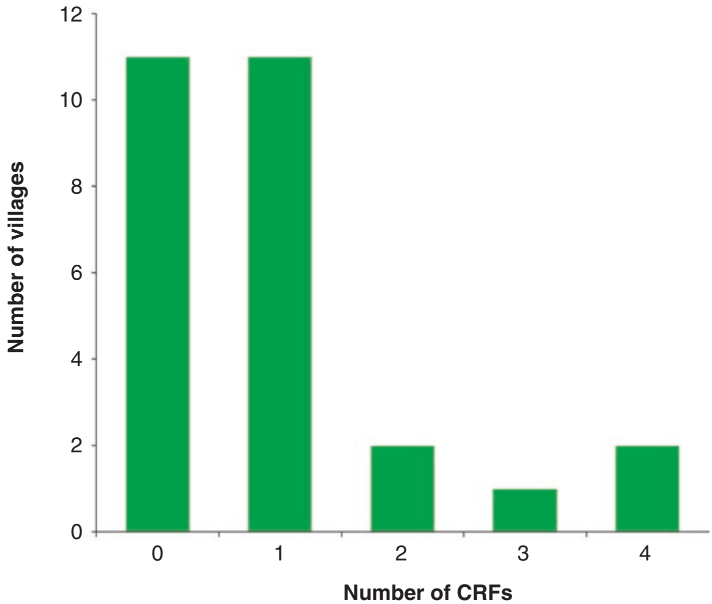


Fig. 21.2 Number of CRFs for the villages in this study

21.3.2 Effect of Accessibility on the Number of CRFs and Presence or Absence of CRFs

The best model for the number of CRFs was model A1 that included accessibility purely by road alone (Table 21.1a). The villages that are accessible by road alone had a significantly smaller number of CRFs. The best model for the presence or absence of CRFs was model B1 that included both effects of travel time from Bintulu town and accessibility by road alone (Table 21.1b). That is, the presence of CRFs would be affected by accessibility, although these effects were not significant (that is, a confidence interval (CI) of 95% overlapping zero).

21.3.3 The Characteristics of CRFs

One of the villages with four CRFs is Rumah Aying, which is home to 31 families and located along the Jelalong River, a branch of the Kemena River. Among the four CRFs, the closest one is Pulau Kerapa, which is surrounded by *temuda* and is only a 20-minute walk from the village. The forest comprises peat swamp and kerangas forest, which is reflected in the name Kerapa, meaning ‘upland swamp’ in the Iban language. The forest was already disturbed in the 1950s but villagers negotiated with the company involved to stop any further disturbance at the site. Since then the fragmented area that was left unlogged has become a forest reserve for the village community. In 2000, when the longhouse was destroyed by fire, the villagers cut timber trees from the forest for longhouse reconstruction; in particular, they selectively logged *selangan batu* (*Shorea selangan batu* group) and meranti (*Shorea* spp.). They also have a water catchment area, Pulau Sengloi, which is a 2-hour walk from the village and surrounded by *temuda* and logged forests. The area was initially not recognised as a CRF but when the state health department installed a water pipe from the Sengloi River to the village, the area surrounding it was then designated as a CRF that was not to be exploited due to its importance as a water catchment forest. A small dam was also installed in the middle of the forest near the upper Sengloi River, which is a branch of the Jelalong River. The other two CRFs are Bukit Pantu, which literally means ‘hill of sago palm’, and Bukit Naga, which means ‘hill of dragon’; specifically, local inhabitants believe that a large rock formation located there was once a dragon’s nest which is where the name is derived from. These CRFs remain relatively bountiful forests because they are less accessible from the village due to the topographical constraint of the steep escarpment as well as being relatively far from the village, taking more than 4 h to reach by both boat and on foot. The size of the CRFs in the Jelalong region ranges between 10 ha and 125 ha (Takeuchi et al. 2017).

Rumah Mancha, located along the Anap River and home to 12 families, contains only one CRF on top of the hill in their territory on the opposite side of the river from their longhouse. Access to this forest is not easy and villagers told us that it

Table 21.1 Bayesian mixed effects models where the model with smallest DIC was chosen as the best model for (**a**) number of CRFs and (**b**) presence or absence of CRFs

Model	Fixed effects in the model	DIC	Coefficients											
			Intercept				Accessibility to the village by road alone				Total time to the village			
			Mean	Lower 95% CI	Upper 95% CI	P value	Mean	Lower 95% CI	Upper 95% CI	P value	Mean	Lower 95% CI	Upper 95% CI	P value
(**a**) Number of CRFs														
Model A1	Accessibility by road alone	70.020	0.289	−0.564	1.232	0.457	−1.014	−2.063	−0.083	0.033				
Model A2	Total time to access	73.978	0.084	−9.631	8.857	0.888					−0.071	−1.918	1.941	0.84
Model A3	Accessibility by road alone, total time to access	70.983	1.747	−9.047	11.888	0.625	−1.082	−2.165	−0.060	0.031	−0.303	−2.455	1.952	0.667
Null model		73.024	−0.218	−0.960	0.506	0.545								
(**b**) Presence or absence of CRFs														
Model B1	Accessibility by road alone	0.864	179.847	−47.754	460.290	0.073	−203.379	−508.416	33.359	0.080				
Model B2	Total time to access	0.748	241.636	−1706.438	2323.149	0.743					−40.090	−492.024	351.624	0.784
Model B3	Accessibility by road alone, total time to access	0.638	410.120	−1981.531	2675.744	0.653	−236.061	−589.655	33.865	0.099	−42.701	−510.941	470.297	0.793
Null model		2.675	40.096	−71.628	188.409	0.399								

Note: The category of river was treated as a random effect would take a whole day to reach the area. Although the CRF is surrounded by *temuda*, the forest still holds large trees including timber trees such as *keladan* (*Dryobalanops oblongifolia*, *Dryobalanops lanceolata*), *kapur* (Dryobalanops spp., primarily *Dryobalanops aromatica*), *keruing* (*Dipterocarpus* spp.), species from both the *Shorea* red meranti group and *Shorea* white meranti group, *selangan batu* (*Shorea selangan batu* group), *belian* (*Eusideroxylon zwageri*) and *menggaris* (*Koompassia excelsa*, *Koompassia malaccensis*), which are typical tree species in lowland primary forests in this region. The villagers observed that a hornbill had a nest in a large tree in the CRF. The residents of Rumah Mancha use the CRF to collect wild vegetables, palms, rattans and occasionally timber (for use in house construction). However, the CRF is too distant to use as a water catchment forest; they must rely on rain and river water to supply their daily needs instead.

Rumah Gawan, which is located along the Kemena River and home to 17 families, is the village closest to Bintulu among all of those surveyed. The village contains two CRFs. One serves as a water catchment forest to supply water and is a 30-minute walk from the village. This CRF used to be farming land about 60 years ago and is not an untouched forest, but rather a fallow forest. The forest contains meranti, *selangan batu* and *geronggang* (*Cratoxylum* spp.) trees, but no *kapur* trees and the forest canopy is not closed yet. The villagers reported that there are no wild boars in the forest, although there are some monkeys. The villagers sometimes visit the forest to hunt birds for personal consumption.

Rumah Dinggai (Penghulu Intu), which is located along the Tatau River and home to 16 families, contains one CRF that is an hour's walk from the village. As this CRF has been previously logged, it appears to be more like a secondary forest. Residents of Rumah Dinggai use the CRF as a water catchment to supply stream water to the village. The forest is currently prohibited from being developed or disturbed.

Rumah Bilong used to be located along the upper Anap River. The village contained a CRF for water catchment at that time, which was not very disturbed. However, the CRF was logged by a company in 2012. Rumah Bilong then split into two with more than half the villagers moving to a new longhouse located further inland from the river, beside a logging road built by a timber company. This new settlement of residents from Rumah Bilong also obtains its daily water from the new CRF, although the forest has already been logged at least three times in the past. On the other hand, several families in the old Rumah Bilong (now called Rumah Philip) did not move to the new location, choosing to stay in the old longhouse. However, the village does not use the CRF for water catchment any more.

Rumah Ugal, which is located along the Jelalong River, has one CRF that serves as a water catchment area. The CRF holds a small dam within the forest with a pipeline running from the dam to the village. However, the CRF is surrounded by forest with ongoing logging, which was implemented and is controlled by a private company. The company had approached the villagers of Rumah Ugal for permission to cut trees within the water catchment area. The village head then allowed them to cut only about half the forest, but did not allow them to disturb its core, where the dam is situated; in return, the company replaced the old pipeline with a new one.

21.3.4 Joint Management System of CRFs

Interestingly, we found that some CRFs were jointly managed and shared by multiple neighbouring villages. For example, by the Jelalong River one CRF is managed by the neighbouring villages of Rumah Jusong and Rumah Malek. Both villages use the CRF as a water catchment area, although they use two different streams within the CRF. In addition, Rumah Aying and Rumah Ugal share the Bukit Naga CRF, which is located on the border that separates the villages' territories, although the area is hilly and not very accessible to either village. Around 2013 it was agreed that the northern part of Bukit Naga is to be logged; once Rumah Ugal gave their consent for the logging, Rumah Aying followed suit soon after.

21.3.5 Individually Owned *Pulau Umai*

Some people in several villages own private reserved forests on their farming land, referred to as *pulau umai*, which enable individuals to decide how much of it they cultivate for farming. In this case, one can choose an area of land for farming not to be reclaimed and just leave it as it is; this remainder of forest is then regarded as a *pulau umai.* With shifting cultivation, villages cultivate neighbouring forests every year by transforming them into land for rice farming; the right to this cultivated land is given to the villager who reclaims it. As the neighbouring forest beside the villager's farming land is expected to be cultivated by him as well, priority access to the forest is given to him. Even if the man decides not to cultivate the forest and leave it as it is for the following year, the forest can become a private *pulau umai.* The areas of *pulau umai* were relatively small compared to CRFs, usually ranging from 0.2 to 2 ha, but in some cases in the upper Anap River these *pulau umai* were larger than 10 ha. The owners of *pulau umai* access the forest in order to collect rattan for crafts or cut trees to sell as timber. Sometimes fruit trees and rattan are also planted and cultivated in *pulau umai.* On the other hand, when *pulau umai* are needed for farmland they are reclaimed. One middle-aged man in Rumah Ugal told us that he had a small *pulau umai* within his plot of agricultural land. As his forest had valuable timber species (*belian* and meranti), he considered the forest as a backup for timber and intended to leave the land for his offspring to inherit.

21.4 Discussion

In Sarawak, local indigenous communities practise the traditional land-use system of shifting cultivation with CRFs located within each village's territory. This research aimed to investigate the current condition and geographic distribution of CRFs in the Bintulu region.

As expected, the number or even the existence of CRFs per village seem to have decreased. This is largely due to strong development pressure from both logging and plantations (oil palm and acacia), as reported by local villagers. As is often the case with this region, many local rural communities had issues with logging companies infringing on their land, as timber companies cut and extract timber trees from CRFs, sometimes without any compensation (Barr and Sayer 2012). This affected the number or existence of CRFs in each village in the area. Statistical analysis revealed that accessibility of the village affects the numbers of CRFs; that is, less accessible villages tended to contain more CRFs. Thus connectivity to Bintulu promotes socioeconomic development that affects traditional land-use patterns in rural regions, as well as people's lifestyles and livelihoods. As a result, the number of CRFs may be reduced. Road expansions can also trigger environmental issues such as habitat degradation and the overexploitation of wildlife and natural resources. In fact, most CRFs were not untouched forests but rather had already been logged in the past. On the other hand, no clear relationship between the presence or absence of CRFs and accessibility was found. This may be due to the fact that the data regarding the presence or absence of CRFs were less sensitive as they do not take into account the degradation of the CRFs or a reduction in the number of CRFs if a village had more than one CRF. There could be other reasons that affect the presence or absence of CRFs that are specific to each individual community, such as depopulation and the relationship between each village with logging companies.

From the interviews with local inhabitants, we found several reasons why CRFs remain to this day. One usual reason is because of limited access and difficulties in cultivating these areas (Bukit Pantu). Another reason is because they may be regarded as sacred places (Bukit Naga). For example, a large rock formation on a hill may have caused local inhabitants to believe that a spiritual being lived in the forest, leading the area to be known as a sacred place. This is a typical 'taboo' forest, although local people in this region still access the forest occasionally. Some CRFs may thus remain relatively untouched due to an element of chance. The main uses of CRFs include supplying daily water needs, jungle products, traditional building materials and backup timber reserves.

As we expected, the concepts or perceptions of CRFs have changed from conventional ideas. This is probably due to socioeconomic reasons, as development pressure has been increasing in this area since the 1950s. In a traditional sense, CRFs or primary forests were not supposed to be disturbed. However, most of the CRFs that we visited in this region have already been exploited by logging companies and/or shifting cultivation at least once. The level of disturbance varied among the villages and CRFs. Some CRFs were still not badly affected because, according to the villagers, they prohibited disturbances to the forest after a one-time logging operation approximately 30 years ago. Those forests seemed to still maintain a relatively high level of tree species diversity, including important timber tree species such as meranti and *selangan batu*. On the other hand, even though some CRFs were disturbed severely and hold only smaller trees, some villages still regard them as CRFs. The major reason for this is to ensure a stable water supply from the forest; most villagers acknowledged the importance of CRFs as a vital water resource. For a constant water supply, local people also preserve secondary forests as though they are CRFs. In other words, an absence of CRFs would indicate an unstable and inconsistent water supply to the villages, and most villages contain at least one CRF to maintain this water supply. However, about one in five villages apparently did not even have a water catchment forest, and people used river water or rainwater stored in water tanks to supply their daily water needs instead. The quality of this river water is not very good in several locations and water levels are not always stable. For example, the village headman in Rumah Ugal considered the water supply from the CRF as being essential to the community and their daily life. In fact, many local people are increasingly recognising the importance of water from the forest because the rivers are becoming muddier and polluted by chemical herbicides and fertilisers from oil palm plantations (see Tokuchi et al., Chap. 11; Fukushima et al., Chap. 12).

As noted above, we found that 11 of the 27 villages had no CRFs. This indicates that inhabitants of these villages do not receive the forest products or ecological services that CRFs provide. There could be several reasons for this. First, urbanisation and the market-based economy have changed local people's livelihoods and lifestyles. In the areas near Bintulu, local people have tended to abandon shifting cultivation in order to become oil palm smallholders, as socioeconomic changes have enabled people to access the city easily and obtain substitutes to replace traditional jungle products. Though this may cause CRFs to become undervalued, these people no longer have to depend on forest-based products to the same extent. Second, local communities cannot avoid the pressure of development. In some villages, inhabitants suffer problems related to native customary rights land, which enables companies to develop their land, including CRFs. Disputes over land ownership between the government and local communities often occur, with local communities trying to maintain their rights and ownership to seemingly 'unused' or 'idle' native customary rights land. To avoid being taken over and developed by the government or private companies, a CRF in a village was partly opened by the villagers in order to stake their claims. As a result, untouched CRFs have been declining especially in this region where socioeconomic pressure is high. This is somewhat similar to the behaviour noted by Ryoji Soda et al. (Chap.15) with local villagers trying to establish their land ownership.

A CRF is usually managed by a local community but in this study we found shared management systems involving multiple communities. However, this was only observed in cases where a CRF was located on the border separating two villages' territories. This indicates that the operating policy of a village with respect to their portion of the CRF affects that of the village. For example, in the cases of Rumah Ugal and Rumah Aying, one village decided to convert the CRF to another land-use pattern and the other village involved in the co-management of the CRF soon followed suit.

We also found that some villagers own their own individual *pulau umai*, which are located within land that they have reclaimed, though information on these types of CRFs is limited (see Lembat 1994). As the number and condition of CRFs have been decreasing, *pulau umai* are an alternative option for obtaining necessary products from the forest. This is in line with the fact that villagers mentioned that the relative importance of individually reserved forests has been increasing for local inhabitants.

21.5 Conservation Remarks and Future Perspectives

The tropical forests of Borneo contain some of the highest biodiversity in the world, although these lowland forests have been decreasing rapidly in the last two decades (Wilcove et al. 2013). In the fragmented tropical forest landscape, CRFs may be the only option for contributing to regional biodiversity conservation (Takeuchi et al. 2017). However, CRFs may not be permanently protected and are easily developed under the pressure of economic incentives provided by external actors.

One villager who was around 70 years old remarked: ‘Access to the primary forest was not difficult 50 years ago as the forest encircled the entire village. However, the primary forest has become further and further away in the years since. Now we recognise the value of CRFs as the source of natural forest-associated materials.’ This demonstrates that the perception and significance of CRFs among local people have changed over time amid different social contexts. Although the patchy and fragmented remaining CRFs have lost their cultural significance, they have become more important in both an ecological and economic sense (for example, for rattan as mentioned by Takeuchi et al., Chap. 22), and provide many ecosystem services. CRFs are the last places to provide forest-based products including food, timber and canes, which are also related with local people’s traditional culture (Takeuchi et al., Chap. 22). The absence of CRFs will not only lead to a loss in biodiversity but also cultural diversity and indigenous heritage.

To realise a sustainable society in this tropical region, future studies should examine whether it is possible to maintain both regional biodiversity and ecosystem services within the region’s traditional land-use system. In addition, it is also necessary to investigate the social and economic determinants pertaining to CRF maintenance in order to realise a mutually beneficial relationship between biodiversity conservation and rural development.

References

Barr, Christopher M., and Jeffrey A. Sayer. 2012. The political economy of reforestation and forest restoration in Asia–Pacific: Critical issues for REDD+. *Biological Conservation* 154: 9–19.

Cooke, Fadzilah Majid. 2006. Expanding state spaces using ‘idle’ native customary land in Sarawak. In *State, communities and forests in contemporary Borneo*, Asia-Pacific environment monograph 1, ed. Fadzilah Majid Cooke, 25–44. Canberra: ANU Press.

de Jong, Will. 2002. *Forest products and local forest management in West Kalimantan, Indonesia: Implications for conservation and development*, Tropenbos-Kalimantan series 6. Wageningen: Tropenbos International.

Gao, Hong, Zhiyun Ouyang, Shengbin Chen, and C.S.A. van Koppen. 2013. Role of culturally protected forests in biodiversity conservation in southeast China. *Biodiversity and Conservation* 22 (2): 531–544.

Goh, Pei Pei. 2015. Palm oil, a catalyst for Sarawak's economic growth. *New Straits Times*, 16 March.

Kaga, Michi, Kuniyasu Momose, Masahiro Ichikawa, and M. Koizumi. 2008. Importance of mosaic of vegetations to the Iban of Sarawak, Malaysia. In *Sustainability and biodiversity assessment on forest utilisation options*, ed. Masahiro Ichikawa and Tohru Nakashizuka, 396–404. Kyoto: Research Institute for Humanity and Nature (RIHN).

Kishimoto-Yamada, Keiko, Takao Itioka, Michiko Nakagawa, Kuniyasu Momose, and Tohru Nakashizuka. 2011. Phytophagous scarabaeid diversity in swidden cultivation landscapes in Sarawak, Malaysia. *The Raffles Bulletin of Zoology* 59 (2): 285–293.

Laurance, William F., Gopalasamy Reuben Clements, Sean Sloan, Christine S. O'Connell, Nathan D. Mueller, Miriam Goosem, Oscar Venter, David P. Edwards, Ben Phalan, Andrew Balmford, Rodney Van Der Re, and Irene Burgues Arrea. 2014. A global strategy for road building. *Nature* 513: 229–232.

Lembat, Gerunsin. 1994. Native customary land and *adat*. Paper presented at the Seminar on NCR Land Development, 29 September–3 October, Kuching, Sarawak.

Matsumoto, T., Takao Itioka, Seiki Yamane, and Kuniyasu Momose. 2009. Traditional land use associated with swidden agriculture changes encounter rates of the top predator, the army ant, in Southeast Asian tropical rain forests. *Biodiversity and Conservation* 18 (12): 3139–3151.

Nakagawa, Michiko, Hideo Miguchi, and Tohru Nakashizuka. 2006. The effects of various forest uses on small mammal communities in Sarawak, Malaysia. *Forest Ecology and Management* 231 (1–3): 55–62.

Nakagawa, Michiko, Kuniyasu Momose, Keiko Kishimoto-Yamada, Tamaki Kamoi, Hiroshi O. Tanaka, Michi Kaga, Satoshi Yamashita, Takao Itioka, Hidetoshi Nagamasu, Shoko Sakai, and Tohru Nakashizuka. 2013. Tree community structure, dynamics, and diversity partitioning in a Bornean tropical forested landscape. *Biodiversity and Conservation* 22 (1): 127–140.

R Development Core Team. 2014. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Ray, Rajasari, M.D. Subash Chandran, and T.V. Ramachandra. 2014. Socio-cultural protection of endemic trees in humanised landscape. *Biodiversity and Conservation* 23 (8): 1977–1994.

Sutlive, Vinson H., and Joanne Sutlive, eds. 2001. *The encyclopaedia of Iban studies: Iban history, society, and culture*. Kuching: Tun Jugah Foundation with Borneo Research Council.

Takeuchi, Yayoi, Michiko Nakagawa, Bibian Diway, and Tohru Nakashizuka. 2013. Reproductive success of a tropical tree, *Shorea laxa*, in a pulau (forest reserve) managed by a local community in Borneo. *Forest Ecology and Management* 289: 416–424.

Takeuchi, Yayoi, Ryoji Soda, Bibian Diway, Tinjan ak. Kuda, Michiko Nakagawa, Hidetoshi Nagamasu, and Tohru Nakashizuka. 2017. Biodiversity conservation values of fragmented communally reserved forests, managed by indigenous people, in a human-modified landscape in Borneo. *PLoS One* 12 (11): e0187273.

Upadhaya, Krishna, Harendra Nath Pandey, P.S. Law, and Radhey Shyam Tripathi. 2003. Tree diversity in sacred groves of the Jaintia hills in Meghalaya, northeast India. *Biodiversity and Conservation* 12 (3): 583–597.

Wadley, Reed L., Carol J. Pierce Colfer, and Ian G. Hood. 1997. Hunting primates and managing forests: The case of Iban forest farmers in Indonesian Borneo. *Human Ecology* 25 (2): 243–271.

Wilcove, David S., Xingli Giam, David P. Edwards, Brendan Fisher, and Lian Pin Koh. 2013. Navjot's nightmare revisited: Logging, agriculture, and biodiversity in Southeast Asia. *Trends in Ecology & Evolution* 28 (9): 531–540.

Chapter 22
Transitions in the Utilisation and Trade of Rattan in Sarawak: Past to Present, Local to Global

Yayoi Takeuchi, Atsushi Kobayashi, and Bibian Diway

Abstract Rattan is a non-timber forest product important to both forest biodiversity and local livelihoods in Southeast Asia. In this chapter, we aim to understand the changing patterns of socioeconomic activities in local communities and in the global market, as well as human–nature interactions in Sarawak from the perspective of the transition of rattan utilisation from the past to the present. For the analysis, we employed a multidisciplinary approach using a socioecological survey and historical study, and set three spatial scales as a framework. First, we found that people recognise and make use of various rattan species based on the diversity of surrounding forests. The high diversity of rattan species in these forests supports the preservation of knowledge and culture, and local communities are able to acquire multiple benefits from the forests through rattan. Second, we show the effects of development on traditional knowledge and rattan use by comparing a rural village to villages close to more developed urban areas in which people use a limited number of rattan species because primary forests are no longer accessible. Utilisation of rattans in peri-urban villages has also changed, departing from the close relationship with primary forests that is vital for selecting and using particular rattan species for various needs. Third, we pay attention to the emergence of the regional market for rattan materials provided by a rattan-processing factory in the urban area of Bintulu. In suburban villages, inhabitants who have limited access to primary forests now buy machine-processed rattans for making crafts, possibly leading to a decline of traditional knowledge and the culture of rattan in these communities.

Y. Takeuchi (✉)
Center for Environmental Biology and Ecosystem Studies, National Institute for Environmental Studies, Tsukuba, Japan
e-mail: takeuchi.yayoi@nies.go.jp

A. Kobayashi
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: akoba@cseas.kyoto-u.ac.jp

B. Diway
Botanical Research Centre, Sarawak Forestry Corporation, Kuching, Sarawak, Malaysia
e-mail: bibian@sarawakforestry.com

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_22

Finally, we discuss the trajectory of rattan exports from Sarawak on a global scale over the last 150 years. From the late nineteenth century onwards, rattan exports for the global market enabled local people to gain commercial profits, and we confirm that such a trade connection has lasted through the boom of rattan exports from Sarawak in the mid-1980s. As such, this local to global, past to present study of rattan shows that Sarawak's highly biodiverse society, which depends on various kinds of natural resources from primary forests, has altered in response to the impacts of the world economy and land-use change over the last two centuries.

Keywords Sarawak · Rattan · Trade · Traditional knowledge · Land-use change · Indigenous people

22.1 Introduction

Sarawak is recognised as an area with both a high biomass and high biodiversity given its location close to the equator where there is high annual rainfall coupled with abundant sunlight and a warm tropical climate. Throughout its history, the state has been and is still connected to global commodity chains by being a major exporter of both timber and non-timber forest products, with a shift from primary forests to planted forests and plantations in recent decades. Historically, being a high biomass and biodiverse society was not mutually exclusive in Sarawak, because indigenous people traditionally used many types of resources from the natural primary forests for food, materials for crafts and construction, and medicines, with a high diversity of species being used. For example, the Iban once used approximately 240 plant species collected from natural forests in their daily lives (Chai 2000). These forest-based resources were also essential for local people to gain an income through trading with middleman and merchants from towns and downriver areas.

However, since the late twentieth century, natural forests in Sarawak have been rapidly cleared and transformed into oil palm and acacia plantations due to the growing demand in the global market. Thus the rich biodiversity in primary rainforests that characterised both the human and ecological environment has been decreasing drastically with this expansion of monocultures, as the state transitions from being both highly biodiverse and having high biomass to only having a high biomass through these plantations. Given the changes in landscape and land use even in highly rural areas, the lifestyles of local communities are also likely to have altered in response to the changing ecological environment. These lifestyle changes can encompass valuable knowledge and skills regarding forest products that are passed on from generation to generation, as well as traditional livelihood strategies and established longhouse-style communal living. A comprehensive understanding of the effects of the expansion of plantations on transforming nature and human societies in contemporary Sarawak is thus crucial for predicting future outcomes in the region.

It is not straightforward to grasp the transitions in both human and ecological environments holistically by conventional methods of study that specialise in an individual field. To shed light on these socioecological changes, this study focused on a single non-timber material: rattan. Rattan was chosen for two reasons. First, it is a species-rich taxon that the indigenous people of Sarawak have incorporated into their traditional lifestyles in a variety of ways. And second, rattan has historically been a major export commodity, given the availability of rattan's high biomass and biodiversity. Hence, this research employed a multidisciplinary approach through collaboration between an ecologist who observed the current state of rattan species diversity, local knowledge and transitions in rattan utilisation, and a historian who considered the trajectory of regional market dynamism from the past to the present.

Nowadays, rattan is well known worldwide as a material for Asian-style furniture and crafts. These climbing palms are distributed only in the Old World tropics of Southeast Asia and Africa. In the wild, they usually grow in deep forests, climbing up the canopy by hooking onto nearby trees. The long stems sometimes reach more than 150 m (Wan Razali et al. 1992). The name 'rattan' comes from the Malay word *rotan*, suggesting a close connection with Southeast Asia, a region which is home to rattan hotspots from biological, economic and cultural standpoints.

There are approximately 600 species of rattan belonging to 13 genera of the *Calamoideae* subfamily of palms, of the palm family Palmae (also known as Arecaceae). The highest species diversity of rattan is found in Borneo, where an estimated 150 species exist, and the Malaysian state of Sarawak holds the highest species diversity, with 107 species (Dransfield 1992). The characteristics of rattan vary among species; some species do not have climbing stems but are just ground shrubs. Stem diameters range from less than 1 cm in the smallest species to about 10 cm in the largest. The quality of canes also varies in terms of smoothness of surface and colour. It is also reported that industrial rattan species are limited to about 10% of the total number (Dransfield et al. 2002).

In the local communities in Sarawak, rattan is closely related to the livelihoods of indigenous people. For example, people eat palm hearts and fruits from the rattan plants, collect cane for making crafts, and sell canes to local buyers. As rattans are commonly found in primary forests, they are one of the most accessible and beneficial non-timber forest products for local people. However, not all rattans are useful for eating and making materials. Based on their practical knowledge, indigenous people choose the appropriate rattan species according to its intended use.

Likely dating back to no later than the sixteenth century, the global trade in rattan has one of the longest histories of non-timber forest products utilised by local communities to gain commercial profits (Peluso 1992). Sarawak has exported significant amounts of rattan since the nineteenth century (see Kobayashi and Sugihara, Chap. 27), and the rattan industry there continues to play an important role in the commodity supply chain for regional and global markets today.

Local people have therefore had a long and multifaceted relationship with rattan, as the plant provides food ingredients, materials for daily use and also commercial gains. With high species diversity in primary forests, rattans provide a wide range of functional values; they also acquire a socioeconomic value through human utilisation for a specific purpose. This so-called ‘rattan utility’ has varied along with the environmental and economic conditions in the region.

In this chapter, we set three spatial scales to examine rattan utility in Sarawak, namely local, regional and global. At each spatial scale, rattan utility has a distinctive socioeconomic significance in the everyday lives of people. A change of rattan utility at one scale brings about changes at the other two scales. Specifically, the social and ecological analysis deals with the present state of rattan utility in the Bintulu area from the perspective of local and regional scales. This is followed by a historical analysis of rattan commerce in Sarawak at the regional and global levels. This chapter explores the transition of the importance of rattan to the forests, local communities and business in Sarawak. First, we investigate the traditional knowledge and utilisation of rattan by local people in the middle part of the Jelalong basin, where the indigenous Iban people still use rattan in their daily life. Second, we examine the effect of development on their traditional knowledge and use of rattan by comparing a community in the middle part of the Jelalong basin with two communities close to the urban areas of Bintulu. Third, we report on the export of processed rattan from a factory in the town of Bintulu to foreign countries and on the emergence of the regional market for rattan materials. We then discuss how this has affected the traditional use of rattan for villagers near Bintulu. Fourth, we examine the trajectory of rattan exports in Sarawak since the late nineteenth century, focusing on the relationship between local commercial activities and the global market. Finally, we discuss the development of human–nature interactions in Sarawak from the perspective of the changing importance of rattan for local indigenous communities.

22.2 Knowledge and Utilisation of Rattans by the Iban Communities in the Jelalong Basin

People in Borneo use various kinds of plants in the forest. Among the most useful, species-rich and popular of these plants are rattan palms. Many practical items used in daily life, such as mattresses, baskets, hats and backpacks, are made from rattan (Blehaut 1994; Table 22.1, Fig. 22.1). People also eat the palm hearts and fruits of rattans. It is reported that traditional uses of rattan included the fruits for medicine, resin and dye, and the leaves are used for thatching, cigarette papers and so on (Sunderland and Dransfield 2002). Rattans are one of the most multifunctional and highly versatile non-timber forest products in Southeast Asia (Meijaard et al. 2014). They usually grow in primary forests that have high species diversity (Dransfield and Manokaran 1994). While some species are also found in secondary forests beside villages, the number of species is limited compared to the diversity found in primary forests. Because the recent development of forests has resulted in decreasing untouched forest areas near villages (Takeuchi et al. Chap. 21), both the species diversity and the use of rattan by local inhabitants have consequently decreased.

Table 22.1 Traditional rattan crafts in Iban communities

Use	English	Iban name	Figure 22.1
Daily life	Mattress	*Tikai*	a
	Basket	*Bakor*	b
	Tray	*Timpa*	c
	Food cover	*Tangkuplauk*	d
	Hat	*Tangi*	e
	Burden basket	*Selabit*	f
	Seed basket	*Raga*	g
	Seed basket	*Uyut*	h
	Storage basket	*Baka*	i
	Carrying basket	*Bangkat*	j
	Dish, bowl and pot holder	*Ringka*	k
Agriculture	Rice-carrying basket	*Lanji*	l
	Winnowing basket	*Chapan*	m
	Reaping basket	*Sintung*	n
	Sowing basket	*Seluk*	o
Fishing	Tray for fish	*Nyuru*	p
	Fish basket	*Pemansai*	q
	Fish trap	*Bubu*	r

We studied the identification and use of rattans in the Iban community of Rumah Aying in the Jelalong region (Fig. 22.2).[1] People in this region collect rattans from the surrounding forests—the *kampong* or primary forest, the *pulau* or remnant primary forest or 'communally reserved forest' (Takeuchi et al. Chap. 21), the *temuda* or fallow forest and/or the *pengerang* or old-growth secondary forest. We first describe how the Iban identify and distinguish different rattan species, whether they use each species and the corresponding scientific name for each local name. We also identify how each species is used, either as a food product or in the making of rattan crafts.

To investigate the species diversity of rattans, we surveyed rattans within nine plots that had been established for a tree species survey (Takeuchi et al. 2017) in five *pulau* in three villages in the Jelalong region in February 2014. Each plot was 0.25 ha in size. We noted the local names of all rattans above 20 cm in height in the plots. When we encountered an unknown species, the specimen was taken to a herbarium in Kuching for scientific species identification. The informants for identifying local names were Iban and Penan villagers between 40 and 70 years old. Study sites also included a secondary forest that had been logged about 30 years before. Sample specimens were identified and stored in the Botanical Research Centre in Kuching. As for rattans used by people for making crafts, we conducted interviews from November 2013 to February 2014 with inhabitants of Rumah Aying. In this

[1] *Rumah* refers to the Iban longhouse, a traditional residence for multiple families with both private and communal living areas that forms a village.

Fig. 22.1 Different rattan craft products including (**a**) mattresses (*tikai*), (**b**) baskets (*bakor*), (**c**) trays (*timpa*), (**d**) food cover (*tangkuplauk*), (**e**) hat (*tangi*), (**f**) type of burden basket known as *selabit*, (**g**) type of seed basket known as *raga*, (**h**) type of seed basket known as *uyut*, (**i**) storage basket (*baka*), (**j**) carrying baskets (*bangkat*), (**k**) dish, bowl and pot holder (*ringka*), (**l**) rice-carrying basket (*lanji*), (**m**) winnowing basket (*chapan*), (**n**) reaping basket (*sintung*), (**o**) sowing basket (*seluk*), (**p**) tray for fish (*nyuru*), (**q**) fish basket (*pemansai*), and (**r**) fish trap (*bubu*). (Photographs: Yayoi Takeuchi 2014)

Fig. 22.1 (continued)

village more than 15 women frequently weave rattan baskets and sell them to visitors. In other villages in the Jelalong region there were not so many people who make and sell rattan crafts.

22.2.1 Rattans Identification by the Iban

In all the plots, consisting of a total area of 2.25 ha, five genera and 36 species of rattans were found (Table 22.2). One local name sometimes referred to multiple scientific species. For example, *wi duduk* and *wi semut* referred to three scientific species, while *wi buloh*, *wi tut*, *wi empunuk*, *wi ruak ai*, *wi tekuyong* and *wi danan* altogether referred to two species. Iban names for rattans were based on similarities in morphological characteristics. For example, *wi tunggal*, one of the most common rattan in this region, means 'independent rattan' because the stem of the species is single and not clustered (Fig. 22.3a). The *Korthalsia* species have swollen ochreas

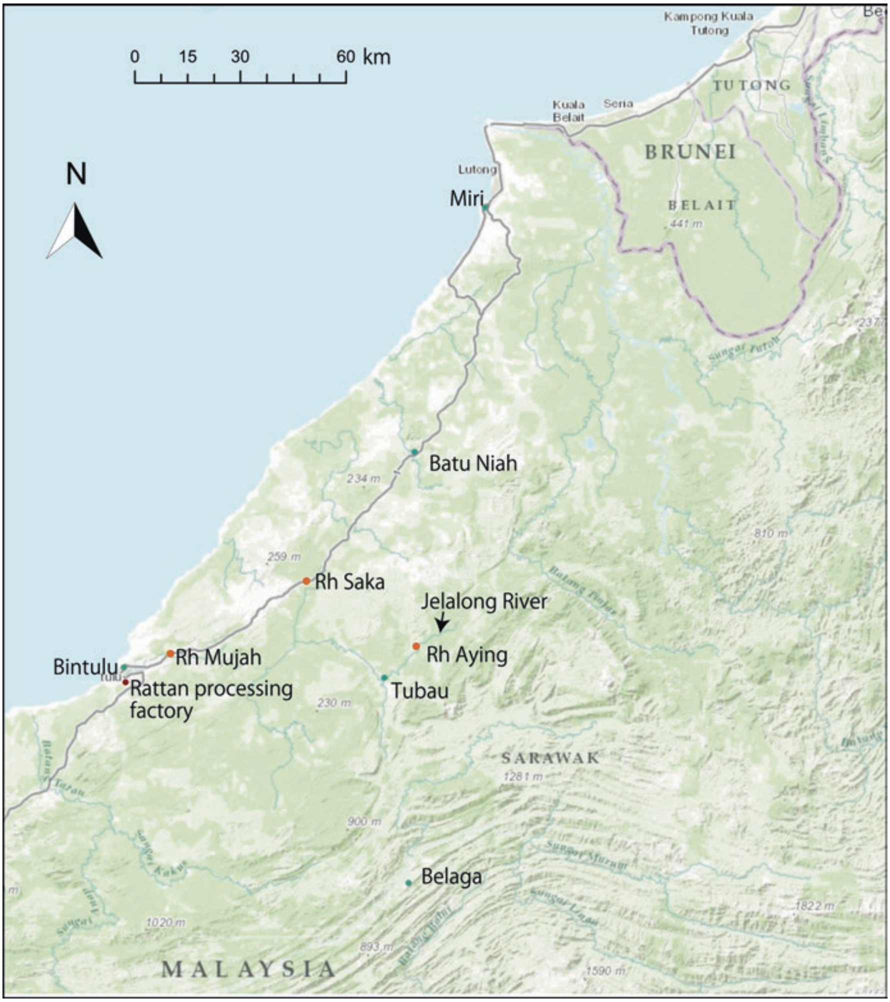


Fig. 22.2 Study area
Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, and the GIS User Community

that harbour ants; the Iban name *wi semut* or 'rattans with ants' corresponds to this characteristic (Fig. 22.3b). *Wi cit* ('rattans with rodents') also have ant-filled ochreas (Fig. 22.3c, d), but the ochreas are smaller than those of *wi semut* and the shape of the ochrea looks like a rodent. *Wi tisil* is also called *wi sial* or 'unlucky rattan' because it is not used by the local community for construction, crafts or consumption. Nearly 50% of local names for rattan species are based on morphological characteristics (Table 22.2).

Table 22.2 Rattans collected and the use of each rattan, February 2014

Iban name	Translated meaning	Scientific name	Uses		
			Edible palm heart	Edible fruit	Craft
Wi sega		*Calamus optimus*	✓	✓	✓
Wi batu	Rock	*Calamus gonospermus*	✓	✓	✓
Wi buloh	Bamboo	*Calamus erioacanthus*	✓	✓	✓
		Calamus sarawakensis			
Wi jelayang		*Calamus ornatus*	✓	✓	✓
Wi lia	Ginger	*Calamus laevigatus*	✓	✓	✓
Wi matahari	Sun	*Calamus marginatus*	✓	✓	✓
Wi mulong		*Calamus pilosellus*	✓	✓	✓
Wi semanbu		*Calamus scipionum*	✓	✓	✓
Wi seru		*Calamus convallium*	✓	✓	✓
Wi takong		*Calamus flabellatus*	✓	✓	✓
Wi tinkas (wi rengo)		*Calamus paspalanthus*	✓	✓	
Wi tunggal	Standing alone	*Calamus ashtonii*	✓	✓	✓
Wi tut		*Calamus javensis*	✓		✓
		Calamus pogonacanthus			
Wi tisil (*wi sial*)	(Unlucky)	*Ceratolobus concolor*			
Wi duduk	Sit	*Daemonorops ruptilis*	✓	✓	
		Daemonorops microstachys			
		Daemonorops oxycarpa			
Wi empunuk		*Daemonorops cristata*	✓	✓	
		Daemonorops periacantha			
Wi jerenang	Red	*Daemonorops didymophylla*	✓	✓	✓
Wi lepoh		*Daemonorops sabut*	✓	✓	✓
Wi ruak ai		*Daemonorops fissa*	✓	✓	
		Daemonorops sparsiflora			
Wi tekuyong	Snail	*Daemonorops hystrix*	✓	✓	
		Daemonorops longistipes			
Wi semut	Ant	*Korthalsia rigida*	✓	✓	✓
		Korthalsia furcata			
		Korthalsia hispida			
Wi cit	Rodent	*Korthalsia rostrata*	✓		✓
Wi danan		*Korthalsia flagellaris*		✓	✓
		Korthalsia jala			
Wi seruk		*Korthalsia echinometra*	✓	✓	✓
Wi matar	Sago worm	*Plectocomiopsis geminiflora*	Poisonous		
		Plectocomiopsis mira			

Fig. 22.3 Rattan species and the identifying characteristics of (**a**) *wi tunggal*, (**b**) *wi semut* and (**c**) *wi cit*, with (**d**) a close-up of the *wi cit* ochrea. (Photographs: Yayoi Takeuchi 2014)

22.2.2 Utilisation of Rattan

According to the local villagers, most rattans are edible except for a few species that contain poison (e.g. *wi matar*). People enjoy eating the palm heart of several rattan species, particularly those of *wi empunuk* and *wi tekuyong*, which have softer textures with a slightly bitter taste. The fruits of most rattans are also edible. People consume the fruits from rattans, such as *wi sega*, when they are ripe. The fruits of *wi jerenang* are used as a red dye (*jerenang* means the colour red in the Iban language).

More than 18 species of rattans can be used for making crafts (Tables 22.2 and 22.3). Various items made from rattan have traditionally been used for household, agricultural and fishing needs (Blehaut 1994). Local people distinguish different types of rattan and use the appropriate type depending on their characteristics and intended use. For example, for the spine of the bigger baskets, thicker and stronger canes can be used. The 'cane' rattan is limited to some species, such as *wi semanbu* and *wi matahari*, which are commonly used for the spine of *raga* (a type of seed basket, Fig. 22.1g) and *lanji* (Fig. 22.11). These rattan species also have larger diameters of canes compared to other species. The species used to make strings are also limited because the rattan skin has to be split into thin strings. The villagers also utilise the natural colour of rattans in their crafts. Most rattans have white or yellow

Table 22.3 Various rattan usages in basket making

Iban name	Use in basket making				Colour
	Body	String	Frame	Spine	
Wi sega	✓		✓		Yellow
Wi batu	✓	✓	✓		White
Wi buloh	✓	✓	✓		White
Wi jelayang			✓		White[a], green[b]
Wi lia	✓	✓			White
Wi matahari				✓	Yellow
Wi mulong	✓				Yellow
Wi semanbu				✓	White[a], green[b]
Wi seru	✓				White
Wi takong	✓				White
Wi tunggal	✓	✓	✓		White
Wi tut	✓	✓	✓		White
Wi jerenan		✓			White
Wi lepoh	✓	✓	✓		White[a], green[b]
Wi semut	✓	✓	✓		Brown
Wi cit	✓	✓	✓		Brown
Wi danan	✓			✓	Brown
Wi seruk	✓	✓	✓		Brown

Note: [a]younger cane, [b]older cane

skin, especially when they are young (Table 22.3). The skins of the *Korthalsia* species, however, are red or brown, and female weavers prefer these species for designing baskets (Fig. 22.1c, d).

22.2.3 Rattan Handicrafts in Rumah Aying

We conducted interviews with several female rattan weavers aged 40–70 years who often make baskets in the village of Rumah Aying. We asked them how they collect rattans, what crafts they make and how they sell the products they make. These women often go to the secondary forest near the village to collect rattans. The villagers are knowledgeable about the sites where rattans grow with the most common place to look for them being the relatively old *temuda* (20–30-year-old fallow/secondary forest that emerges after shifting cultivation and holds relatively large trees). They do not often go to primary forests because this kind of *temuda* is often closer to the village. On average, they collect 25 bundles of rattans at once and 50 bundles at the very most. One bundle is 3–10 m long and 1–2 cm in diameter. They collect rattans once or twice a month, depending on how much rattan they use in that period. After drying the raw rattans (Fig. 22.4a), they split the rattan skins using a knife (Fig. 22.4b). Then, using special equipment, they grind down the edges to ensure a

Fig. 22.4 Traditional rattan basket weaving and processing stages performed at Rumah Aying including: (**a**) drying hand-processed rattan, (**b**) splitting the rattan skins, (**c**) grinding the edges, and (**d**) weaving. (Photographs: Yayoi Takeuchi 2014)

uniform width of the rattan skin (Fig. 22.4c). After the split rattans are prepared, they can begin the weaving process (Fig. 22.4d). It takes 1–3 days to weave a single basket or tray, seven to 10 days for a food cover and 1 month for a mattress.

The women mainly sell the rattan products to visitors. The prices for a basket, tray and food cover were RM30–90 (US$8–25), RM30–50 (US$8–14) and RM50–130 (US$8–36), respectively. Depending on the individual weavers and their productivity, they sell approximately 4–5 items per month. The majority of customers are visitors to the village such as teachers who are working at a nearby boarding school who buy rattan baskets to bring home as souvenirs. Most women rarely sell their products at markets because they can sell a sufficient amount of rattan products and crafts to these visitors. Rattan handicrafts thus provide an important source of income for these female weavers.

22.3 Change in Utilisation of Rattans Near the City

Livelihoods have changed from shifting cultivation to oil palm cultivation in some villages (see Soda et al. Chap. 15; Soda and Kato, Chap. 17), affecting people's lifestyles and their tendency and ability to collect and use forest products. As these practices are conducted less and less frequently, the likelihood of the knowledge concerning the utilisation of rattan being passed on to the next generation decreases.

In February 2014 we conducted a survey on the knowledge and utilisation of rattans in two suburban villages, Rumah Mujah and Rumah Saka (Fig. 22.2), and compared the results with those in Rumah Aying. In Rumah Mujah and Rumah Saka, people stopped practising slash-and-burn agriculture more than 10 years ago and 3 years before the survey, respectively. Rumah Mujah is located along the Miri–Bintulu road, some 20 km from Bintulu. There are many female weavers and they sell baskets in a rattan crafts shop in front of the village (Fig. 22.5). Rumah Saka is also located along the road, 50 km from Bintulu. Women in the village usually make regular rattan baskets to sell while male weavers often make special carrying baskets called *bangkat* for collecting oil palm fruits (Figs. 22.1j and 22.6). It is interesting to note that a *bangkat* is traditionally used for collecting illipe nuts (known locally as *engkabang* and collected from *Shorea* species) in the forest. Buyers from Rumah Mujah often visit Rumah Saka to buy regular baskets and then sell them in the shop in Rumah Mujah via those suppliers. The *bangkat*, by contrast, are sold in Chinese-owned shops in Batu Niah.

Fig. 22.5 Rattan crafts for sale in front of Rumah Mujah. (Photographs: Yayoi Takeuchi 2014)

Fig. 22.6 A *bangkat* basket being woven by a female weaver with bundles of rattan in the background in Rumah Saka. (Photograph: Yayoi Takeuchi 2014)

Table 22.4 Number of rattan types (based on local names) used as materials for modern baskets in three villages

Village	Rumah Aying	Rumah Saka	Rumah Mujah
Number of rattan types used	9	3	2 (plus factory-processed rattan)

We asked female weavers in Rumah Mujah and Rumah Saka how many types of rattans they know, collect and use for making crafts. In both villages, older women recognised or had heard about most of the Iban rattan names listed in Table 22.2. We also inquired about how many rattan species they had recently used in making baskets and crafts for selling; we compared this number to the number of species that people in Rumah Aying used. The number of species used for baskets was smaller in both Rumah Mujah and Rumah Saka than that in Rumah Aying (Table 22.4). The people in Rumah Saka collected and used three rattan species (*wi batu*, *wi tunggal* and *wi lia*), which are available even in the degraded secondary forests near the village. The people in Rumah Mujah primarily collected and used just two species, *wi batu* and *wi tunggal*. In addition, they bought machine-sliced rattans from a factory in Bintulu (Fig. 22.7a). These rattans are processed by special equipment that peels the skins and divides the cane core into several small round-shaped pieces (Fig. 22.7b) before being dried (Fig. 22.7c) In the factory process, unlike traditional processing, rattan skins are completely removed and only the core of rattans is used, so they usually are not naturally glossy. The villagers purchasing this type of processed rattan do not possess much knowledge regarding the species that are processed and they do not seem to particularly care either. They then make their rattan

Fig. 22.7 Machine processing of rattans at the factory including: (**a**) bundles of rattan selling for RM30 per kg, (**b**) special machinery that peels and splits the rattan into several cores, (**c**) processed rattan drying, (**d**) bundles of rattan with different coloured string indicating the grade of the rattan, and (**e**) thousands of bundles of rattan being prepared for export to Singapore. (Photographs: Yayoi Takeuchi 2014)

handicrafts using a combination of self-harvested rattan and this machine-sliced rattan. The price of baskets made from machine-sliced rattan does not differ from those made from traditionally processed rattan in Rumah Aying. The number of species that local people use for making crafts has decreased because the degraded forests near the villages contain fewer rattan species, and primary or secondary old-growth forests where a greater diversity of rattans grow are far away and thus difficult to access. The availability of machine-sliced rattans is also related to the decline of traditional knowledge of rattan species and uses, and rattan collecting. This affects the ability to pass on knowledge of rattan utilisation to younger generations. In fact, one young female weaver in her twenties in Rumah Mujah has only ever used processed rattans for making baskets. As the factory-processed rattans are not specific to the end product's use, processed rattans may also affect the quality and durability of rattan crafts compared to traditionally processed rattan.

22.4 Rattan Processing Factory in Bintulu

The factory that sells machine-sliced rattans for local people is located in the urban area of Bintulu near the Kemena River. To better understand the role of the factory in the local rattan commodity chain, we interviewed its manager in January 2014 and February 2015.

The factory mainly processes raw rattan canes in order to improve the preservation and quality of products for overseas export, mostly to Singapore and China (Fig. 22.7d, e). The factory processes 30–40 tonnes of rattans per month and 300–400 tonnes per year. Nearly 70% of the rattan processed in the factory is collected by local suppliers from villages across Sarawak, including from the regions of Tatau, Tubau, Batu Niah, Bekenu, Sibu and Kuching. Another 30% of rattan processed in the factory comes mainly from the Philippines.

In the factory, the canes are classified according to eight levels of quality from the top (first) to the bottom (eighth) and are bundled accordingly (Fig.22.7d). The price of processed rattan canes depends on the quality (Table 22.5). The highest price is SG$5 per cane for the best quality canes (each cane is 28–32 mm in diameter and 4 m in length).[2] The price decreases by SG$0.5 with each decrease in the level of quality. From Singapore, the rattans are then sold to Europe, the Middle East and India. The first-class and second-class canes are mainly exported to Europe, while the third to seventh classes are exported to the Middle East. Good quality canes are used for making furniture while lower quality canes are exported to India and used for making everyday rattan items such as baskets.

Selling machine-sliced rattan for domestic basketry has been an unexpected side business for the factory. *Wi tunggal* is the species primarily sold to local buyers. The price for the processed rattans was RM30 per kg in January to February 2014

[2] According to exchange rates in 2017, SG$5 was approximately equal to US$3.49–3.71.

Table 22.5 Price of rattan canes, export destinations and main uses

Class	Price (SG$) per cane	Final export destination	Main use
1	5.00	Europe	Furniture
2	4.50	Europe	Furniture
3–4	4.00	Middle East	Furniture
4–5	3.50	Middle East	Furniture
5–6	2.50	Middle East	Furniture
7	1.50	Middle East, India	Baskets
8	1.00	India	Baskets

Note: Each cane has a 28–32 mm diameter and a length of 4 m

(Fig. 22.7a), and the factory produced about 500 kg per month for the local market.[3] The amount of processed rattans sold to the local market is only a small fraction of the factory's total sales.

The factory can be seen as a key player in both the regional and global rattan trade. Although rattan transactions had previously been from the local to the global market only, this recent development in supplying machine-sliced rattans for handicraft making to local inhabitants has resulted in two significant sociocultural effects. First, the machine-sliced rattans are a convenient substitute for the wild rattans that are now difficult to collect for weavers making traditional rattan crafts. Second, and perhaps more importantly, the easily accessible machine-sliced rattans might contribute to the loss of traditional knowledge relating to the use of different types of rattans in the forest and the variety of methods and techniques involved in harvesting and processing them.

The entire role of the rattan processing and export factory in Bintulu in connecting regional and global markets has yet to emerge; however, similar commercial activities can be seen in the course of the development of the regional economy over the past two centuries.

22.5 Trajectory of the Rattan Trade in Sarawak

This section examines the trajectory of rattan exports in Sarawak from the late nineteenth century to the 1990s with a focus on the relationship between local commercial activities and the global market. Rattan as a commercial forest product was traded across broad regional networks, including to China, India and the Middle East, contributing to the livelihood of local people in Southeast Asia for many centuries (Peluso 1992; de Beer and McDermott 1996). Large-scale exports of rattan started around the late nineteenth century, facilitated by the construction of mass transport infrastructure and the evolution of commercial and institutional networks under Western colonialism in Southeast Asia. In Sarawak, which was established as

[3] RM30 was approximately equal to US$9.05–9.08 in January and February 2014.

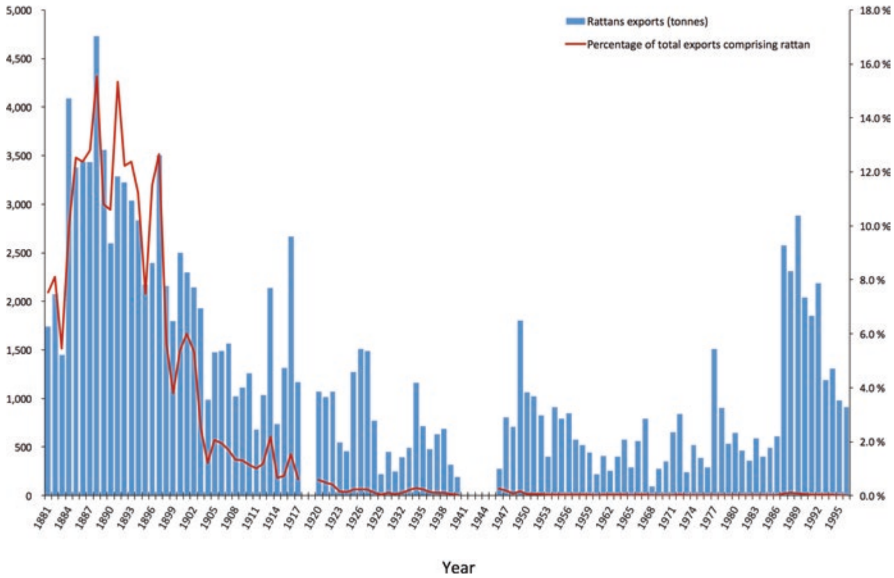


Fig. 22.8 Volume and total market share of rattan exports from Sarawak, 1881–1996
Sources: *Sarawak Gazette*, Sarawak trade returns for the year (1881–1917), Department of Trade and Customs, *Annual report* (1920–1940, 1946–1953), Department of Trade and Customs, Colony of Sarawak (1954–1960), Statistics of external trade for the year (1961–1996)

an independent kingdom in 1841 by the British colonist James Brooke, rattan exports began to increase in the 1880s. The analysis here therefore begins from that period and is divided into two phases in accordance with the pattern of development of rattan exports from Sarawak shown in Fig. 22.8. The first phase was the period from the late nineteenth century to the eve of the Second World War. In the late nineteenth century, rattan exports from Sarawak had expanded through a connection with the global market via Singapore, but gradually declined under the expansion of other exports from Sarawak after the early twentieth century (see Sugihara and Kobayashi, Chap. 27). Consequently, the next phase was during the postwar period, from the late 1940s to the 1990s. Rattan exports from Sarawak stagnated for a long time but suddenly increased in the mid-1980s in response to changes in the global market that were heavily affected by a 1979 protectionist ban on exports of unprocessed rattan exports from Indonesia (Meijaard et al. 2014).

22.5.1 *Expansion of Rattan Exports Through Commercial Networks, 1881–1940*

In the second half of the nineteenth century, rattan exports from Southeast Asia began to expand in response to increasing demand in the global market. Exports from Sarawak began to supply an important share of total global exports by the late nineteenth century and an export tariff generated sizeable revenue for the Brooke government after the 1880s (*Sarawak Gazette* 1 May 1883, 1 March 1884). The officers who administered each district paid special attention to rattan commerce and they published a number of reports on the conditions of the rattan trade at the time. These reports were published in the *Sarawak Gazette* and the *Sarawak Government Gazette* from the 1870s to the early 1940s, and from a great number of them we are able to understand many aspects regarding rattan commerce in Bintulu district around the early twentieth century. One report stated:

> The great demand for rattan—even the very common kinds—this month has resulted in the jungle having been cleared for miles on either bank of these rattans and the Bazaars from here to Kabulu [Kebulu] are overflowing with bundles..… Tubau I notice is going ahead, several Chinese and Malays having applied for ground for new shops there. There seems to be a brisk trade with Belaga going on from there and the Belaga fire has given an impetus to the trade with Tubau. Rattan Sega is coming over in large quantities from Baloi and the Tubau. Bazaar is full of this kind of rattans. The traders of both Bintulu and Tatau have applied for the steamer, they having very large quantities of rattans and dammar on hand. (*Sarawak Gazette*, Bintulu District Reports, 3 February 1903)

According to this report, riverine trade of rattan between bazaars in the coastal towns of Bintulu and Tatau and the upriver towns of Tubau and Belaga increased rapidly in response to the great demand for rattan. Chinese and Malay merchants who owned the shops in the coastal bazaars were those who primarily dealt in rattan and, consequently, these merchants exported rattan to Kuching or Singapore using steamships.

In the forests, indigenous people collected rattans and traded them with merchants in exchange for foreign goods; silver coins in particular were preferred by local Dayaks according to another description of rattan commerce in district reports:

> These people are exceedingly busy carrying rattan sega [a specie of rattan] over land from Belaga and while I was at Tubau some 10,000 bundles of this rattan were either in Tubau Bazaar or on their way over from Belaga, I found Tubau very badly in want of supplies the Bintulu Chinese keeping their agents there very short of rice and other foodstuffs. The whole of the Tubau trade is with Belaga and thousands of dollars (silver coins) go over to Belaga as the price of rattan during the year and the consequence is a shortage of silver here. Dayaks keep large quantities of silver in their houses and always refuse copper in payment of rattans. (*Sarawak Gazette*, Bintulu District Reports, 3 September 1903)

Local people actively collected rattans in the forests and traded them with the merchants coming from the bazaars at Belaga and Tubau, who offered supplies and silver coins in exchange. Additionally, this description indicates that indigenous people responded well to the market conditions; they seemed to initiate a greater collection of rattan in response to the rise in price, the news of which was transmitted through the merchants' networks from Singapore to Kuching, the coastal bazaars, and finally to the upriver markets.

According to data concerning rattan prices, the trade peaked in the late nineteenth to early twentieth centuries, including the dates of the above reports. Figure 22.9 shows the export prices of rattan from 1881 to 1940 extracted from trade statistics. The price of rattan rose rapidly after the mid-1880s and reached its peak around 1902–1903 and then declined gradually until 1940. The volume of rat-

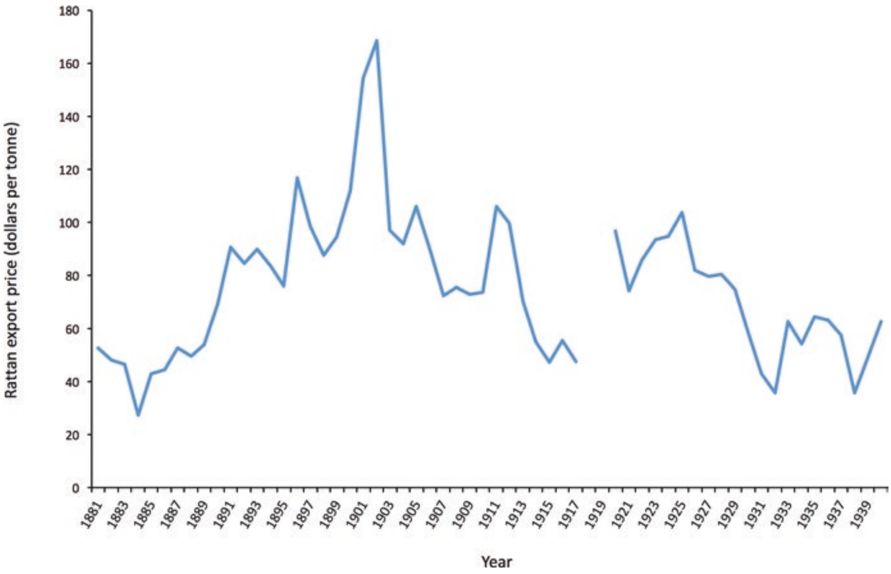


Fig. 22.9 Export prices of rattan from Sarawak, 1881–1940
Sources: *Sarawak Gazette*, Sarawak trade returns for the year (1881–1917), Department of Trade and Customs, *Annual report* (1920–1940)

tan exports from Sarawak also peaked in the late nineteenth to early twentieth centuries (Fig. 22.8). Owing to the decline in the price of rattan in the early twentieth century, indigenous people and merchants lost the incentive to harvest and trade; the volume of exports subsequently decreased. It is also suggested that exports of forest products (such as gutta-percha, jelutong and rattan) declined as a percentage of total exports after 1900 (Kobayashi and Sugihara, Chap. 27). Meanwhile, non-forest products obtained by farmers (such as pepper, gambier and plantation rubber) and fossil fuels from the oilfields of Miri began to dominate the state's total exports. In the course of the development of Sarawak trade, the importance of rattan for the livelihood of local people and the revenue of the Brooke government had apparently waned and export levels remained low for a long while thereafter.

22.5.2 Resurgence of Rattan Exports, 1946–1996

During the postwar period, rattan exports from Sarawak remained stagnant for years but expanded drastically after the mid-1980s (Fig. 22.8). The expansion of the trade was brought about by export bans on rattan put in place by neighbouring countries. The volume of rattan exports from Sarawak remained at the same level after the decline of exports in the 1900s until the mid-1980s. After 1986, however, the volume of rattan exports suddenly increased from approximately 500 tonnes to 2500 tonnes. Looking at the destinations of exports from Sarawak after 1970, we can see that while almost all exports went to Singapore from the 1970s to the mid-1980s, in 1986 rattan began to be exported to other destinations such as Hong Kong, Sabah and Taiwan, though Singapore still held the largest share (Fig. 22.10). A few years after this increase, rattan exports gradually declined. At present, we are unable to examine details regarding rattan exports from Sarawak after 1996 due to a lack of statistical data.

The main factor for the rise in rattan exports from Sarawak beginning in 1986 was likely to have been the ban on the export of rattan from Indonesia. Indonesia occupied the foremost position in the global market in the 1970s, supplying 75–90% of rattan (de Beer and McDermott 1996). After 1979 the Indonesian government implemented export bans in order to develop a domestic rattan furniture industry. This ban prohibited the export of unfinished rattan as a raw material. Subsequently, the decree was extended to include the prohibition of semi-finished rattan in 1988. These prohibitions remained until 1992 (Peluso 1992; Myers 2014). Similarly, the Philippines has banned the export of rattan cane since 1977 and succeeded in developing a domestic rattan industry (Peluso 1992; de Beer and McDermott 1996). Other producers, such as peninsular Malaysia and Thailand, have also applied trade restrictions to encourage domestic rattan industries (de Beer and McDermott 1996). These prohibitions in major rattan-producing regions decreased supply in the global market. According to Indonesian trade statistics (Biro Pusat Statistik 1970–1996),

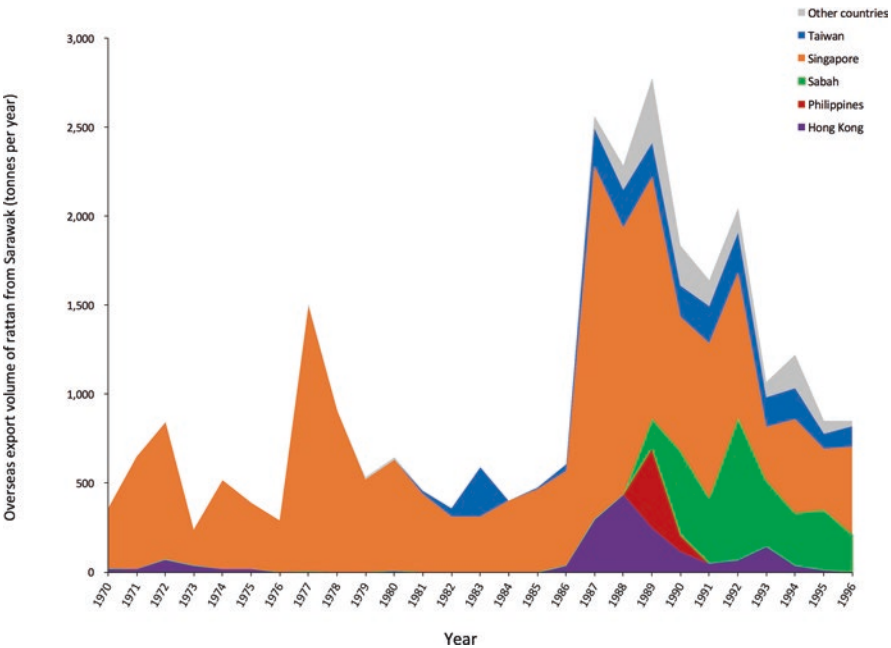


Fig. 22.10 Regional exports of whole rattan from Sarawak, 1970–1996
Source: Central Statistics. 1970–1996. *Statistics of external trade*

the export volume of rattan from Indonesia had increased steadily from 32,427 tonnes in 1970 to 130,501 tonnes in 1987, but dropped drastically to almost nothing after 1988. This indicates that the bans on rattan exports by the Indonesian government succeeded in affecting both the local and global markets and rattan industry. However, rattan smuggling reportedly flourished among insular Southeast Asian countries at the same time (Peluso 1992; Myers 2014). To take advantage of the short supply in the global market, Sarawak expanded its rattan exports rapidly, amounting to 2775 tonnes in 1989 (Fig. 22.8). After 1992, with the Indonesian bans on exports of raw and semi-finished rattan lifted, Sarawak exports fell back towards previous levels.

The resurgence of rattan exports from Sarawak was most likely due to bans on rattan exports by neighbouring Southeast Asian countries and the resulting changes in the global market. In Sarawak, rattan began to be exported to the global market on a large scale in the late nineteenth century through the commercial networks connected to the international entrepot of Singapore. This linkage with the global market never vanished completely, even with the decline of exports after the early twentieth century. In rural Southeast Asia, including in Sarawak, commercial networks delivering non-timber forest products between indigenous collectors, merchants and urban buyers have been in place to the current day (de Beer and McDermott 1996). Through the trading networks historically formed in the region, Sarawak could enjoy a temporary expansion of rattan exports again in response to a demand in the global market in the mid-1980s. Although it is difficult to study the current state of rattan exports in Sarawak, it is possible that exports are again increasing because Indonesia resumed its implementation of an export ban on both raw and semi-processed rattan in 2012 (Myers 2014).

22.6 Concluding Remarks

Based on the discussion above, we classify rattan utilisation in Sarawak in three spatial scales (Fig. 22.11). First, local people utilise rattans for foods and handicrafts in their daily lives based on the highly biodiverse surrounding forests. Through a forest survey and interviews with villagers, we found a high species diversity of rattans in the 20- to 30-year-old recovering secondary forests near rural villages. Local people possess a deep knowledge of the different species of rattans and their corresponding uses for each species were based on long-standing cultural patterns and practices. The high species diversity of rattans in forests supports the preservation of indigenous knowledge and culture, from which local communities can benefit from through the utilisation of rattan.

Second, at the regional scale, the situation has changed in villages near cities due to the development and exploitation of primary forests. The communities in these areas use a limited number of rattan species because primary forests are not easily accessible any more. Under these circumstances, people have no choice but to purchase rattan materials from the factory in Bintulu. This provides processed rattans

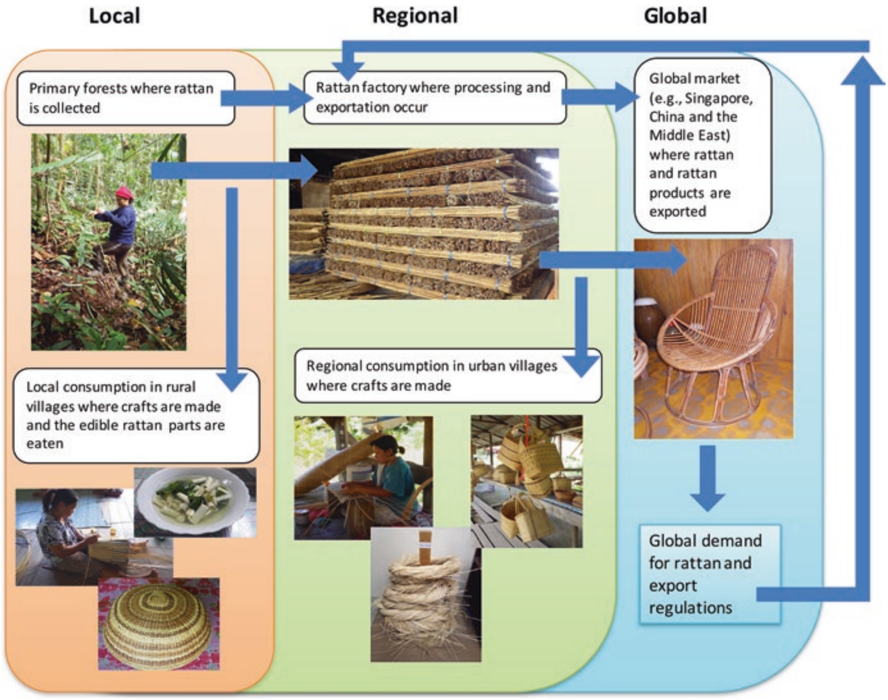


Fig. 22.11 Transitions in the utilisation and trade of rattans in Sarawak

not only for the global market but also for a newly formed regional market. At the regional scale, local people use machine-processed rattans and no longer require detailed knowledge of the species of naturally occurring rattans in primary forests. Their utilisation of rattans has also changed, departing from the close relationship with primary forests that is necessary in order to choose appropriate species for a specific product being made. This departure may eventually impact on the ability to pass down traditional knowledge and techniques of rattan crafting to future generations.

In addition to local and regional scales, we discussed the development of rattan exports from Sarawak to the global market since the nineteenth century. Through an analysis of trade statistics, we found at least two big booms in rattan exports: in the late nineteenth century and then again in the mid-1980s. In the late nineteenth century commercial networks connecting local people with merchants and enterprises were formed, which enabled export booms of rattan in response to an increasing demand in the global market. This trading framework survived in the postwar period and functioned well under the second boom that was triggered by Indonesian regulation of rattan exports in the mid-1980s. During these two booms, local communities intensified the collection of rattans from regional primary forests which were more abundant at that time. At present, the role of trade enterprises connecting local suppliers of rattan with the global market has been partly taken over by the rattan factory in Bintulu. This factory responds to fluctuations in the global market and at the same time provides processed rattans for the regional market. The global trade of rattan in Sarawak has thus been intertwined with regional utilisation of rattan by local people in suburban areas via a local agency such as the rattan factory.

Sarawak's highly biodiverse society, which depends on a variety of natural resources from primary forests, has been changing in response to impacts of the world economy and land-use change over the last two centuries. Although rattan is just one of many non-timber forest products in the region, within the changing patterns of rattan utilisation transformations happening throughout the state can be detected on both biological and socioeconomic levels and with far-reaching implications for the future. Foremost of these implications are those concerning the future of local indigenous communities. The change of land use from primary forests to intensive monoculture and high biomass yield plantations (due to pressure from the global market) will reduce the species diversity of rattans and will undermine the significance of traditional culture and knowledge. It may also hinder the close relationships between humans and nature that have long been nurtured in Sarawak. A comprehensive study of the transition of the area to a high biomass society with a focus on declining forest products would provide new perspectives and greater insight on the foundations of a sustainable society that conserves biodiversity, traditional knowledge and human wellbeing.

References

Biro Pusat Statistik. 1970–1996. *Statistik perdagangan luar negeri Indonesia: Ekspor menurut jenis barang, negeri tujuan dan pelabuhan ekspor asal* [Indonesian foreign trade statistics: Exports by commodity, country of destination and port of export]. Jakarta: Biro Pusat Statistik.

Blehaut, Jean-François. 1994. *Iban baskets*. Kuching: Sarawak Literary Society.

Central Statistics Bureau Government of Sarawak. 1961–1996. *Statistics of external trade for the year*. Kuching: Central Statistics Bureau Government of Sarawak.

Chai, Paul P.K. 2000. *Development of Lanjak Entimau wildlife sanctuary as a totally protected area, phase II: Project 15/95 rev. 3(F) final report*. Yokohama/Kuching: International Tropical Timber Organisation/Sarawak Forest Department.

de Beer, Jenne H., and Melanie J. McDermott. 1996. *The economic value of non-timber forest products in Southeast Asia: With emphasis on Indonesia, Malaysia and Thailand*. Amsterdam: Netherlands Committee for IUCN.

Department of Trade and Customs, Colony of Sarawak. 1954–1960. *Annual statistics for the year*. Kuching: Government Printer.

Department of Trade and Customs, Sarawak. 1920–1940, 1946–1953. *Annual reports*. Kuching: Government Printer.

Dransfield, John. 1992. *The rattans of Sarawak*. Kew: Royal Botanic Gardens, Kew and Kuching Sarawak Forest Department.

Dransfield, John, and N. Manokaran. 1994. *Rattans*. Wageningen: Centre for Agricultural Publishing and Documentation (PUDOC), Plant Resources of South-East Asia (PROSEA) No. 6.

Dransfield, John, Florentino O. Tesoro, and N. Manokaran. 2002. *Rattan: Current research issues and prospects for conservation and sustainable development*, Non-wood forest products. Vol. 14. Rome: Food and Agriculture Organisation of the United Nations.

Meijaard, Erik, Ramadhani Achdiawan, Meilinda Wan, and Andrew Taber. 2014. *Rattan: The decline of a once-important non-timber forest product in Indonesia*. Bogor: Centre for International Forestry Research, CIFOR Occasional Paper No. 101.

Myers, Rodd. 2014. What the Indonesian rattan export ban means for domestic and international markets, forests, and the livelihoods of rattan collectors. *Forest Policy and Economics* 50: 210–219.

Peluso, Nancy Lee. 1992. The rattan trade in East Kalimantan, Indonesia: Can extraction be reserved? In *Non-timber products from tropical forests: Evaluation of a conservation and development strategy*, Advances in economic botany, ed. Daniel C. Nepstad and Stephan Schwartzman, vol. 9, 115–127. New York: New York Botanical Garden.

Sarawak Gazette. 1870–1917. Various issues.

Sunderland, Terry C.H., and John Dransfield. 2002. Species profiles rattan (*Palmae*: *Calmoideae*). In *Rattan: Current research issues and prospects for conservation and sustainable development*, Non-wood forest products, ed. John Dransfield, Florentino O. Tesoro, and N. Manokaran, vol. 14, 9–22. Rome: Food and Agriculture Organisation of the United Nations.

Takeuchi, Yayoi, Ryoji Soda, Bibian Diway, Tinjan ak. Kuda, Michiko Nakagawa, Hidetoshi Nagamasu, and Tohru Nakashizuka. 2017. Biodiversity conservation values of fragmented communally reserved forests, managed by indigenous people, in a human-modified landscape in Borneo. *PLoS One* 12 (11): e0187273.

Wan Razali Mohd Wan, John Dransfield, and N. Manokaran. 1992. *A guide to the cultivation of rattan*. Kuala Lumpur: Forest Research Institute Malaysia.

Chapter 23
Oil Palm Plantations and Bezoar Stones: An Ethnographic Sketch of Human–Nature Interactions in Sarawak

Katsumi Okuno and Tetsu Ichikawa

Abstract Over the last 10 years, indigenous populations of Sarawak have gained previously unseen sums of money from hunting porcupines and selling bezoar stones found in their stomachs which are valued in Chinese medicine. This has spurred new and expanded hunting methods, impacting on the relationships between humans and nature. At first glance, the boom in bezoar stones seems to have become widespread after the expansion of oil palm plantations. To investigate this further, multisited research was conducted in bezoar stone source areas, along the downriver trading network and in metropolitan cities where they are consumed. It was found that the progress of the bezoar stone boom among indigenous populations in Sarawak varied by river basin. As far as the relationship between oil palm plantations and porcupine bezoars is concerned, we can see an 'inter-disturbance' interaction between humans and nature. The expansion of oil palm plantations can be described as a 'human disturbance' in this tropical natural environment, while the porcupines that eat the oil palm fruits can be described as a 'natural disturbance' to human lives, providing inhabitants with opportunities to garner vast sums of money from the bezoars.

Keywords Sarawak · Bezoar stones · Porcupines · Leaf monkeys · Oil palm plantations · Chinese medicine

K. Okuno (✉)
Graduate School of Humanities and Social Sciences Society and Collaboration, Rikkyo University, Toshima, Japan

T. Ichikawa
Nagoya City University, Nagoya, Japan
e-mail: tetsu-i@kb3.so-net.ne.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_23

23.1 Introduction

One of the authors visited a Penan village in the upper reaches of the Belaga River in Sarawak, Malaysia, in March 2013. The inhabitants there spent much of their time hunting and fishing, and occasionally sought out wage labour—living much like hunting peoples from time immemorial. One male Penan had gone hunting just before Christmas of 2012 and found a ‘stone’ in the internal organs of a hunted porcupine. He sold that stone to a trader, which enabled him to obtain a loan payment in order to purchase a four-wheel-drive truck in January 2013 (Fig. 23.1). He then started a business using the truck to transport Penan labourers and various materials from the Kenyah people, who are oil palm smallholders. From this story it seems that a porcupine bezoar obtained by chance and regarded as a ‘stone of treasure’ of high economic value is potentially taking the Penan into another era. Other Penan and Kenyah people in the same village have also found porcupine bezoars and sold them for large sums of money.

Hunter-gatherers have long played an important role in providing forest products from the interior of Borneo, such as camphor, ironwood, rhinoceros horns, dammar (a resin), jelutong (a hard latex), *gaharu* (aromatic wood) and bezoar stones, to shifting cultivators and Chinese traders (Brosius 1995). But the vast sums of money that people now receive for porcupine bezoars is a recent development, occurring only in the last 10 years. How did this kind of growth in porcupine bezoars occur in Sarawak? How widespread is it? Is there any difference in this phenomenon between

Fig. 23.1 Four-wheel-drive truck purchased with the profits from selling a porcupine bezoar. (Photograph: Katsumi Okuno 2013)

different regions? Who buys these porcupine bezoars and where are they taken? Why are they in demand and who needs them? Such questions came to mind in response to the discovery that a Penan man could suddenly afford to buy a four-wheel-drive vehicle.

Before delving into this ethnographic sketch, here we provide some general information about porcupine bezoars. Porcupine bezoars—generally called *batu landak* or *guliga landak* in the Malay language—are one of two types of bezoar stones occasionally found in the internal organs of certain animals, the other being leaf monkey bezoars, which are referred to as *batu monyet* or *guliga monyet* in Malay. Daniel Beeckman (1718) was probably the first Westerner to record the bezoar stones of Borneo at the beginning of the eighteenth century. Just as the name suggests, porcupine bezoars come from porcupines, which are nocturnal animals that inhabit Asia and Africa and intimidate predators using their needles. The porcupines of Borneo live together in groups of several individuals and dig dens and burrows underground in forests. When a porcupine is attacked, it protects itself by erecting its thick needles, which sometimes impale predators. Their canine teeth are strong enough to bite and eat oil palm fruits, something that only wild boars can also do.[1]

In the story cited earlier, the Penan man had hunted the porcupine in an oil palm plantation and not in the rainforest. This new style of hunting, which began around 2000, involves ambushing game animals coming into the plantations at night. It is regarded as the primary reason for the increase in the number of porcupine bezoars being sold by the Penan and other indigenous people. It might be argued that the Penan could not obtain much food from the surrounding environment due to the forest destruction that resulted from commercial logging beginning in the 1980s. In an unintended fashion, the resulting oil palm trees planted in open land terraces have attracted wild boars and porcupines and this has led to great fortunes being made from the 'stones of treasure' within the porcupines. Interestingly, just as Beeckman referred to false bezoars being created as far back as the eighteenth century, false stones continued to be made by the people in Borneo in order to deceive traders (Everett 1879). This practice shows the ingenuity of some people in adapting to market demands in order to garner wealth.

The wealth provided by bezoars stems from the Chinese who have prized the stones for centuries as having medicinal value (Hoffman 1986).[2] The Chinese have

---

[1] There are three kinds of porcupines on Borneo. The Malayan porcupine (*Hystrix brachyura*) is generally a black mammal that has long white spines or quills with black bands towards the tip. The thick-spined porcupine (*Thecurus crassispinis*) is generally dark brown, and both males and females have hollow quills on their tails, which are shaken to make noise. These two types of porcupines are referred to as *landak* in Malay. The long-tailed porcupine (*Trichys fasciculata*), called *angkis* in Malay, has a brown upper body and whitish lower body, giving the overall impression of a large rat. For more details, see Junaidi Payne and Charles Francis (2005). Porcupine bezoars are produced by all three kinds of porcupines, and in this chapter the term 'porcupine bezoar' is used generally.

[2] Porcupines in China are widespread, ranging from the north of the Chang Jiang basin southwards towards Shanxi province. Porcupines have been referred to as 豪猪 or 箭猪, and their stinging hair, stomach (including its contents) and muscles have been used in Chinese medicine. It is difficult to

a long history of migrating overseas, dating back to at least the Ming dynasty (1368–1644). The total population of ethnic Chinese in Southeast Asia is estimated to be more than 50 million. As such, unique traditional Chinese medicines incorporating porcupine bezoars have been developed in each region of Southeast Asia, which are different from those practised in mainland China.

23.2 Methods

To learn more about porcupine bezoars, multisited research was conducted in bezoar stone source areas, along the downriver trading network, and in metropolitan cities where they are consumed. Specifically, we visited villages in the upper reaches of the Belaga and Jelalong river basins in addition to tributary areas of the Baram River in August 2013 and February–March 2014 in order to learn more about the reality of the boom in porcupine bezoars. We interviewed Chinese traders and merchants who work as middlemen buying bezoars from indigenous people, and visited two cities located in peninsular Malaysia, Kuala Lumpur and Penang, where they are consumed.

23.3 Acquisition of Porcupine Bezoars

The initial questions are as follows: How do the Penan and their neighbours find porcupines? When a bezoar is found who is it sold to and for how much? What is done with the profits?

23.3.1 U Village

LB, the Penan chief from U village (located along the upper reaches of the Belaga River), is the man described at the beginning of this chapter who sold a porcupine bezoar and bought a truck. He hunted a porcupine in an oil palm plantation before Christmas of 2012 and found a stone in its stomach, which he then sold for RM21,000 to a trader from Long Lama in the upper reaches of the Baram River.[3] Afterwards, he made a down payment of RM7000 for the RM78,000 truck and paid RM1300 per month for a five-year loan payment.

find a description regarding porcupine bezoars in the Chinese medicine practised in mainland China. On the other hand, porcupine bezoars are generally known as 箭猪棗 in the Chinese societies of peninsular Southeast Asia, but it is also difficult to find a description of their medical value.

[3] In 2013, US$1 was equivalent to approximately RM3.60.

Fig. 23.2 Photograph of a porcupine bezoar displayed in IV's shop. (Photograph: Katsumi Okuno 2013)

IV is a Kenyah Pawa who runs the grocery shop in U village. He owns a Toyota Hilux truck and frequently travels to Bintulu and Miri. He told us that he had found four porcupine bezoars thus far, although according to him they are difficult to find. They were sold to Chinese traders in Miri for between RM10,000 and RM18,000 each. A commemorative photograph of a porcupine bezoar was taken on 6 February 2009 and is displayed in his shop (Fig. 23.2). IV said that he had been targeting porcupines as well as wild boars as these two animals regularly go to oil palm plantations at night. As a result of his hunting, his family often eats porcupine meat.

JD is an Eastern Penan from the Tinjar River who married into U village and is good at hunting. He told us that he found a bezoar in the stomach of a porcupine at an oil palm plantation in May 2013 and then sold it to a trader in Miri for RM11,000. He also said that he caught a live pangolin in the same month and sold it for RM70 per kg at a logging camp. He deposited almost all the money received from these two hunting trips into his bank account.

These three people were those we were able to interview in U village who had sold porcupine bezoars, although we also obtained several pieces of related information from other inhabitants.

JG, a Penan from U village, stated that he and others had formerly found bezoar stones in the stomachs of leaf monkeys or red leaf monkeys. He himself had found a leaf monkey bezoar in the early 1990s, which he sold to some nearby Kenyah people for RM600. According to LA, such animal resources were exchanged for goods with traders or sold to merchants. He told us that even if a porcupine bezoar had been found in those days it would generally have been thrown away. However, porcupine bezoars found today are precious enough to sell for tens of thousands of ringgit, while leaf monkey bezoars are also worth at least thousands of ringgit. In the past, bezoars were primarily regarded as coming from leaf monkeys, but they have now been replaced by porcupines.

We heard from several Penans that PE, an Indonesian national who had come to U village for labour and married a Penan woman, had found and sold two porcupine bezoars. He was also said to have sold one recently for RM8000. In addition, we also learned that a Penan used a dog to hunt a porcupine and sold the bezoar found in its stomach to a Chinese trader in Miri.

23.3.2 Jelalong River Basin

There were other stories about the discovery and sale of porcupine bezoars along the Jelalong River. At the trading point in the upper reaches of the Kemena–Jelalong valley, where the Jelalong and Tubau rivers meet in Tubau, we heard from AK, an ethnic Chinese, that indigenous people upstream of the Jelalong River had previously brought down and sold porcupine bezoars, although he had yet to see any for himself. AK told us that these bezoars have an extremely bitter taste, to the extent that if you held one you could taste the bitterness when you licked the back of your hand. Clearly, it is not true that a bezoar's bitterness passes through or is transmitted to the back of the hand, yet we heard this kind of claim everywhere we went in Sarawak. This type of fanciful talk has most likely spread among people who have never touched or seen a porcupine bezoar.

The inhabitants of J longhouse located along the Ketab River, a tributary of the Jelalong River, also hunt porcupines. About 7 years ago, with assistance from the government, they decided to plant oil palm seedlings that they acquired in the secondary growth forest behind their longhouse. We were told that wild boars and porcupines would come at night to eat the fruit of the oil palms, bananas and hearts of the banana plants. The people of J longhouse set traps in the secondary forest and oil palm area behind their longhouse, catching wild boars and porcupines (Fig. 23.3). During a visit to J longhouse in March 2014, residents supplied one of the authors with porcupine meat cooked with wild boar organs. YN of J longhouse also obtained two thumb-sized stones in the stomach of a single porcupine he had caught while trapping in 2013. However, since he did not know who to sell the bezoars to or where best to sell them, he was keeping the bezoars safe and had not yet sold them.

23.3.3 Baram Mid-River Basin

The trading of porcupine bezoars also takes place in the Baram basin. A Kenyah man originally from the Baram River and currently living in Bintulu told us that his brother had found porcupine bezoars and sold them for RM3000 in Marudi.

Fig. 23.3 YN placing a trap in the secondary forest behind J longhouse. (Photograph: Tetsu Ichikawa 2014)

However, in N village, where the Kayan reside near Long Lama within the Baram basin, slightly differing conditions are seen compared to the two river basins already mentioned.

Inhabitants of N village also hunt porcupines in the rainforest. KN of N village, a Kayan, told us that since his father's generation they have gathered bezoars from porcupines and leaf monkeys and sold them to the Chinese in Long Lama and Marudi. His father and grandfather also used to acquire bezoars by hunting leaf monkeys with blowpipes when they went to salt licks. However, he told us that when several companies began logging in the 1970s the population of leaf monkeys gradually dwindled. Other residents of N village also said that since about 2003 the number of porcupines has been decreasing. Several reasons for this have been considered. But it is generally supposed that in addition to the continued hunting of porcupines in this region their numbers in the surrounding forest area have declined because of deforestation. Around 2005 N village decided that they would plant oil palms and following this an increasing number of porcupines have been trapped. Thus, although the number of hunted porcupines in the forest has been decreasing, the number of porcupines trapped in oil palm plantations has increased as these animals enter plantations more frequently to find sources of food.

As mentioned above, in contrast to traditional hunting methods, trapping is carried out in N village within the oil palm plantation. Villagers set cage traps in plantations and smallholders' farms, placing oil palm fruits in the traps and catching porcupines that come to eat the fruit at night. KN's brothers sold bezoars obtained in this way to ethnic Chinese middlemen in Marudi for RM35,000.

With the exception of villagers killing porcupines immediately after trapping them to check whether there are bezoars in their stomachs, villagers also capture

Fig. 23.4 Captured porcupine kept in N village. (Photograph: Tetsu Ichikawa 2014)

porcupines alive, take them home and feed them in cages (Fig. 23.4). In N village, we were shown a porcupine caught in 2013 by KN. According to him, they had caught two porcupines in 2013, and when checking the stomach contents of one killed in 2014 they came across bezoars. The other one was still being kept alive as of March 2014 and was being given oil palm fruit as well as other fruits and vegetables as feed. According to KN, porcupine bezoars often include oil palm fibres, and therefore if the villagers continue to feed the captured porcupines bezoars may be formed in the animals' stomachs. In this way, inhabitants of N village are not only obtaining bezoars from porcupines trapped in the oil palm plantations, they are also intentionally attempting to acquire bezoars by keeping captive porcupines and feeding them oil palm fruits.

23.4 The Porcupine Bezoar Trade: Traders as Middlemen

Next we examine the activities of ethnic Chinese by analysing the case of the Baram River basin, where Chinese merchants play an intermediary role in the porcupine bezoar trade. We discuss the activities of three Chinese traders and merchants whom we encountered: AP from Long Lama, LS from Marudi and SY from Miri, all of whom either live in the Baram basin or in Miri. It should be noted that the trade in porcupine bezoars appeared to be less active in Bintulu and the surrounding region.

23.4.1 AP from the Upper Basin Area

AP, who lives in the town of Long Lama in the upper reaches of the Baram basin, frequently acquires bezoars on his visits to indigenous settlements. Although he originally dealt with forest products such as agarwood (*gaharu*) and edible birds' nests, he then started to invest his energy and resources in the porcupine bezoar trade. He not only purchases bezoars by visiting the settlements of hunter-gatherers such as the Penan, or the longhouses of swidden cultivators such as the Kayan and Kenyah, but also has a shop in Long Lama where his dealings include bezoar trading. Indigenous people who have obtained bezoars now visit his shop to sell their goods and, in some cases, even bring in live porcupines. The bezoars obtained by AP are then purchased by merchants in Miri, Kuala Lumpur, Singapore and China's Guangdong province. Ethnic Chinese merchants call on his shop in Long Lama directly, buy the bezoars and then return home.

23.4.2 LS from the Middle Basin Area

LS lives in the town of Marudi in the middle reaches of the Baram basin, where he owns a shop in the market selling household goods. His father was originally from China, where he studied to become a practitioner of Chinese medicine before moving to Sarawak. Since coming to Marudi, LS's father has continued to prepare Chinese herbal medicines at home, both for his own use and to sell to other Chinese merchants. From his father, LS has also acquired knowledge of Chinese medicine including the use of bezoar stones.

At present, as well as selling goods at his shop, LS also trades in bezoars from porcupines and leaf monkeys, edible birds' nests taken from caves, agarwood and bear gall bladders. However, by his own account, unlike birds' nests, porcupine bezoars are not regularly available and account for a very small portion of his trade. When we visited his shop in March 2014, he showed us some photos of bezoars he had previously purchased from local indigenous people, as well as several bear gall bladders, leaf monkey bezoars and porcupine bezoars that he had in stock at the time (Fig. 23.5). In addition, we heard that people from N village were also planning to visit LS's shop to sell porcupine bezoars from recent hunting expeditions in oil palm plantations. In this way, people from upriver areas do not necessarily sell their bezoars only to ethnic Chinese traders in the upper basin but also visit traders living further downriver or in other areas in search of better terms.

Fig. 23.5 Porcupine bezoars in stock in LS's shop in Marudi. (Photograph: Tetsu Ichikawa 2017)

23.4.3 SY from the Lower Basin Area

In the coastal city of Miri in the lower reaches of the Baram basin, SY deals mainly in sea products such as sea cucumbers, shark fins and abalone, in addition to some forest products such as agarwood and edible birds' nests. Although SY started dealing in porcupine bezoars only recently, he has prior experience of dealing commercially with forest products from Sarawak. The trade in porcupine bezoars does not make up a large proportion of SY's business, although like AP he still collects some from throughout Sarawak, buying them on his visits to indigenous settlements, while people from the interior also visit his shop in Miri to sell bezoars along with other forest products to him directly. SY not only runs his commercial business in the city but also makes his own visits to indigenous settlements such as those of the Penan. Through his interactions with them he obtains forest products, which he then exports from Sarawak to places such as Singapore and peninsular Malaysia. In this regard, both SY and AP could be said to be creating links between Sarawak's interior and the outside world.

The Baram basin is therefore a site for the localised circulation of bezoars which are acquired from hunter-gatherers and swidden cultivators by ethnic Chinese middlemen to sell in their shops and are transported from the upriver region to downriver cities. This circulation also extends to the wider world with the sale of porcupine bezoars in peninsular Malaysia, Singapore and China, resulting in the formation of a commodity network that extends to incorporating multiple ethnic groups and regions (cf. Chew 2013).

In the Kemena–Jelalong river system, however, such a porcupine bezoar supply chain network has yet to be sufficiently realised. The boom itself is recent, having been brought about in this region with the intensified cultivation of oil palm. From the experiences of AP, LS and SY, we can observe the role of ethnic Chinese traders as intermediaries, acquiring porcupine bezoars from indigenous people who hunt and kill the animals. Whereas some Chinese traders such as LS have gained familiarity with porcupine bezoars through their knowledge of traditional medicine and have developed businesses incorporating them in the preparation of herbal remedies, others have become deeply involved with local indigenous people as traders, dealing in monkey and porcupine bezoars along with agarwood and edible birds' nests.

23.4.4 Counterfeit Bezoars

A common theme underlying these three interviews was the difficulty of purchasing porcupine bezoars, especially authentic bezoars. The informants all agreed that their indigenous suppliers sometimes attempted to sell fake bezoars created by mixing the contents of porcupine stomachs with sago palm starch and moulding them into a round shape. Because the absolute volume of bezoars in circulation is so low, it is not easy for anyone other than an experienced middleman to determine a bezoar's authenticity. AP spoke of how he had lost a considerable amount of money until he learned how to do so.[4]

23.5 Consumption of Porcupine Bezoars: Demand in Peninsular Malaysia

How are porcupine bezoars actually used? Who consumes them and in what way? Here we report on the demand for porcupine bezoars in peninsular Malaysia from the standpoint of wholesalers and retailers. This inevitably entails an exploration of their use in Chinese medicine. A glimpse into the realities of the demand for porcupine bezoars is presented by discussing the case of medicinal pharmacies in Kuala Lumpur and Penang.

---

[4]As mentioned earlier, reports of the manufacture of false bezoars date back to the eighteenth century (Beeckman 1718). For further information on false bezoar stones in the Rejang River basin in the nineteenth century, see Everett (1879).

23.5.1 Kuala Lumpur

Shop X is a pharmacy located in a shophouse in Kuala Lumpur's Chinatown area. It does not necessarily regard bezoars as an especially major product. Like other typical pharmacies across Malaysia, the shop features over-the-counter sales of Chinese herbal medicine and its clientele ask staff to recommend remedies based on descriptions of their symptoms, purchasing these in the necessary amounts weighed out for them. The shop uses the traditional Chinese measurements of *liang* (1 *liang* = 3.78 g) and *fen* (1 *fen* = 0.378 g) and not metric measurements.

When we visited shop X and asked for porcupine bezoars, the shop assistant immediately went into the back of the shop and brought out a plastic case and small ziplocked plastic bags containing several bezoars which she showed us. According to the assistant, the bezoars had been brought not only from Sarawak but from throughout Borneo, and the majority had come from Indonesia.

Shop Y, another pharmacy, is also located in central Kuala Lumpur, near Pasar Seni station, adjacent to the Chinatown area. Shop Y is not in a traditional shophouse, but rather is outfitted with a glass display window adorned with large printed photographs of Chinese medicine (Fig. 23.6). It also features a restaurant on the second floor providing birds' nest cuisine. This pharmacy also positions porcupine bezoars as one of its major trading products and the shop owners have edited and published a booklet on the subject of bezoars along with an accompanying DVD. The shop advertises the efficacy of porcupine bezoars by providing this booklet free of charge to potential customers as well as by distributing it to ethnic Chinese merchants and other pharmacies throughout Malaysia.

Fig. 23.6 Shop Y in Kuala Lumpur. (Photograph: Tetsu Ichikawa 2014)

While shop Y sells whole porcupine bezoars (measuring 3–4 cm in diameter) in plastic cases, it also prepares powdered bezoar for emergency use, selling doses dispensed into paper sachets. These sachets are available in 0.1 g and 0.2 g doses, which are sold for RM250 and RM500, respectively. One Chinese customer came to the shop and purchased four sachets of powdered bezoar during our visit. However, there are very few shops that operate in this style; the vast majority are more traditional pharmacies like shop X that deal in bezoars only in conjunction with other medicines.

We have discussed local demand in Kuala Lumpur in an attempt to explore the nature of how porcupine bezoars are used and consumed in a retail context. At present we have not yet extended our research to determine how bezoars are used in actual treatments.

Some Chinese pharmacies, like shop X, deal with porcupine bezoars as just one of many types of Chinese herbal medicines. Other establishments, such as shop Y, are actively engaged in promoting the efficacy of porcupine bezoars, preparing individualised doses that patients can easily consume. The latter appear to play an extremely important role in the expansion of contemporary demand for porcupine bezoars. According to our interviews, although powdered bezoar that has been packaged or cut and ground in front of the customer is sold and consumed, there is some variation in the degree of trust and awareness as to the efficacy of porcupine bezoars. While there are those who attest to their efficacy against cancer and various other illnesses and injuries, and who have taken bezoars themselves, there are also those who question whether bezoars have any actual medicinal quality.

23.5.2 Penang

In Penang, as in Kuala Lumpur, traditional Chinese pharmacies coexist alongside shops that sell packaged remedies and health products whose primary consumer base consists of local urban residents.

Shop M is a wholesaler of medical materials located in neighbourhood A, near Kek Lok Si, a famous Chinese temple in Penang. Like any typical Malaysian pharmacy, the shop's walls are covered in wooden drawers filled with medicines. In addition to over-the-counter sales, the shop sells medicinal products in wholesale quantities and handles porcupine bezoars as a part of its trade. As described by the staff, bezoars sold in the shop are a luxury-grade known as *fěn zǎo* (literally 'powdered date'). In practice, while it is the *xuè zǎo* (literally 'blood date') type that commands the highest price, we were informed that this type was not currently in stock. We were told that luxury-grade porcupine bezoars in this shop sell for RM600 per *fen* at a wholesale rate and would likely sell for more at the retail level. Most of the bezoars handled in this shop were from Java and Sumatra in Indonesia with only a handful originating in Malaysia.

Shop N is a retail outlet located next to shop M in neighbourhood A. Shop N provides over-the-counter sales of Chinese medicine and herbal components in response to customer requests. When we asked the shop assistant whether the shop had any porcupine bezoars in stock, we were shown bezoars stored in a plastic case as well as powdered bezoar in ziplocked plastic bags. Like shop Y in Kuala Lumpur, shop N prepares powdered bezoar in advance, and packages portions of it in sachets containing individual doses of one *fen*. These sachets are then sold to customers in volumes tailored to meet their requirements.

The clientele of this shop consist primarily of Malaysian Chinese living in Penang and, according to the staff, there are no mainland Chinese or Singaporean customers. Most of the porcupine bezoars here came from Indonesia. When we enquired as to the types of illness against which bezoars were effective, we were told that in addition to cancer and dengue fever, they are also effective against the formation of bodily tumours in general. Shop N does not keep many bezoars in stock, but only purchases small amounts from wholesalers in order to meet customer demand. Although bezoars are not exactly a rare commodity at shop N, they did not necessarily appear to have been a common product that was always kept in stock.

While shop M and shop N are examples of what might be called traditional Chinese pharmacies, there is also a chain shop outlet in Penang whose target market is focused on the so-called urban middle class and resembles shop Y in Kuala Lumpur. EYS is a retail chain based in Singapore with outlets in Australia, China, Hong Kong, Indonesia, Macao, Malaysia, Singapore and the United States selling health foods and various plant and animal material for use by practitioners of Chinese medicine. In contrast to the two traditional Chinese pharmacies mentioned above, these shops sell pre-packaged products. EYS also sells porcupine bezoars at its Penang store and when we visited we were shown bezoars kept in a glass case. Affixed to the case were labels reading 'bezoar stone' in English and 'porcupine date' (*jiàn zhū zǎo*) in Chinese characters (similar to the *fěn zǎo* or 'powdered date' term used in shop M).

At EYS's Penang outlet, porcupine bezoars sold for RM2800 per g. Shop staff shave the amount requested by the customer from a porcupine bezoar and sell the resulting powder to the customer by weight. While this shop sold its product in metric units, in contrast to shop M and shop N, it also sold to customers in the traditional units of *liang* and *fen* in response to customer demand. We were told that these bezoars sold came from both Indonesia and Malaysia.

When we asked an EYS staff member whether the chain also sold porcupine bezoars at its locations in China or Australia, we were told that there was not much of a market for bezoars in countries other than Malaysia and Singapore, where bezoars are typical medicines for the Chinese. This is not the case in other countries (including China). Furthermore, even if bezoars were sold at EYS outlets in China, they would be priced far above the prices listed in Malaysia due to difficulties in obtaining them. This appears to suggest that porcupine bezoars are expensive in Malaysia and Singapore despite the relative closeness to their place of origin. At the same time, they are not a very rare commodity due to the high volume in circulation in these places compared to other regions.

23.6 Concluding Remarks

This chapter focused on porcupine bezoars as a forest product and medicinal resource based on a multisited ethnographic study that began in source areas, continued through the downriver trading network and ended at metropolitan consumption points. Porcupine bezoars are ultimately ingested primarily by Malaysian Chinese consumers after they are dried, preserved and granulated. Taking porcupine bezoars is said by some people to be effective in curing dengue fever and cancers that are not perfectly treated with biological medical treatments. Indigenous populations, traders working as middlemen, and Chinese retailers and consumers in major cities are deeply involved in this broad commodity network in Southeast Asia.

Though the boom in porcupine bezoars seems to have suddenly and rapidly expanded in the Belaga basin in Sarawak, the trade of bezoars actually started quite a long time ago in the Baram basin and only began in the Jelalong basin in the 2000s.

Throughout our research in regions inhabited by indigenous people, we frequently heard that people who found porcupine bezoars received exceptionally large amounts of money for them, which enabled them to make important financial investments such as purchasing four-wheel-drive vehicles. Such stories about bezoar stones—whether real or exaggerated—have stimulated the imaginations and desires of the people there.

In the Baram basin, where the boom originated, the decrease in the porcupine population due to overhunting has become a concern for local residents. In response to this, a new commercial method was recently invented of keeping captive porcupines and feeding them oil palm fruits in an effort to induce the production of bezoars. Moreover, traders in towns are troubled by cleverly manufactured false porcupine bezoars.

Interesting phenomena were also observed in the regions where the boom started later, the Belaga and Jelalong river basins. For example, as a result of porcupines becoming popular game animals, family members eat porcupine meat much more frequently in the upper reaches of the Belaga. In addition, new traps are being used to catch porcupines coming to eat the fruit in oil palm plantations in the Jelalong basin and some porcupines are kept in captivity in the hope that bezoar stones will form in their stomachs. The use of such traps has been facilitated by the expansion of demand for porcupine bezoars from outside regions. Traders seeking bezoars in the interior distribute their business cards and circulate trading information, which have mobilised indigenous people. However, many indigenous inhabitants do not know who to sell these bezoars to, and thus variations in the progress of the boom depend on the different river basins.[5]

In terms of external factors that led to people's efforts to obtain porcupine bezoars, what needs to be examined further is the radical change in the surrounding natural environment that has occurred recent decades—that is, the expansion of oil

[5] Such differences concerning the progress of the boom are referred to in J. Peter Brosius (1995).

palm plantations that followed commercial forest logging in Sarawak's interior. We can surmise that indigenous people came to pay attention to porcupines and their bezoars as the opportunities to obtain them increased. This coincided with expectations of receiving thousands of ringgit if the porcupines had bezoar stones in their stomachs. It is predicted that the volume of supply increased in accordance with this trend, which then possibly stimulated the demand for bezoars, though there is no solid data to confirm this. We can, however, correlate the porcupine bezoar boom with the expansion of oil palm plantations and the increasing number of porcupine bezoars in the market.

These interactions between humans and nature can be called an 'inter-disturbance' (Soda 2009), which posits that it is not only humans who intervene in nature, but various nonhuman actors in the natural world also affect human society. In this study, we argue that the human demand for commercial logging and oil palm plantations resulted in a radical change in the landscape, causing porcupines and wild boars to spend more time foraging for food and feeding in plantation sites. This has in turn affected human social relations. The habitat changes of wild animals have influenced human activity. Indigenous people are now dedicated to hunting and livetrapping porcupines in plantations to obtain the 'stones of treasure', giving rise to more complex relationships between the natural and cultural milieus in rural Sarawak.

If the traders' viewpoints are included, a different perspective emerges. Traders contend that many porcupine bezoars are today generally obtained from porcupines in oil palm plantations, although these are of lower quality than those formerly obtained from porcupines in the rainforest. There is a resulting inverse relationship: as an increasing number of porcupines are killed in order to find bezoars, the overall porcupine population as well as the overall number of high-quality bezoars decreases (as reported by AP). It can be pointed out that the role of middlemen (such as LS, who personally uses porcupine bezoars for medicinal purposes) is important and demonstrates that some are aware of the effectiveness of the bezoars. On the other hand, the indigenous people, who are hunters involved in the direct capture of porcupines, do not know much about these stones except that they are used as a form of medicine.

The porcupine population might have increased with the expansion of oil palm plantations, but the future of this industry is harder to predict as the animal populations are becoming depleted for commercial purposes and the products can be said to be decreasing in quality. The current state of the trade is both complicated and opaque.

As stones from Sarawak and Indonesia have been exported to places such as Singapore and peninsular Malaysia for medicinal purposes, a market for porcupine bezoars exists beyond Sarawak. The retail market price is quite high, at approximately RM2500–2800 per g in Kuala Lumpur, which is about three times the price paid to indigenous people. Even so, in the local economy porcupine bezoars are like diamonds, as finding them allows indigenous people to afford things they have not been able to purchase in the past.

While porcupine bezoars have not been recognised within the medical practices of mainland China, their efficacy is known throughout Chinese communities of Southeast Asia where they are usually consumed by wealthy Chinese residents of Malaysia. Chinese entrepreneurs are now advertising porcupine bezoars through the internet, signalling that the market could expand further in the future.

References

Beeckman, Daniel. 1718 [1973]. *A voyage to and from the island of Borneo, in the East Indies*. Folkestone: Dawsons of Pall Mall.

Brosius, J. Peter. 1995. Bornean forest trade in historical and regional perspective: The case of Penan hunter-gatherers of Sarawak. In *Society and non-timber forest products in tropical Asia*, Occasional papers environmental series no. 19, ed. Jefferson Fox, 13–26. Honolulu: East-West Center.

———. 2013. The edible bird's nest commodity chain between Sarawak and East Asia. *Equatorial Biomass Society* 7: 1–6.

Everett, A. Hart. 1879. On the guliga of Borneo. *Journal of the Straits Branch of the Royal Asiatic Society* 4: 56–58.

Hoffman, Carl. 1986. *The Punan: Hunters and gathers of Borneo*. Ann Arbor: UMI Research Press.

Payne, Junaidi, and M. Francis Charles. 2005. *A field guide to the mammals of Borneo*. 3rd ed. Kota Kinabalu: The Sabah Society with WWF-Malaysia.

Soda, Ryoji. 2009. River improvement history in Japan: Rethinking human–nature interactions. Paper presented at the Third International Conference on Changing Nature of Nature: New Perceptions from Transdisciplinary Field Science, Kyoto University, Japan, 14–17 December.

Chapter 24
Estate and Smallholding Oil Palm Production in Sarawak: A Comparison of Profitability and Greenhouse Gas Emissions

Fumikazu Ubukata and Yucho Sadamichi

Abstract Using field data and information from a palm oil company and neighbouring independent smallholders in Sarawak, this research estimated the profitability and greenhouse gas (GHG) emissions of oil palm producers, and compared the outputs of estate and smallholder production systems. The results indicate that the estate and smallholders had unique operation styles and costs incurred, with the estate achieving greater productivity (and profitability) per hectare and higher GHG emissions per net profit when the emissions from land-use change were considered. Efficiency in terms of fertiliser application was key to explaining this difference. Nonetheless, it was evident that the overall cost efficiency of smallholders was not lower than that of the estate. If the effect of land-use changes is considered, estate production results in much higher GHG emissions (and hence greater environmental costs) than smallholder production. The results also indicate large variations in the costs, revenues and GHG emissions among smallholders. This may reflect less standardised aspects of operations and therefore a relatively high degree of flexibility in smallholder production, as well as other variables such as site conditions and the age of trees.

Keywords Sarawak · Oil palm plantations · Smallholders · Land-use change · Greenhouse gases

F. Ubukata (✉)
Graduate School of Environmental and Life Science, Okayama University, Okayama, Japan
e-mail: ubukat-f@okayama-u.ac.jp

Y. Sadamichi
Japan NUS Co., Ltd., Yokohama, Japan
e-mail: sadamichi-y@janus.co.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_24

24.1 Introduction

Increasing global demand for palm oil products has created a boom in oil palm plantations in Southeast Asian countries. The global production of palm oil has increased more than ninefold since the 1980s, and since 2005 palm oil has been one of the most consumed edible oils (Teoh 2010). In addition, palm oil and palm kernel oil can be processed into a wide variety of final products such as soaps, cosmetics and even biofuel. This versatility of products as well as the highest per hectare productivity among oil crops makes oil palm a promising plantation crop in tropical regions.

Malaysia and Indonesia, the dominant producers of palm oil, jointly account for more than 80% of global production, which has contributed significantly to their national economies. These industries accounted for around 9% of the total commodity export value in each country in 2013 (Department of Statistics Malaysia 2013; Statistics Indonesia 2014).

However, this boom has led to fundamental changes in the rural landscapes of tropical countries. For example, some researchers have described transformations in rural societies and the viewpoints and opinions held by villagers who are directly affected by these land-use changes (Colchester and Chao 2011, 2013; Pye and Bhattacharya 2013), while others have commented on the ecological damage wrought by oil palm plantations (Fitzherbert et al. 2008). It is therefore important to consider how the balance among economy, environment and society in these areas has changed after the introduction of oil palm.

A key to understanding this shift in balance lies in the coexistence of the oil palm industry and local societies, and the consideration of social equity and fairness. Historically, agroindustrial development in tropical areas created a ‘dual economy’ in rural areas (Boeke 1953). Plantation estates established in colonial times have become enclaves unto themselves, characterised by poor industrial relations, and hence scant economic benefits to neighbouring local communities. In the case of oil palm production, it is generally believed that production by plantation estates outstrips that by local small-scale producers because of the perishability of fresh fruit bunches, economies of scale and the high degree of integration of downstream industries.[1] Based on this conventional understanding, many government officers and palm oil company managers, both in Sarawak and elsewhere, adhere to ‘policy narratives’ (Cramb 2011). Thus oil palm production from estates is prioritised, such as granting concession rights over state land and introducing joint venture schemes for the utilisation of native customary rights land into plantations, though a number of these joint venture schemes have had somewhat negative outcomes.

Contrary to these narratives, however, an increasing number of studies have reported the emergence of small-scale local oil palm producers who are categorised as smallholders (Cramb and Curry 2012; Cramb and Sujang 2013; Nagata and Arai

[1] In order to avoid degradation of oil quality, harvested fresh fruit bunches must be transported to oil mills and processed into crude palm oil within 48 h. Many estates find it advantageous to integrate oil mills into their plantation operations.

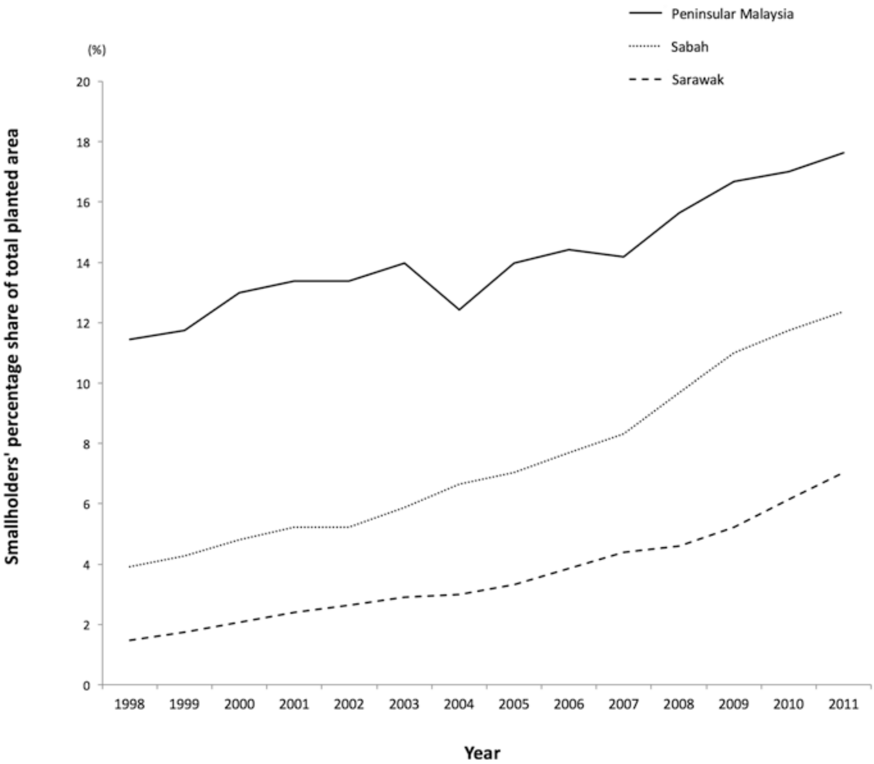


Fig. 24.1 Smallholders' share of oil palm plantation area in Malaysia
Source: MPOB (1999–2011)

2013).[2] Smallholder production as a percentage of overall oil palm production and total oil palm planted area in Malaysia has also increased in line with recent industrial development (Fig. 24.1). Bearing these new trends in mind, some economists have also attempted to compare the cost and benefit structures of different production systems such as estates and smallholders (Azman et al. 2003). In Sarawak, Rob Cramb and Deanna Ferraro (2012) estimated the costs and benefits of various modes of oil palm production systems. They showed the economic viability of smallholdings on native customary land and indicated the existence of a political bias towards large-scale operations. However, their study is based mainly on model estimations, using many assumptions such as the data for yields and so on.

[2] In reality, producers can be subdivided into several more categories. For instance, Cramb (2011) classified producers in Sarawak into five categories: (1) independent smallholders; (2) organised smallholders (under government schemes such as Sarawak Land Consolidation and Rehabilitation Authority [SALCRA] and Federal Land Consolidation and Rehabilitation Authority [FELCRA]); (3) private estates; (4) publicly owned estates; and (5) joint venture estates on customary land. All smallholders in this chapter are independent smallholders who enjoy complete autonomy over the management of their smallholdings.

Another major consideration is the balance between the economy and the environment. In this regard, many studies have analysed the environmental impact of the industry. Using life-cycle assessment, the Malaysian Palm Oil Board (MPOB) estimated the environmental impacts of different phases of oil palm plantation (Zulkifli et al. 2010) and crude palm oil production (Subramaniam et al. 2010). In the same context, many studies have shed light on greenhouse gas (GHG) emissions that contribute to global warming from estates producing palm oil for energy. For example, Mohd Nor et al. (2011) and Birka Wicke et al. (2008) analysed the GHG emissions of biodiesel production from palm oil in Malaysia and revealed that land-use change is a key parameter in increasing GHG emissions.

However, these studies did not address the differences in GHG emissions from land-use change between different types and scales of oil palm producers. As their data are primarily sourced from estates, few studies have focused on local smallholders in the industry. In addition, few attempts have been made to integrate the analyses of profitability and GHG emissions. In other words, economic and environmental performances have not been analysed together. In order to create a fair and balanced view between economic, societal and environmental viewpoints, we believe that it is crucial to integrate these multifaceted concerns, particularly with the involvement of local actors in the industry. Thus, using actual field information from a palm oil company and neighbouring independent smallholders in Sarawak, this research calculated costs, revenues and GHG emissions of oil palm production and compared the outputs of each production system. It is also worth noting that this chapter provides a much-needed interdisciplinary overview of the topic, given that it is a collaboration between a researcher on rural economics and a mechanical engineer.

24.2 Methodology

24.2.1 Data Collection

We obtained data for this study from two different sources: an anonymous palm oil producing company (hereafter 'the estate') and independent smallholders in Bintulu Division, Sarawak, Malaysia. All data were collected in August and November 2011 and September 2012. Authorities at the estate provided access to internal information, including field management information, costs and returns, and material inputs and outputs for 2010. According to a company staff member, the company began its planting programme in 1997, and by 2011 its oil palm estate had expanded to over 5000 ha across 10 production units (also known as divisions). Table 24.1 presents the basic profiles of these selected estate plots/divisions based on the data available. The estate produces approximately 120,000 tonnes of fresh fruit bunches each year, and the attached mill produces approximately 47,000 tonnes of crude palm oil annually. Although this figure is relatively small compared to that of the other estates, the company is regarded as one of the progressive cases in Sarawak in terms of productivity, operation and management.

Table 24.1 Profiles of selected estate plots

Plot name	Initial planting year	Total area planted (ha)	Initial cost data	Annual cost data	Total FFB production (t)	FFB produced per ha (t) in 2010
PT-1	1997	782.1	No	Yes	21,113	27.0
PT-2	1998	1486.7	No	Yes	40,134	27.0
PT-3	1998	380.1	No	Yes	10,264	27.0
PT-4	1999	672.4	No	Yes	19,500	29.0
PT-5	2000	447.6	No	Yes	12,980	29.0
PT-6	2001	82.6	No	Yes	2396[a]	29.0
PT-7	2002	31.0	No	Yes	900	29.0
PT-8	2005	499.5	Yes	Yes	12,987	26.0
PT-9	2006	639.1	Yes	Yes	12,781	20.0
PT-10	2007	325.7	Yes	Yes	4886	15.0
Average	–	5346.9	–	–	–	–

Source: Field surveys in August and November 2011 and September 2012
Note: [a]denotes an estimated value

Table 24.2 Basic profiles of selected smallholder plots

Plot name	Initial planting year	Experience selling products	Total number of palms	Estimated total area planted (ha)	Grouping	Land use prior to oil palm cultivation
SH-A	2004	Yes	2800	18.7	Pioneer	Shifting agriculture
SH-B	2008	Yes	500	3.3	Follower	Rice field
SH-C	2008	Yes	200	1.3	Follower	Timber basin
SH-D	2008	Yes	200	1.3	Follower	Rubber plantation
SH-E	2008	Yes	500	3.3	Follower	Natural forest
SH-F	2011	No	100	0.7	Follower	Natural forest
SH-G	2004	Yes	200	1.3	Pioneer	Vegetable field
SH-H	2003	Yes	2700	18.0	Pioneer	Shifting agriculture
SH-I	2003	Yes	2500	16.7	Pioneer	Shifting agriculture
Average	–	–	1078	7.2	–	–

Source: Field surveys in August and November 2011 and September 2012
Note: The total planted area was estimated by multiplying the total number of trees with the recognised standard number of palms per ha (150 trees per ha)

With regard to independent smallholders, we conducted field interviews with nine smallholders located near the estate. We obtained information about household profiles, reasons behind engaging in oil palm production, costs, returns and material inputs. Table 24.2 presents the basic profiles of the smallholders who participated in this study. Two of them began planting in 2003, two began in 2004, four began in 2008 and one began in 2011. Eight of them have already begun harvesting fresh fruit bunches. In order to obtain accurate data about profitability, we divided the smallholders into two groups: 'pioneer' households that began planting during the period 2003–2004 and 'follower' households that began planting after 2008. The average planted area is around 7 ha, although two different groups exist in terms of size. One group consists of pioneer households whose holdings exceed 10 ha. All pioneer households have gradually expanded their plantation areas since their first planting. For the followers, the planting areas are much smaller, ranging from 0.7 to 3.3 ha.

24.2.2 Calculation and Analysis

Based on the data, we calculated both the profitability and GHG emissions of the estate and smallholders. Further, we compared the differences between them in terms of both economic efficiency and GHG emissions on a per hectare basis. We applied the following methodological procedures in the evaluation.

24.2.2.1 Profitability

Since there were limitations in the data obtained, we established the following methodological assumptions and formats. First, in the estate data, division-wise costs and revenue information were available, but this information appeared in gross figures for each operation (such as land preparation, fertilising and harvesting) and format (costs to maturity and after maturity). Thus, to the extent possible, we applied original definitions when calculating costs and revenues. For example, we divided them into two parts: initial investment costs to maturity (assumed to be 4 years from planting) and annual costs after maturity (from the fifth year onwards). These were calculated independently. We did not rearrange cost items according to production factors (such as labour and capital); rather, we used the original definitions of operation-based items.

Second, we could not obtain reliable data for indirect management costs in estate production (such as housing and welfare costs for estate workers) and non-cash costs in the smallholders' production. Therefore, we focused only on the cash-based operation costs of oil palm production.

Third, we adjusted the effect of inflation as the data span several years. Thus, except for some smallholder cases for which 2011 prices were already available, all the data were adjusted to 2011 prices and values by using the consumer price index of the Malaysian economy (ADB 2007). Moreover, we compared several categories of samples in the analysis to avoid any biases due to inflation and the age of the plantation. For example, data from production units with similar ages (8–9-year-old plantations) were compared to each other as well as to the average of the estate and the average of the smallholders.

Fourth, year-by-year data were not available for the initial cash investments of estate production. Thus we assumed that all initial investments were made in the first year of estate production. These adjustments may occasionally overestimate the price increase of some material inputs but we believe this method to be the simplest and a reasonable one given the limitations of the existing data set. In addition, we assumed a 20-year production period, and that initial costs were evenly distributed across the period while calculating the initial costs and annual costs.

Fifth, the price of fresh fruit bunches was set to RM500 per tonne for the estate. For smallholders, we used the same price except for smallholders who sell to middlemen. This step was largely justified from the interview results. Finally, we did not estimate the net present values for either producer type because doing so would have entailed voluminous assumptions (such as yield curves, input and output prices, and discount values) which may have been unreliable. Although this could be a limitation in assessing the profitability of the whole production period, we prioritised simplicity and original data for the integration with GHG emission analysis.

24.2.2.2 GHG Emissions

Among the multitude of environmental issues of concern in regard to oil palm production, this chapter focuses largely on global warming and GHG emissions. In order to estimate GHG emissions from oil palm production, a system boundary was set (Fig. 24.2). The GHG emissions were calculated across the following stages: land-use change, land preparation, preparation of seedlings, fertilising, pest control (both of weeds and insects) and transport. The GHGs considered during each stage included carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The emissions for each GHG were first calculated from the data collected in this study. The results were then converted into kilograms of equivalent carbon dioxide (kg-CO_2eq) based on each GHG's respective potential for global warming. Lastly, the emissions were summed up in terms of totals per hectare per year of oil palm cultivation. The equation used for these calculations is as follows:

$$\text{GHG emissions}\left[\text{kg}-\text{CO}_2\text{eq}\right]=\sum_i\sum_j\left(E_{i,j}\times P_j\right)$$

i: a stage in the palm oil production system (land-use change, land preparation, preparation of seedlings, fertilising, pest control or transport).
j: a GHG (either CO_2, CH_4 or N_2O).
$E_{i,j}$: emissions of gas j at stage i.
P_j: global warming potential for gas j.

The following section describes the methods used to calculate GHG emissions and the assumptions made for this study.

Land-Use Change According to the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC), GHG emissions for land-use change are computed from carbon loss and gain by comparing the above- and below-ground biomass (IPCC 2006). In this stage, carbon is mainly lost on account of biomass loss during land clearing before oil palm cultivation begins, whereas carbon is gained with the growth of oil palm trees after cultivation begins. Accurate estimates of

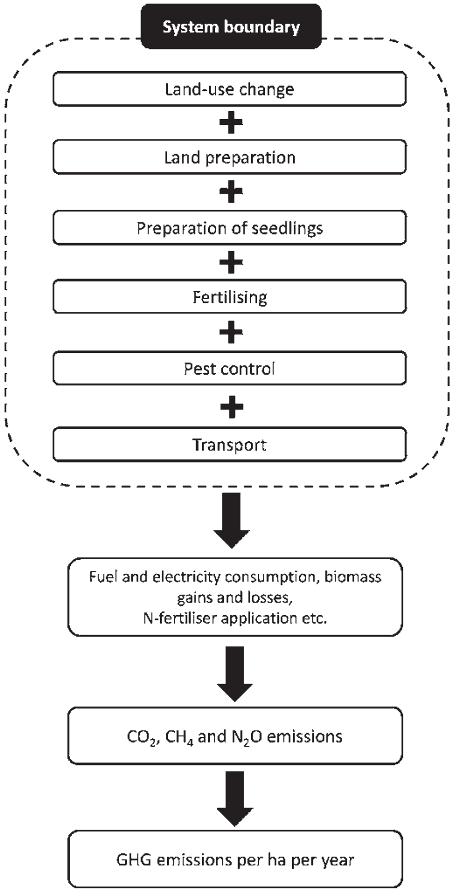


Fig. 24.2 System boundary for the calculation of GHG emissions in this study

carbon loss and gain require close examination and measurement of actual carbon stocks in the fields before and after cultivation. However, because of the time limitations of this research, we employed the default values for biomass stock provided by the IPCC to estimate the land-use change emissions. For smallholders, the land uses prior to oil palm cultivation are presented in Table 24.2. For the estate, the land was natural forest prior to palm oil cultivation.

Land Preparation In the land preparation stage, the land on which oil palm trees are to be planted is cleared using machinery, chainsaws, open burning and so on. As GHG emissions from the burning of biomass are included in the stage of land-use change, only GHG emissions associated with fuel combustion were calculated in this stage. Diesel and gasoline are used as fuel for the clearing machinery by both the estate and the smallholders. GHG emissions for this stage were calculated by multiplying the diesel and gasoline consumption with default emission factors from the IPCC for the respective fuel types.

Preparation of Seedlings The seedlings of the oil palm tree require water and fertiliser to grow. For this stage, this research considered two sources of GHG emissions: (1) fertiliser production; and (2) application of nitrogen fertiliser. GHG emissions from fertiliser production arise from emissions associated with fuel or electricity use, which are calculated by multiplying the amount of fertiliser consumed with the default emission factors provided by the International Sustainability and Carbon Certification (ISCC) for the respective fertilisers (ISCC 2011). GHG emissions from the application of nitrogen fertiliser arise from emissions of N_2O after the fertilisers are applied to the field and they are calculated by multiplying the volume of nitrogen fertiliser consumption with the corresponding default emission factor provided by the ISCC.

In order to compute emissions per hectare per year from the three above-mentioned stages, the emissions estimated for each stage were divided by 20 years, which is the commonly assumed cultivation period for both the estate and the smallholders.

Fertilising Four types of fertilisers were applied in estate production, whereas the smallholders utilised only one or two types of fertilisers. The emissions from fertiliser production and N_2O emissions from nitrogen fertiliser were calculated in the same manner as described in the preparation of seedlings. Total annual fertiliser consumption was used to calculate per year GHG emissions.

Pest Control Several types of agrochemicals including pesticides and herbicides are applied in oil palm plantations. GHG emissions from the production of these agrochemicals were calculated by multiplying the annual amount of agrochemicals used in the field with the default emission factors provided by the ISCC (2011).

Transport Once harvested, the fresh fruit bunches are taken to collection points and then transported to nearby processing mills. GHG emissions for the estate were calculated by multiplying the distance from each plot to the mill by the distance-based emission factors (kg-CO_2eq km^{-1}) for truck transportation (IPCC 2006). Similarly, in calculating transport-based emissions for smallholders, we first estimated the distances from the respective smallholder's cultivation fields to the mills via collection points. Then we multiplied the distances by the relevant emission factors (kg-CO_2eq km^{-1}) (IPCC 2006).

24.3 Results and Discussion

24.3.1 Comparative Profitability

As described above, the costs and returns of oil palm production were compared on a per hectare basis between the estate and smallholders. They were divided into two parts: (1) initial investments to maturity; and (2) annual costs and revenues after maturity. A summary of the initial investments over 4 years by the estate and smallholders is presented in Table 24.3, and annual costs and revenues after maturity are presented in Table 24.4. Noting all the limitations described in the previous section, the comparison between estate and smallholder production reveals the following three aspects.

First, the data indicate that the estate and smallholders have different cost structures. In the former, fixed investments (such as land preparation and infrastructure development) comprise a major proportion of costs, while material costs (such as fertiliser input) are more prevalent for smallholders. In smallholder production, land preparation is performed using mainly family labour and expensive operations such as terracing are not undertaken. These aspects considerably lower the expenditure for smallholders compared to the estate.

It is striking that the cost of fertilising is higher in smallholder production. This is because smallholders tend to apply more fertiliser per hectare, which entails higher costs and indicates lower production efficiency and poor economies of scale. It is not clear why smallholders apply more fertiliser per hectare. One possible reason is that they may equate higher fertiliser application with higher yield given their limited production areas; smallholders often space trees closer during planting than in estate production due to less available land and labour. Another reason may be the absence of terracing for preventing soil erosion and nutrient leaching. However, further studies are necessary to confirm these hypotheses.

Second, smallholders have lower initial financial investments than the estate, but also have lower levels of production and thus earn less revenue. It appears that the high fertiliser input is not reflected in smallholders' yields which results in lower profits per hectare. In addition, some smallholders could only sell their fresh fruit bunches for lower prices and paid higher transportation costs due to poor or limited transportation options. For example, some smallholders (SH-B and SH-G) had to pay 10% margins to their acquaintances for transporting their fresh fruit bunches to a collection point, where a middleman then purchased them. Thus profitability in terms of the total revenue generated tends to be higher for the estate than the smallholders. Nonetheless, it is clear that production efficiency is not likely to be drastically different; this is evident in the fact that the revenue per cost ranges between 2.14 and 2.40 when we compare 8–9-year-old plantations of both the estate and smallholders. Moreover, smallholders record an even higher efficiency when we consider the initial costs in the calculation. This is clearly seen from the fact that both the costs and the revenues of pioneer smallholders are as large as 67–70% of those of the estate divisions of similar plantation ages. This implies that when cost efficiency is examined, the potentiality of smallholders may not be lower than that of the estate, reinforcing the findings of Cramb and Ferraro (2012).

Third, we found larger variations of costs and revenues among smallholders than among estate divisions (Fig. 24.3). In order to examine the factors that influence the variation, we subcategorised smallholders into several sets of groups—such as pioneers/followers, previous land use and cultivation scale—and compared costs and revenues. Only the results for the 'previous land use' group differ significantly, thereby indicating that the costs of oil palm cultivation using former croplands are higher than those using former forests and timber basins. Though the reasons for

Table 24.3 Per hectare initial costs[a] of oil palm production based on prices in 2011

Costs	Estate (average of plots 8, 9 and 10)		Smallholders (average of all the smallholders)		Smallholders (average of 'pioneer' group)	
Planted area (ha)	1464.3		7.2		13.7	
	Cost (RM)	Percent of total costs	Cost (RM)	Percent of total costs	Cost (RM)	Percent of total costs
Land preparation and capital investment	2179	22.5	95	1.4	94	1.5
Seedling and planting	1085	11.2	1165	16.8	604	9.6
Fertilising	1774	18.3	3933	56.8	4361	69.5
Pest control	1168	12.1	1114	16.1	588	9.4
Estate general overhead costs[b]	1911	19.8	0	0.0	0	0.0
Others (such as tools and transport)	1553	16.1	620	9.0	631	10.0
Total initial costs	9670	100.0	6927	100.0	6278	100.0
Initial costs divided by production years (20 years)	484	–	346	–	314	–

Source: Field surveys in August and November 2011 and September 2012
Note 1: Costs calculated include both the material cost and employed labour inputs and costs were adjusted to 2011 prices and values by using the CPI of the Malaysian economy using data from ADB
Note 2: [a]Initial costs are those incurred in the first 4 years of operation, before palm trees reach maturity and before they begin producing fresh fruit bunches that can be harvested
Note 3: [b]Estate general overhead costs related to the management of the estate and this was assumed to be zero for smallholders

Table 24.4 Per hectare annual costs and revenues of oil palm production based on prices in 2011

Costs	Estate (all plots)		Estate (sum of plots 6 and 7 which are 8–9-year-old plantations)		Smallholders (average of all smallholders producing fresh fruit bunches)		Smallholders (average of pioneers with 8–9-year-old plantations)	
Planted area (ha)	5347		113.6		8.0 (average)		13.7 (average)	
	Cost (RM)	Percent of total costs	Cost (RM)	Percent of total costs	Cost (RM)	Percent of total costs	Cost (RM)	Percent of total costs
Fertilising	2070	41.0	1657	26.4	2204	63.0	3023	71.3
Pest control	286	5.7	294	4.7	250	7.1	83	2.0
Transport[a]	379	7.5	277	4.4	703	20.1	563	13.3
Harvesting	818	16.2	913	14.5	224	6.4	449	10.6
Other farm operations[b]	88	1.7	82	1.3	0	0.0	0	0.0
Other capital inputs[c]	1411	27.9	3058	48.7	119	3.4	123	2.9
Total annual costs	5052	100.0	6281	100.0	3500	100.0	4241	100.0
Initial costs divided by production years (20 years)[d]	484	–	484	–	346	–	314	–
Harvested products (tonnes)	25.8	–	29.0	–	17.7	–	21.4	–
Revenue	12,899	–	14,498	–	8063	–	10,270	–
Annual net profit	7847	–	8217	–	4564	–	6030	–
Revenue per annual cost	2.55	–	2.3	–	2.3	–	2.4	–
Annual net profit minus initial costs	7363	–	7733	–	4218	–	5716	–
Revenue per cost (initial plus annual)	2.33	–	2.14	–	2.10	–	2.26	–

Source: Field surveys in August and November 2011 and September 2012
Note 1: Costs calculated include both the material cost and employed labour inputs
Note 2: [a]This includes general transport, field transport and transport of fresh fruit bunches
Note 3: [b]This includes pest and disease control, pruning and supervision
Note 4: [c]This includes infrastructure, tools and water management
Note 5: [d]Assuming same initial costs for all estate categories and applying average initial costs of all smallholders to all fresh fruit bunch producing smallholders with the costs stated in Table 24.3

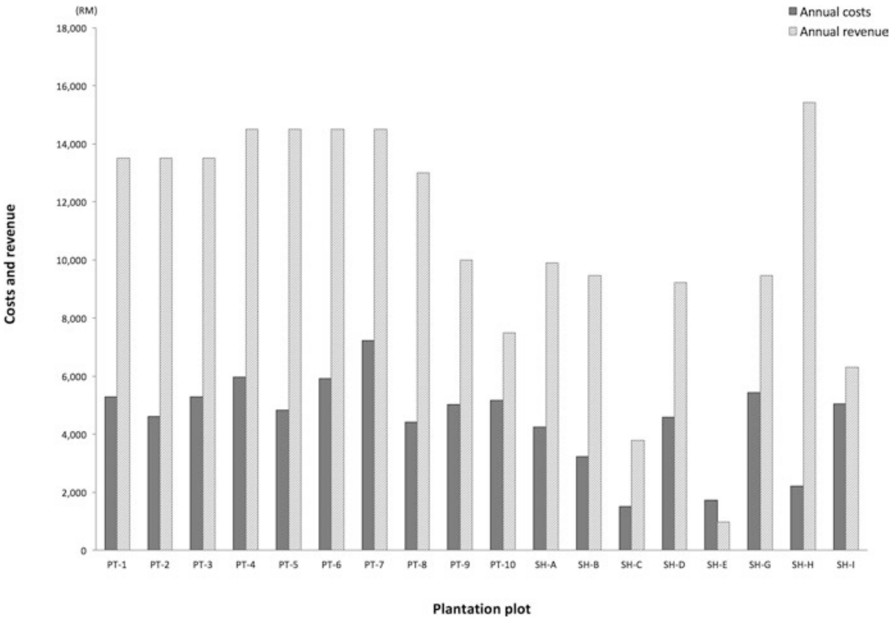


Fig. 24.3 Variations in total annual costs and revenue from oil palm production
Source: Field surveys in August and November 2011 and September 2012
Note: PT denotes estate plots and SH denotes smallholders

this may be unclear, it is possible that the soils of former cropland may be less fertile than the soils of forests and timber concessions, requiring more fertiliser though this is merely an assumption.

In contrast, the lower revenues in plots 8, 9 and 10 of the estate compared to other plots can be attributed mainly to younger palm trees. Although the sample size is small, these simple comparisons enforce the view that the production performances of smallholders vary greatly on an individual basis.

We can propose two possible explanations for this result. The first explanation is that smallholder production is flexible in terms of labour and material usage. For example, a smallholder (SH-C) who has no time to work in his oil palm field (as he often works at a logging camp) employs part-time workers for planting seedlings, while the others utilise self-supplied labour. Two smallholders (SH-A and SH-I), who have relatively large cultivation areas, rely on Indonesian workers for harvesting their fresh fruit bunches. Some smallholders (SH-H and SH-I) also utilised the aid scheme devised by the palm oil company in the early 2000s for obtaining materials such as seedlings and fertilisers.

The second possible explanation is that the smallholders' production is not standardised in terms of location, operations and management. For example, even in a single operation spanning 4 years, the cost of fertiliser application per hectare ranged from RM1189 to RM6509 among smallholders.

Overall, these results may partly suggest that the estate enjoys higher land productivity and profitability, which is in agreement with conventional opinions. Nonetheless, it is impressive that smallholder production is also highly profitable and their cost-effectiveness (although varying considerably among individuals) is almost as high as that of the estate. This indicates the high potential and flexibility of smallholder production, as has been implied in previous studies (see Cramb and Sujang 2013). Smallholder inclusion (or the promotion of smallholdings) is thus desirable not just from the viewpoint of social equity but also from that of the industry. On the other hand, a lower degree of standardisation among smallholdings may be problematic from an industrial viewpoint. A greater and more widespread exchange and dissemination of efficient smallholding practices and other useful technical information may overcome these obstacles.

24.3.2 Comparative GHG Emissions

GHG emissions on a per hectare basis from oil palm production are presented in Table 24.5. It is evident that the largest GHG emissions come from land-use change and there is a large difference between the GHG emissions of the estate and smallholders. This is because the plantations for the estate were usually converted from forests, whereas most smallholders began oil palm cultivation on the cropland they already held. Since the carbon stock in forests is usually higher than that in croplands, the carbon loss caused by forest clearing results in a greater loss of carbon stocks than that caused by cropland clearing. Although a portion of the carbon emitted is not immediately converted into CO_2 after the land clearing (for example, the cut timber may be used for furniture), this research assumed that all the carbon so 'removed' from the land is ultimately released into the air in the form of CO_2. In Table 24.5 the negative emissions from land-use change indicate that the amount of carbon lost by clearance of cropland is smaller than the amount of carbon gained by the growth of the oil palm trees. Positive emissions indicate that the carbon loss due to forest clearing exceeds the carbon gains. Some previous studies have also pointed out that conversion from forests to oil palm plantations results in considerable GHG emissions while conversion from degraded land to plantations reduces these emissions (Wicke et al. 2008; Mohd Nor et al. 2011).

The second largest source of emissions is fertilising, which is responsible for CO_2 and N_2O emissions from chemical fertiliser production and nitrogen fertiliser application, respectively. The comparison of these emissions between the estate and smallholders for eight-year-old oil palm trees shows that the emissions of smallholders exceed those of the estate. This is because smallholders apply more nitrogen fertiliser on a per hectare basis, as described in Sect. 24.3.1. Our field observations indicate that it is likely that smallholders tend to overuse nitrogen fertiliser because of their lack of knowledge in proper fertiliser application, while the estate uses fertiliser more accurately based on periodical measurements of the nitrogen content in the leaves of the trees.

Table 24.5 Per hectare GHG emissions from oil palm production

	Estate (all plots)		Estate (sum of plots 6 and 7 which are 8–9-year-old plantations)		Smallholders (average of all smallholders producing fresh fruit bunches)		Smallholders (average of 'pioneers' with 8–9-year-old plantations)	
Source of GHG emissions	kg-CO_2eq	Percent of total GHG emissions[a]	kg-CO_2eq	Percent of total GHG emissions[a]	kg-CO_2eq	Percent of total GHG emissions[a]	kg-CO_2eq	Percent of total GHG emissions[a]
Land-use change	5867	–	5867	–	−8135	–	−12,467	–
Land preparation	0	0.0	0	0.0	0	0.0	0	0.0
Preparation of seedlings	0	0.0	0	0.0	7	0.0	8	0.0
Fertilising	1400	74.0	1611	76.0	1045	57.0	1892	74.0
Pest control	58	3.0	62	3.0	371	20.0	242	9.0
Transport	440	23.0	440	21.0	402	22.0	431	17.0
Total GHG emissions without land-use change	1898	100.0	2113	100.0	1825	100.0	2573	100.0
Total GHG emissions with land-use change	7765	–	7980	–	−6310	–	−9894	–
GHG emissions per net profit without land-use change	0.26	–	0.27	–	0.43	–	0.45	–
GHG emissions per net profit with land-use change	1.05	–	1.03	–	−1.50	–	−1.73	–

Source: Field surveys in August and November 2011 and September 2012
Note 1: Negative values of GHG emissions indicate carbon sequestration
Note 2: [a]This is excluding GHG emissions from land-use change

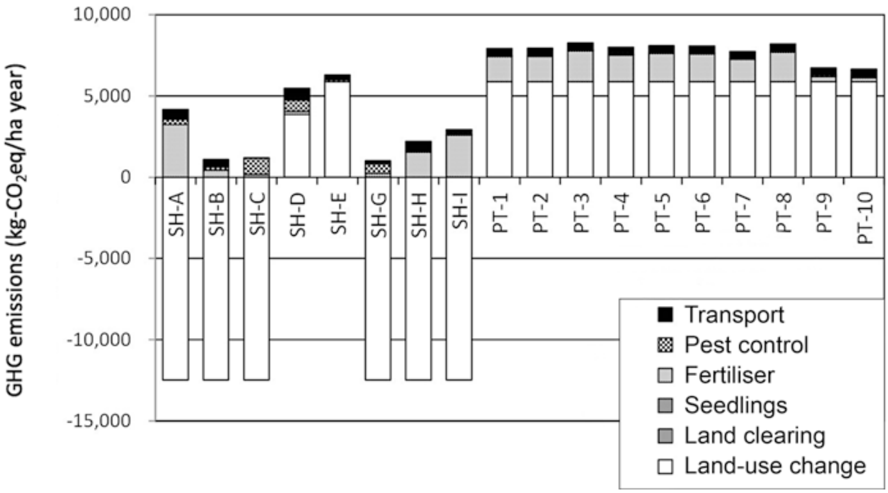


Fig. 24.4 Variations GHG emissions per hectare per year from oil palm production
Source: Field surveys in August and November 2011 and September 2012

Figure 24.4 depicts a closer examination of the differences in GHG emissions per hectare by smallholder type. The figure indicates large variations in GHG emissions among smallholders. These variations arise, first, from differences in land use prior to oil palm cultivation, and second, from differences in the amounts of fertilisers and agrochemicals applied to the soil. Coupled with the results from the analysis of profitability, these findings imply that smallholders' management skills in oil palm cultivation vary widely on an individual basis.

24.3.3 GHG Emissions vis-à-vis Profits

In order to simultaneously evaluate economic and environmental performance, we conducted a combined analysis of the profitability and GHG emissions described in Sects. 24.3.1 and 24.3.2, respectively. GHG emissions per net profit for both the estate and the smallholders were calculated by dividing GHG emissions per hectare by the annual net profit per hectare (while factoring in initial investment costs over the life of the plantation). The results are displayed in Table 24.5. In order to emphasise the differences in cultivation practices between the estate and smallholders, we compared the results of GHG emissions per net profit with and without land-use change in Fig. 24.5.

For GHG emissions per profit that exclude land-use change, the result shows that the emissions from smallholders are larger than those from the estate. This indicates that for every RM1 of annual profit, smallholders emit more GHGs than the estate. As noted previously, this result can largely be attributed to the higher fertiliser use of smallholders coupled with their lower yields. Since this condition could be possibly due to a lack of sufficient knowledge about fertiliser application, there is a

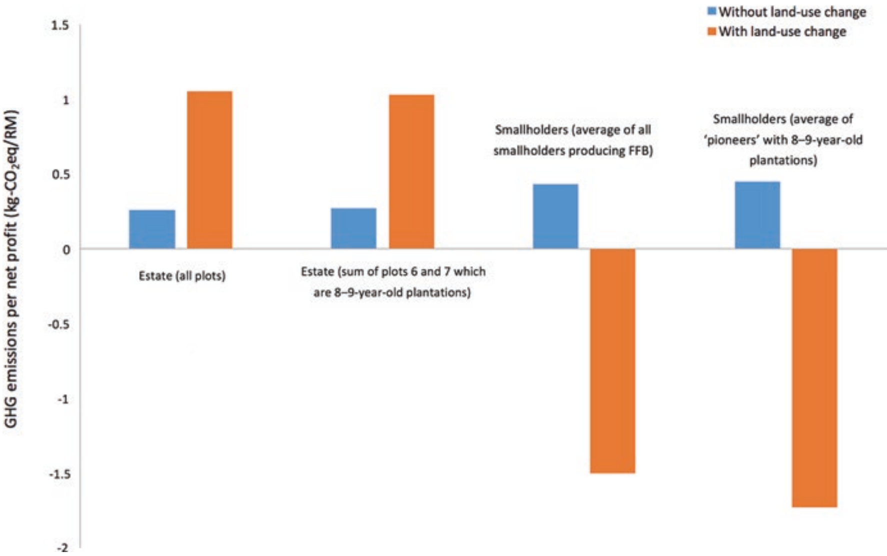


Fig. 24.5 GHG emissions per profit for the estate and smallholders
Source: Field surveys in August and November 2011 and September 2012

sizeable potential for a reduction of GHG emissions per profit by improving smallholders' management practices; this may be effectively achieved by providing appropriate information or training and enabling useful technology transfer to the smallholders. In contrast, in terms of GHG emissions per profit that include land-use change, smallholders produce lower emissions than the estate because smallholders use lands with lower carbon stocks (such as existing croplands) to establish new oil palm plantations. However, the future GHG emissions of both the smallholders and the estate will therefore depend greatly upon the type of land that is converted into new plantations. Regardless of the type of oil palm producers, the conversion of lands with high carbon stocks (primary forests) results in high emissions, and thus regulatory mechanisms are necessary to provide incentives to preferentially convert lands with lower carbon stocks.

24.4 Conclusion

In this chapter, we calculated the profitability and GHG emissions of oil palm production in Sarawak, using data obtained directly from an estate company and smallholders. Despite the limitations of the data, we offer the following conclusions from the results of the analysis. First, the estate and smallholders had unique operation styles and cost structures. Second, the estate was more productive and profitable in terms of per hectare and per unit GHG emissions when the effect of initial land clearance (land-use change) was excluded. The estate's superior efficiency in terms of fertiliser application accounts for this difference.

Nonetheless, it is important to note that the cost efficiency of smallholders is not much lower than that of the estate. Indeed, when the following aspects as well as social equity are considered, it would be wrong to generalise the result that the estate performed better: (1) if we consider the effect of land-use change, the estate does emit more GHGs and hence entails greater environmental costs than the smallholders; and (2) the estate that consented to this research is regarded as one of the more progressive oil palm companies in Sarawak, and thus its performance may be biased and vary significantly from the average performance of oil palm companies in the state. Finally, the results also indicate large variations in costs, revenues and GHG emissions among smallholders. This may imply less standardised aspects in smallholder production as well as other variances such as site conditions and the age of trees.

Therefore, the overall results of this research point to the high potential and flexibility of smallholders, which may partly explain their high cost efficiency. Their production system is also economically viable and if they utilise land with lower carbon stocks, smallholding could be a better option for reducing GHG emissions. Considering that most estate-based productions begin operations by taking over forested areas with high carbon stocks, these results have important implications for ongoing plantation development in Southeast Asia and elsewhere. Smallholder inclusion not only improves the social equity of the industry, but their small scale and flexibility have the potential to enhance both economic and environmental efficiency.

However, the lower degree of standardisation among smallholders can also be seen as a constraint, as it is problematic from an industry viewpoint. The other potential concern related to smallholders is the uncontrolled expansion of plantations that is likely to damage the natural environment. Thus a regulatory mechanism that provides incentives to preferentially use land with low carbon stocks may contribute to reducing GHG emissions. Measures to utilise smallholders' potential and improve their shortcomings are likely to help balance economic, social and environmental concerns about oil palm plantations and secure a sustainable future of the industry.

Acknowledgements This study was supported by the Grants-in-Aid for Scientific Research (S) of the Japan Society for the Promotion of Science for the project titled 'Planted Forests in Equatorial Southeast Asia: Human-Nature Interactions in High Biomass Society'. The authors would like to express their gratitude to the estate company staff and smallholders in Sarawak for their sincere cooperation during the research.

References

Asian Development Bank [ADB]. 2007. Statistical database system. https://sdbs.adb.org/sdbs/index.jsp. Accessed 9 July 2018.

Azman, Ismail, Mohd Arif Simeh, and M. Mohd Noor. 2003. The production cost of oil palm fresh fruit bunches: The cases of independent smallholders in Johor. *Oil Palm Industry Economic Journal* 3 (1): 1–7.

Boeke, Julius Herman. 1953. *Economics and economic policy of dual societies as exemplified by Indonesia*. New York: International Secretariat, Institute of Pacific Relations.

Colchester, Marcus, and Sophie Chao, eds. 2011. *Oil palm expansion in South East Asia: Trends and implications for local communities and indigenous peoples*. Moreton-in-Marsh: Forest Peoples Program and Bogor: Perkumpulan Sawit Watch.

———, eds. 2013. *Conflict or consent? The oil palm sector at a crossroads*. Moreton-in-Marsh: Forest Peoples Programme, Bogor: Perkumpulan Sawit Watch and Jakarta: Transformasi untuk Keadilan Indonesia.

Cramb, Rob A. 2011. Re-inventing dualism: Policy narratives and modes of oil palm expansion in Sarawak, Malaysia. *Journal of Development Studies* 47 (2): 274–293.

Cramb, Rob A., and George N. Curry. 2012. Oil palm and rural livelihoods in the Asia–Pacific region: An overview. *Asia Pacific Viewpoint* 53 (3): 223–342.

Cramb, Rob A., and Deanna Ferraro. 2012. Custom and capital: A financial appraisal of alternative arrangements for large-scale oil palm development on customary land in Sarawak, Malaysia. *Malaysian Journal of Economic Studies* 49 (1): 49–69.

Cramb, Rob A., and Patrick S. Sujang. 2013. The mouse deer and the crocodile: Oil palm smallholders and livelihood strategies in Sarawak, Malaysia. *Journal of Peasant Studies* 40 (1): 129–154.

Department of Statistics Malaysia [DOS]. 2013. Monthly external trade statistics, December 2013. http://www.statistics.gov.my/portal/index.php?option=com_content&view=article&id=2248&Itemid=111&lang=en. Accessed 9 July 2018.

Fitzherbert, Emily B., Matthew J. Struebig, Alexandra Morel, Finn Danielsen, Carsten A. Brühl, Paul F. Donald, and Ben Phalan. 2008. How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution* 23 (10): 538–545.

Intergovernmental Panel on Climate Change [IPCC]. 2006. *2006 IPCC guidelines for national greenhouse gas inventories*. Prepared by the National Greenhouse Gas Inventories Programme, ed. Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara, and Kiyoto Tanabe. Japan: Institute for Global Environmental Strategies.

International Sustainability and Carbon Certification [ISCC]. 2011. *ISCC 205 GHG emissions calculation methodology and GHG audit*. Cologne: International Sustainability and Carbon Certification.

Malaysian Palm Oil Board [MPOB]. 1999–2011. Malaysian oil palm statistics. http://econ.mpob.gov.my/economy/ei_statistics_content.htm. Accessed 19 Aug 2018.

Mohd Nor, Azman Hassan, Paulina Jaramillo, and W. Michael Griffin. 2011. Life cycle GHG emissions from Malaysian oil palm bioenergy development: The impact on transportation sector's energy security. *Energy Policy* 39 (5): 2615–2625.

Nagata, Junji, and Sachiho W. Arai. 2013. Evolutionary change in the oil palm plantation sector in Riau province, Sumatra. In *The palm oil controversy in Southeast Asia: A transnational perspective*, ed. Oliver Pye and Jayati Bhattacharya, 76–96. Singapore: Institute of Southeast Asian Studies.

Pye, Oliver, and Jayati Bhattacharya, eds. 2013. *The palm oil controversy in Southeast Asia: A transnational perspective*. Singapore: Institute of Southeast Asian Studies.

Statistics Indonesia. 2014. http://www.bps.go.id/eng/hasil_publikasi/SI_2014/index3.php?pub=Statistik%20Indonesia%202014. Accessed 9 July 2018.

Subramaniam, Vijaya, Choo Yuen May, Halimah Muhammad, Zulkifli Hashim, Tan Yew Ai, and Puah Chiew We. 2010. Life cycle assessment of the production of crude palm oil (part 3). *Journal of Oil Palm Research* 22: 895–903.

Teoh, Cheng Hai. 2010. *Key sustainability issues in the palm oil sector: A discussion paper for multi-stakeholders consultations*. Washington, DC: International Finance Corporation, World Bank Group.

Wicke, Birka, Veronika Dornburg, Martin Junginger, and André Faaij. 2008. Different palm oil production systems for energy purposes and their greenhouse gas implications. *Biomass and Bioenergy* 32 (12): 1322–1337.

Zulkifli, Hashim, Halimah Muhammad, Chan Kok Weng, Y.M. Choo, and Mohd Basri Wahid. 2010. Life cycle assessment for oil palm fresh fruit bunch production from continued land use for oil palm planted on mineral soil (part 2). *Journal of Oil Palm Research* 22: 887–894.

Chapter 25
Tropical Timber Trading from Southeast Asia to Japan

Hiromitsu Samejima

Abstract Southeast Asian countries have been important suppliers of tropical timber to Japan since the early twentieth century. This chapter begins with a comparative examination of the history of the timber trade in the Philippines, Malaysia (Sabah and Sarawak), Indonesia and Papua New Guinea, for whom Japan has historically been the major market for round logs and plywood. Three common characteristics stand out: the significant role of the Japanese market in shaping the dynamics of forest resource exploitation and export; the use made of timber revenues by political actors to further their power; and the vast scale and subsequent depletion of natural forests, although logging operations themselves targeted only large commercial trees. The analysis then turns to the current features of the timber trade from Malaysia and Indonesia to Japan, with the most important sector being plywood. Japanese trading companies have established cross-cutting and flexible relationships with Malaysian and Indonesian plywood-producing companies. The timber trade has been closely shaped by both domestic and international policies and regulations. The growing perception of the negative impact of degradation and deforestation has spurred the emergence of critical anti-logging movements and the use of voluntary and mandatory instruments—notably forest certification and legality verification—with mixed results. The establishment of sustainable management of natural forests and the regulation of forest conversion to industrial tree plantations are urgent priorities.

Keywords Southeast Asia · Japan · Timber trade · Plywood

H. Samejima (✉)
Institute of Global Environmental Strategies, Hayama, Kanagawa, Japan
e-mail: samejima@iges.or.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_25

25.1 Introduction

Since the 1950s large amounts of timber, mainly round logs and plywood, have been exported from some Southeast Asian countries to Japan. The timber is known as *Nanyozai* (South Sea logs), and consists mostly of Dipterocarpaceae (*Shorea* spp., *Dipterocarpus* spp. and *Dryobalanop* spp.). The trade has supported economic growth and government revenues in both Japan and some Southeast Asian countries, but at the same time it has caused the destruction of large areas of the rich tropical rainforests. This chapter describes the history and the current situation of timber production and trade from Southeast Asia to Japan.

25.2 History of the Tropical Timber Trade from Southeast Asia to Japan

Tropical timber from the Philippines and British North Borneo (Sabah) were already known in Japan as good materials for plywood before the Second World War. After the war, the plywood industry in Japan was one the few sectors that was in a position to earn foreign currency. The industry was therefore given special dispensation by the government to import raw materials from overseas under a foreign exchange allocation system (1945–1964). More than 30% of plywood produced in Japan was exported, mostly to the United States, during the period from 1954 to 1959 (JFPPFA 2008). Following increased competition for the US market with Taiwanese and Korean plywood producers, and a rapid increase in demand for domestic housing from the early 1960s, most of the plywood produced in Japan came to be consumed in the domestic market. The main source of round logs in the 1950s and 1960s was the Philippines, but this shifted to Sabah and Indonesia (mostly Kalimantan) during the 1970s and 1980s, and to Sarawak during the 1990s and beyond (Fig. 25.1). Japan was also the largest market for logs from Papua New Guinea and the Solomon Islands from the 1970s to 1990s. However, Japan is the largest export destination of logs and timber products only for these Southeast Asian countries and regions. Other countries and regions—such as peninsular Malaysia, Myanmar, Thailand, Cambodia and Java—export logs and timber products (especially teak) mainly to Europe, Australia and China.

The Japanese market had strong purchasing power and at first mostly imported round logs from Southeast Asian countries. On the other hand, those countries have struggled to acquire the power to determine log prices and promote value-added manufacturing. The Philippines, Sabah and Indonesia established the South-East Asia Lumber Producers' Association (SEALPA) in 1974 in an attempt to control log prices after a succession of increases in the price of oil in 1973 by members of the Organisation of the Petroleum Exporting Countries (OPEC). However, SEALPA became inactive after Indonesia banned log exports in 1985. Bans or limits on exports of round logs by Indonesia, Sabah and Sarawak were meant to help develop their own plywood industries from the 1980s onwards, and Japan was compelled to shift away from importing round logs to plywood (Fig. 25.2).

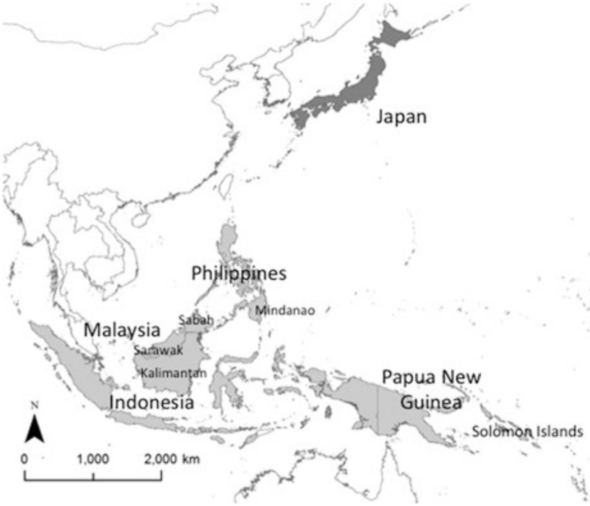


Fig. 25.1 Major exporting countries and regions of tropical timber to Japan

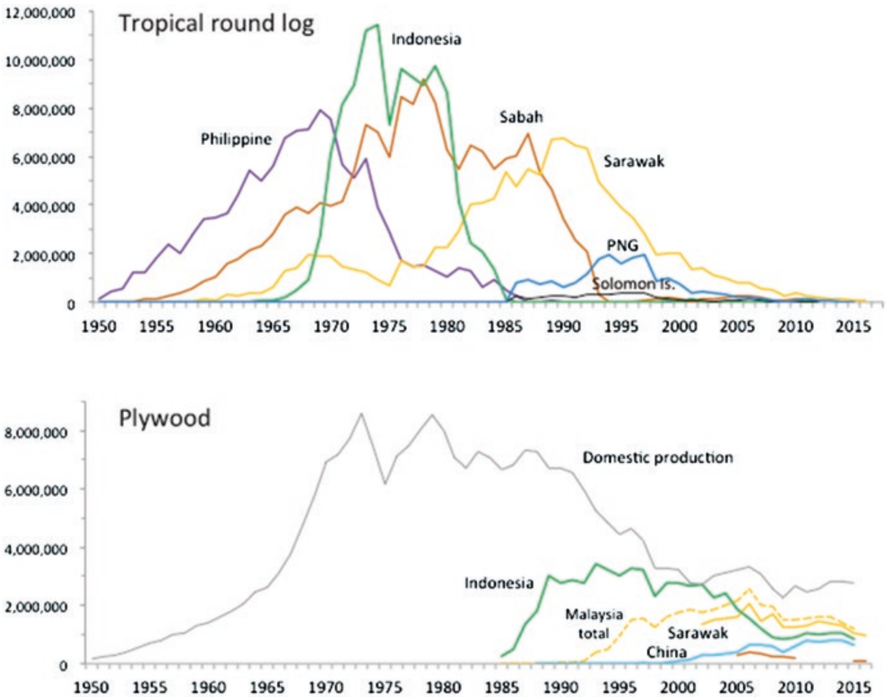


Fig. 25.2 Imports of round logs and plywood to Japan from tropical countries and regions
Source: Japan Federation of Plywood Producing Factories' Association (2008)

25.2.1 *The Philippines*

The Philippines was the first dominant supplier of tropical logs to the Japanese market. The rainforests of the Philippines, especially in eastern Mindanao, were known to have a very high density of commercial tree species. A US company introduced a modern logging operation system in 1904 in order to exploit the rich dipterocarp forests in northern Negros in the Visayas (Roth 1983). The Philippines was the largest log supplier in Asia from the 1920s to the 1960s (Ross 2001). By 1940, 163 sawmill and logging companies were operating nationwide (De la Cruz 1941). About 40% of the investment was owned by Americans and 33% by Filipinos.

After the Second World War, a great deal of heavy machinery formerly belonging to the US army was made available to the logging companies, and so logging operations in the Philippines were mechanised earlier than in either Indonesia or Malaysia. Most of the harvested logs were processed to sawn timber, veneers and plywood in the Philippines and exported, especially to the US market, in the early 1950s. However, Japan directly imported a huge volume of round logs, not those timber products, for its own plywood-producing factories during the 1950s and 1960s (Fig. 25.3). In 1963, of the 6.5 million m^3 of logs produced 70% was exported, especially to Japan (84% of total exports from the Philippines) (Shiotani 1969). Log production reached a peak in 1969 when 14.7 million m^3 were produced and 9.4 million m^3 were exported (Murashima and Araya 2000).

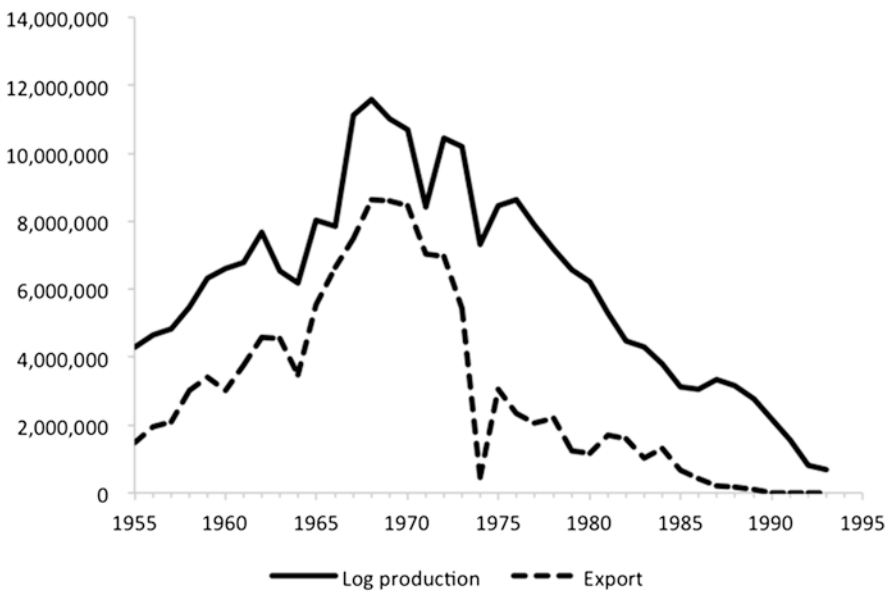


Fig. 25.3 Log production and exports from the Philippines, 1945–1995 (m^3)
Sources: Shiotani (1969) and Dauvergne (1997)

The Philippines had long-term logging licences (up to 20 years) for large areas and short-term logging licences (1–4 years) for small areas. In 1968–1969 logging licences were issued for 9 million ha, almost all natural forests, and 62% of this area was issued for short-term licences (Japan South Sea Lumber Council 1975). Presidents of the Philippines changed every 4 years with the electoral cycle and new short-term licences were issued with each new administration (Ross 2001). During the martial law period (1972–1981), President Ferdinand Marcos (in office 1965–1986) stopped issuing many short-term licences, but he sought to control timber-producing companies by holding the export permits. The logging system was selective cutting with a minimum cutting limit of 60 cm diameter at breast height (dbh) and a cutting cycle of 25–35 years. However, it was common for logging companies to also harvest trees of less than 60 cm dbh (Shinohara 1981). As the forests of the Philippines had high densities of commercial trees, logging operations often exhausted the forests irreversibly. While forest cover was 17.2 million ha in 1941 (57% of total land), it declined to 10.0 million ha in 1969 (33%) (Chokkalingam et al. 2006). Log production decreased after the 1970s and log exports were banned in 1982. However, forest loss was compounded by social problems. Inequitable access to land and assets for the majority, high population growth and a lack of urban job creation led to widespread poverty, migration to the uplands and dependence on forests after the 1960s, a situation that peaked between 1980 and 1985 (Cruz et al. 1992; Chokkalingam et al. 2006).

After the 'People Power' revolution of 1986, President Corazón Aquino (in office 1986–1992) cancelled most of the logging licences (143 licences in 1987 fell to just 32 in 1992) and banned all logging operations in the remaining primary forests and forests in steep areas and at high elevations (Hirsch and Warren 1998; Murashima and Araya 2000). However, a lack of government manpower led to widespread and uncontrolled illegal logging activities in the former licensed logging areas. Forest cover decreased to a historic low of 6.5 million ha (22%) in 1988 (Chokkalingam et al. 2006; Rebugio et al. 2007). The forest loss meant the Philippines became a timber-importing country.

In recent decades, forest cover has gradually recovered and stood at 8.0 million ha (27%) in 2015 (FAO 2015). But these are mostly secondary and planted forests. In 2015 the Philippines produced 0.79 million m^3 of logs, but 98% of the total logs was from planted trees, especially *Albizia* (*Falcataria moluccana*). The major sources include the Caraga region (62% of total log production) in northeastern Mindanao (FMB 2016).

25.2.2 Sabah, Malaysia

Along with Mindanao, the east coast of Sabah was also known for its rich forest resources even before the Second World War. There were high-standing stocks of commercial trees in the primary forests around Cowie Bay and Serudong River in Tawau district (Shiotani 1969). Commercial logging began in 1895 with a British company, and the Sabah Forestry Department was established in 1914 under the rule of the British Borneo Chartered Company. Before the independence of Malaysia in 1963, 12 logging companies obtained 80-year licences to manage 70% of the all production forests sustainably. However, the chief minister of Sabah, Mustapha Harun (in office 1967–1975), issued many annual licences and special licences (5–10 years) in order to win elections. He also established the Sabah Foundation (Yayasan Sabah) in 1970 to take over the logging concessions of the 80-year licence-holders and manage them directly (Ross 2001).

Sabah had rich forests but a small population, and domestic consumption of timber was very limited. Most of the logs produced were exported (Fig. 25.4). During 1980s Sabah was the largest exporter of tropical logs to Japan (Fig. 25.2). Plywood industries were developed after the 1990s, and the main export products shifted from round logs to plywood. Revenues derived from forest products exceeded 50% of state income by the early 1990s (Fig. 25.5). Rapid logging depleted the primary forest cover from 56% in 1975 to 22% in 1992 (Ross 2001).

In 2016 total log production from natural stands was 647,657 m^3 and from industrial tree plantations was 522,851 m^3 (Sabah Forestry Department 2016). Exports of timber products from Sabah became smaller than those from Sarawak in recent years. Japan is still the largest timber trading partner, accounting for 20% of the total export value of timber products from Sabah (Sabah Forestry Department 2016). Half of Sabah's timber and timber products export value came from plywood, and two companies—Sinora (based in Sandakan) and Kalabakan (based in Tawau)—are major suppliers of plywood to Japanese trading companies (*Mokuzai Kenzai Weekly* 21 March 2011, 11 July 2011, 19 March 2012).

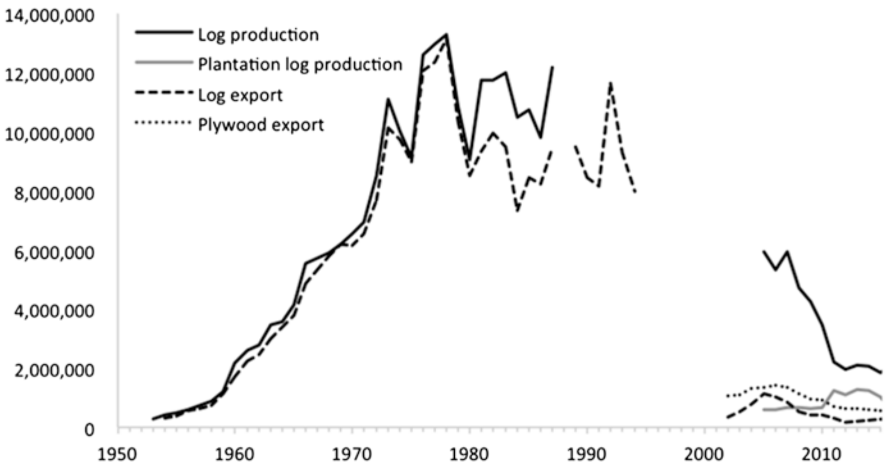


Fig. 25.4 Log production and exports from Sabah, 1950–2010 (m^3)
Sources: Shiotani (1969), Dauvergne (1997) and Sabah Forestry Department (2003–2016)

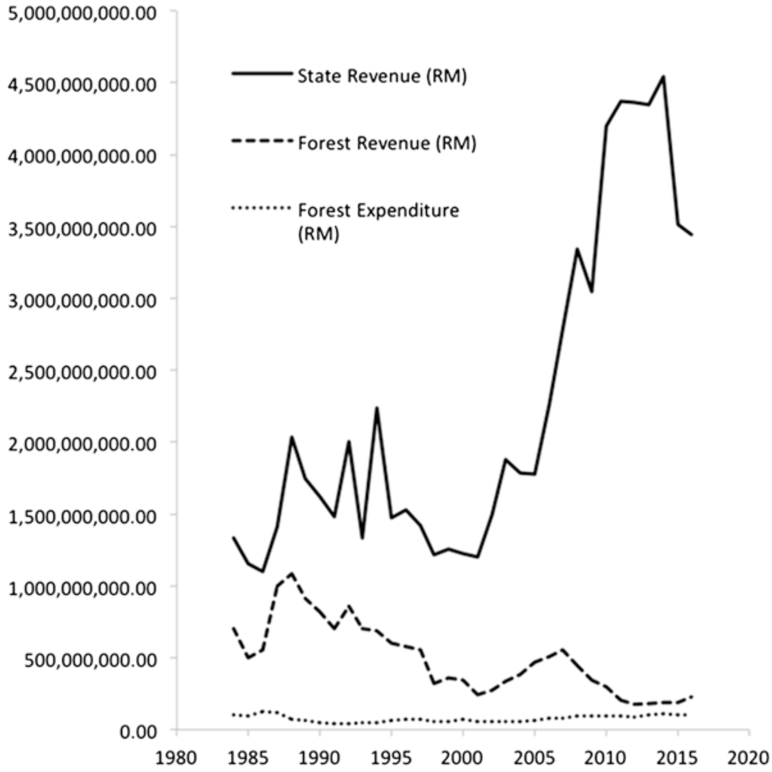


Fig. 25.5 State revenues, forest revenues and forest expenditure in Sabah, 1984–2016 (RM)
Source: Sabah Forestry Department (2006, 2016)

25.2.3 Indonesia

In the East Indies (later Indonesia), the Dutch colonial government established a teak forestry system in Central and East Java and Madura in the nineteenth century, with the first regulation of forestry affairs enacted in 1830 and the first forest ordinance issued in 1865 (Kartasubrata 1985). Planted teak forests have been managed by Perum Perhutani (the state forestry company) since the independence of Indonesia in 1949. Log production from Java and Madura was 44–57% of total log production from Indonesia during the period from 1939 to 1955. On the other hand, Japan has imported mostly dipterocarp logs, especially from Kalimantan, as raw materials for plywood-producing industries in Japan. The density of harvestable commercial trees in Kalimantan was lower than those in the Philippines and Sabah, but Kalimantan had a huge area of primary forests.

While timber production and export were not active during the Sukarno era (in office 1949–1965), his successor Suharto (in office 1967–1998) passed laws on foreign investment (1967), forestry (1967) and domestic investment (1968), and allowed foreign investors to procure logging concessions in the outer islands (especially Kalimantan and Sumatra) in 1967. Many foreign companies from the United States, the Philippines, Malaysia and Japan acquired these concessions. The first plywood-producing companies were established in North Sumatra and South Kalimantan in 1973, followed by Kutai Timber Indonesia in East Java established by Sumitomo Forestry in 1974 (Murashima and Araya 2000).

However, Suharto changed his policy after the second global oil crisis in 1978–1979. His government limited the maximum volume of round logs for export and finally banned all exports in 1985 in order to develop domestic plywood industries. His strong centralised political power, together with the support of the army and significant revenues from oil exports, enabled this drastic policy change. One of his strongest supporters, Mohamad Bob Hassan, established Asosiasi Panel Kayu Indonesia (Apkindo, Indonesian Wood Panel Producers Association) in 1984 and monopolised plywood exports. Japanese trading companies shifted the source of round logs from Indonesia to Sarawak (Murashima and Araya 2000). In the early 1980s Indonesian producers still could not produce high-quality plywood acceptable to the Japanese market. However, they managed to improve the quality and were certified by the Japan Agriculture Standard in the late 1980s. Hassan established a joint trading company, Nippindo, with a Japanese trading company Uematsu Shoji, Osaka, in 1988 to exploit the Japanese market. As a result, Indonesian plywood took a 79% share of the world plywood market (including Japan) in the late 1990s and hundreds of plywood-producing companies in Japan were bankrupted by this competition. The export value of plywood was 10.6% of total exports from Indonesia in 1990 (Murashima and Araya 2000; Fig. 25.6).

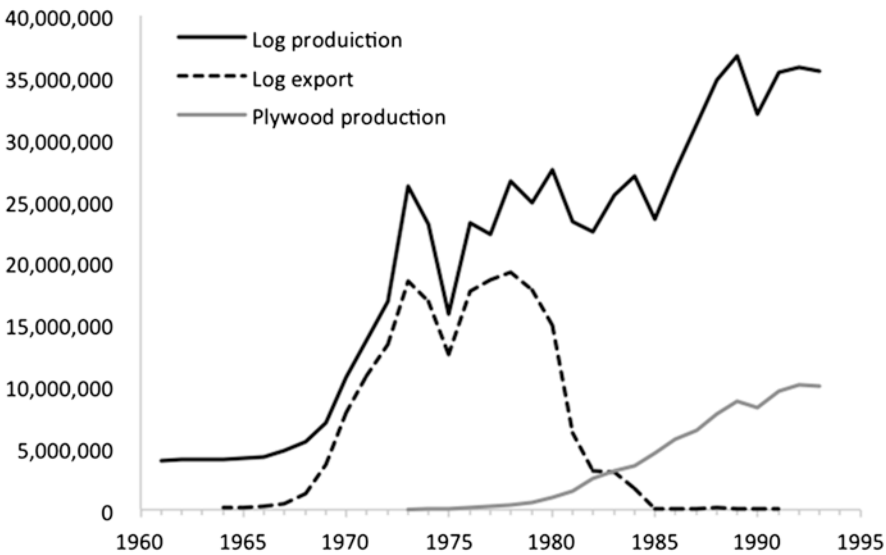


Fig. 25.6 Log production and exports from Indonesia, 1961–1992 (m^3)

Suharto stepped down from power after the Asian financial crisis in 1998. Apkindo's monopoly and the log export ban were ended by the insertion of forestry conditionalities in the bail-out loan agreement with the International Monetary Fund. As a part of the democratisation and decentralisation process known as *reformasi*, the forestry authority was brought under the control of district governments under a new forestry law (1999). This weakened law enforcement and triggered very active illegal logging and led to a huge area of deforestation and forest degradation. Illegally harvested logs were consumed by domestic factories but also exported to Malaysia and other countries. Forest fires during the El Niño event of 1997–1998 also destroyed a huge area of natural forest, especially in East Kalimantan.

Indonesia banned log exports again in 2001 and authority over forestry was moved from district governments back to the Ministry of Forestry. The area devoted to logging concessions decreased drastically. The government of President Susilo Bambang Yudhoyono (in office 2004–2014) struggled to tackle illegal logging and, as a result, many plywood factories that used illegal logs were closed and plywood exports from Indonesia to Japan decreased by 65% from 2004 to 2008.

As the government decided to impose an upper limit for concession areas, the size of Indonesian companies is smaller than their competitors in Sarawak. The plywood-producing factories not only use logs from their own concessions but also buy logs from concessions of other companies. Major plywood producers/suppliers to Japanese trading companies named in *Mokuzai Kenzai Weekly* (21 March 2011, 11 July 2011, 19 March 2012, 16 July 2012) were as follows: Erna Djuliawati (West Kalimantan), Alas Kusuma (West Kalimantan), Korindo (Central Kalimantan), Tanjung Selatan Makmur Jaya (South Kalimantan), Surya Satrya Timur (South Kalimantan), Tanjung Raya (South Kalimantan), Wijaya Tri Utama Plywood (South Kalimantan), Daya Sakti Unggul (South Kalimantan), Tirta Mahakam Resource (East Kalimantan), Kayu Lapis (East Kalimantan), Idec Abadi Wood Industries (East Kalimantan), Intracawood Manufacturing (North Kalimantan), Sumber Mas Indah Plywood (East Java), Kutai Timber Industry (East Java), Katingan Timber Celebes (Jakarta) and Sumatra Timber Utama Damai (Jambi).

The Indonesian government has also supported the development of plantations of fast-growing tree species, for example *Acacia* and *Eucalyptus*, since the 1990s, mostly to produce raw materials for the pulp and paper industries. Timber production from industrial tree plantations exceeded logging concessions during the *reformasi* era (from 1998 to early 2000s) and increased continuously until around 2010 (Fig. 25.7; Center for Forestry Planning and Statistics 2009; Forest Trends and Koalisi Anti-Mafia Hutan 2015; Ministry of Environment and Forestry 2016). Asia Pulp and Paper (APP) based in Sumatra and Asia Pacific Resources International Limited (APRIL) in Sumatra became the largest pulp and paper producers in Southeast Asia. Log production from industrial tree plantations comprised 66% of total log production from Indonesia in 2016.

Smallholder plantations of fast-growing tree species have also become very active especially in Java since the 2000s. *Albizia* (*Falcataria moluccana*) and teak

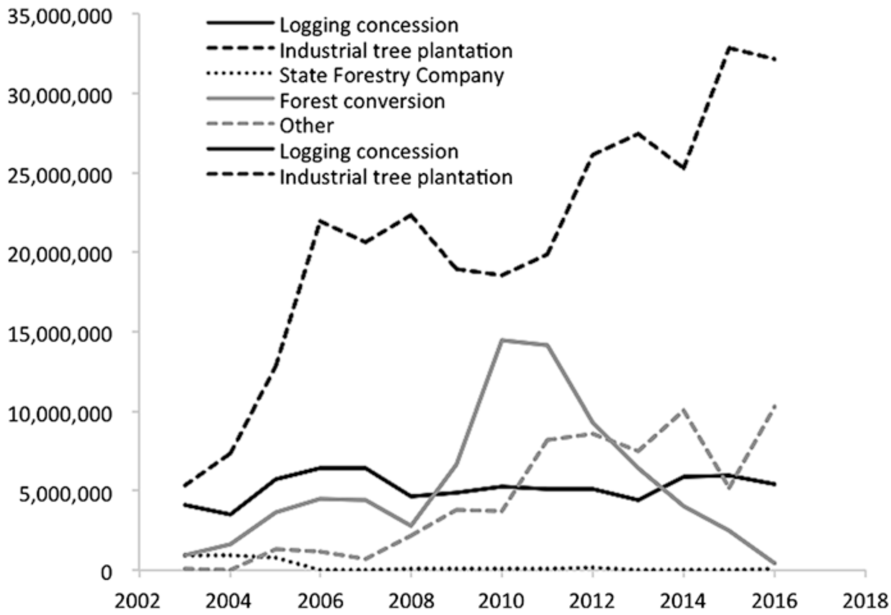


Fig. 25.7 Log supply from different sources to industry (capacity >6000 m³/year) in Indonesia (m³)
Source: Ministry of Environment and Forestry (2016)

(*Tectona grandis*) are the most popular planted species. Plywood-producing companies in Java started to buy logs not only from the logging concessions in Kalimantan and Papua but also from local smallholders in Java. The consumption volume of wood from smallholders (*kayu rakyat*) by large industries (capacity >6000 m³/year) has increased to 5.0 million m³ in 2016, not much different from wood from logging concessions, which amounted to 5.3 million m³ (Ministry of Environment and Forestry 2016).

25.2.4 Sarawak, Malaysia

Sarawak is a latecomer to the timber trade. As the soil is oligotrophic and sandy, the density of big commercial trees without holes in the primary forest was generally lower than that of the Philippines, Sabah and Kalimantan. As with Indonesia, oil and liquefied natural gas have been the main export items (Murashima and Araya 2000). The state government therefore did not need to depend on timber export royalties to the same extent as the Philippines and Sabah. The exception was ramin (*Gonystylus* spp.), found in peat swamp forests, one of few valuable tree species in Sarawak. In 1965, of the total of 1.1 million m³ logs exported from Sarawak, 76% was from swamp forests, especially ramin.

Sarawak logs were exported to Japan since 1958 and 62% of the total was destined for Japan in 1975 (Shinohara 1981). However, the volume did not increase much during the 1960s and 1970s when Japan was still able to import huge quantities of round logs from the rich forests of Sabah and Kalimantan.

Logging production and exports increased drastically during the administrations of the chief minister Abdul Taib Mahmud (in office 1981–2014) (Fig. 25.8). After the export ban on round logs in Indonesia was implemented in 1985, Japanese trading companies came to Sarawak to establish joint ventures with local companies in order to supply the huge demand for round logs for plywood factories in Japan. The proportion of the forestry sector as part of the state revenues increased from 5.5% in 1975 to 50.3% in 1989 (Murashima and Araya 2000). A harvesting rotation of a logging concession was regulated at 25 years, but the government allocated only 10-year licences to the licence-holders. These licences were given on the basis of political interests and financial support to policymakers. In addition, annual logging licences were also issued that overlapped with existing logging concessions. The licence-holders thus rushed to harvest as many logs in their concessions as possible during a given licence period.

Following Indonesia, the Sarawak government began to promote domestic plywood industries since the 1990s. In 2016, 49% of the total export value of timber products came from plywood, followed by round logs (24%) and sawn timber (13%) (STIDC 2016).

The major logging concession licence-holders are known as the 'big six': Samling, Rimbunan Hijau, Shin Yang, Ta Ann, WTK and KTS, plus the state's own Sarawak Timber Industry Development Corporation (STIDC) (*Mokuzai Kenzai Weekly* 21 March 2011, 11 July 2011, 19 March 2012, 16 July 2012). In the 1990s Rimbunan Hijau, Samling, WTK and KTS were known as the 'big four' (Cooke

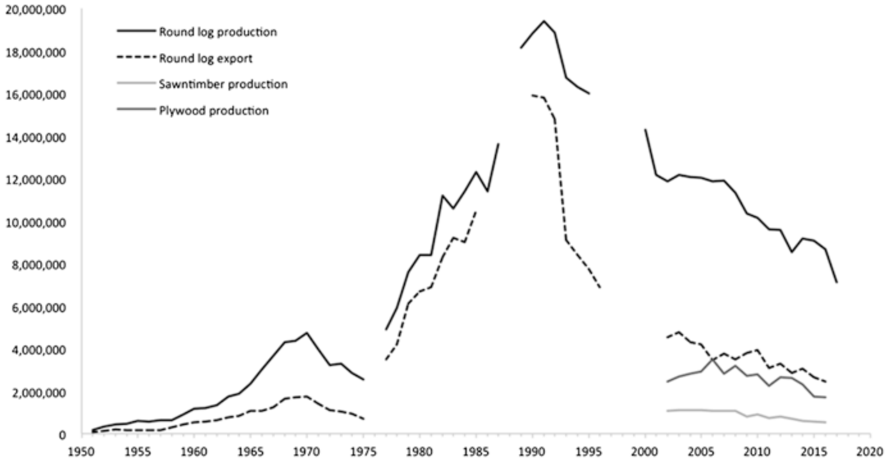


Fig. 25.8 Export volume of timber and timber products from Sarawak (m^3)
Sources: Shiotani (1969), Caldecott (1996), Murashima and Araya (2000), STIDC (2006, 2009, 2016) and Sarawak Forest Department (2017)

1999), but Shin Yang and Ta Ann grew rapidly in the 1990s and 2000s, and Shin Yang is now the biggest plywood supplier from Sarawak to Japan. Of the 5 million ha of all production forests, 70% (3.7 million ha) was allocated to the big six as of 2015 (Table 25.1; *Borneo Post* 2015a).

Since the last logging concession with primary forests was harvested in the last decade, the conversion of degraded forests to plantations has become the major source of round logs in Sarawak. It is estimated that two-thirds of timber production in 2010 originated from clear-cutting for forest conversion (Lawson et al. 2014).

Following the decline of timber resources in Sarawak, the logging companies have also expanded their operations to foreign locations since the 1990s, including Papua New Guinea, the Solomon Islands, Cambodia, Russia, Africa, Brazil, Australia and Canada (Faeh 2011). They have also extended their business to plantations of oil palm and fast-growing tree species, such as *Acacia* and *Albizia*. Palm oil production in Sarawak has increased rapidly and large forest reserves have been converted to oil palm plantations, especially in peat swamp areas since 2000s (Gaveau et al. 2016). For some of the big six, revenue from the oil palm business already exceeds that from the logging business. Log production from planted forests has also grown in recent years, amounting to 1.2 million m^3 in 2016, but its importance is still low compared with that of Indonesia and Sabah (Sarawak Timber Association 2017). Unlike Indonesia and Sabah, pulp and paper mills are still not established in Sarawak and the planted trees are used as raw material for plywood.

Table 25.1 Portfolio of the six big conglomerates in Sarawak

Group	Forest concessions (ha)	Log production (year)	Oil palm plantations (ha)	Crude palm oil (tonnes)	Industrial tree plantations (ha)
Samling	1,288,389 (2015)	816,764 (2009)	>101.966 (2009)	NA	530,910 (2008)
Rimbunan Hijau	1,001,877 (2015)	1,026,438 (2009)	130,000 (2009)	155,767 (2009)	555,073 (2008)
WTK	357,017 (2015)	594,000 (2016)	120,000 (2010)	625,000 (2010)	144,472 (2008)
Ta Ann	433,003 (2015)	359,203 (2016)	87,151 (2016)	169,389 (2008)	310,713 (2018)
KTS	144,485 (2015)	NA	152,148 (2008)	NA	278,761 (2008)
Shin Yang	500,904 (2015)	860,000 (2013)	100,000 (2009)	226,919 (2009)	272,918 (2008)
Sarawak total (2010)		8,668,222 (2016)		5,954,605 (2017)	

Source: Faeh (2011), Malaysian Palm Oil Board (2017) and Ta Ann Group (2018)

25.2.5 Papua New Guinea

While the majority of forests in the Philippines, Indonesia, Sabah and Sarawak belong to the government, most forests in Papua New Guinea belong to communities. While around 50% of canopy trees in the Philippines and Borneo (Kalimantan, Sabah and Sarawak) are of the Dipterocarpaceae family, large tree species are more diverse in Papua New Guinea.

The first logging company was established in Papua New Guinea in 1954. Some 80–90% of the round logs were exported to Japan in the period from 1969 to 1975 (Shinohara 1981). Log exports increased during the 1990s and were still mostly destined for Japan. However, the volume of log exports to China has increased since around 2000 and comprises approximately 80% of all exported logs in the past 10 years. Rimbunan Hijau, Samling and other Sarawakian companies have gone to Papua New Guinea to log the forests.

25.3 Current Timber Trade from Malaysia and Indonesia to Japan

Malaysia and Indonesia are today the main suppliers of tropical plywood to Japan. Of the total consumption of wood materials in Japan of 70.9 million m^3 in 2015, 9.9 million m^3 was plywood (Forestry Agency 2017). Of this, 2.0 million m^3 was imported from Malaysia and 1.5 m^3 from Indonesia; 89% of the Malaysian plywood was imported from Sarawak (Fig. 25.9). Meanwhile, Malaysia and Indonesia are not major suppliers of round logs and sawn timber to Japan. The main suppliers of round logs, totalling 3.5 million m^3 of imports in 2015, are the United States, Canada and New Zealand; the main suppliers of sawn timber, 9.5 million m^3 of

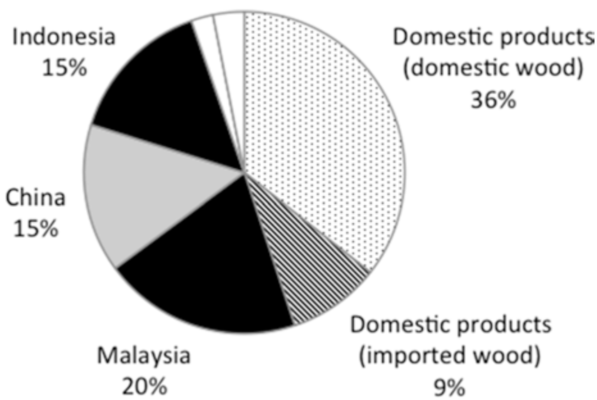


Fig. 25.9 Sources of plywood consumed in Japan, 2015
Source: Forestry Agency (2016)

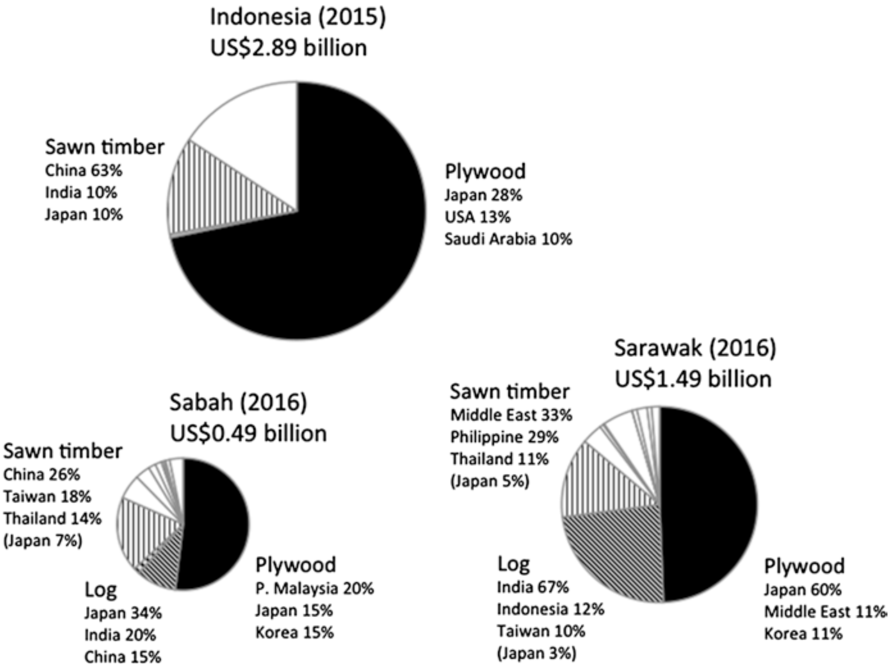


Fig. 25.10 Revenue from timber products (excluding pulp and paper)
Source: FAO (2015), Sabah Forestry Department (2017) and STIDC (2017)

imports in 2015, are Canada, Finland, Russia and Sweden. Japan is still the largest importer of the timber products for Sarawak, Sabah and Indonesia, except for paper and pulp (Fig. 25.10). Sarawak in particular is strongly dependent on the Japanese market, with 60% of total export value of timber products in 2015 coming from exports to Japan.

25.3.1 Types of Plywood

There are several types of plywood. The main difference is thickness: normal plywood (2.5–24 mm), including floor base; structural plywood (5–30 mm); and concrete-forming panels (12–15 mm). Plywood made from tropical timber can be thin but also strong and it has a smooth surface. Thus plywood is the best material for floor base and for concrete-forming panels—30% of imported plywood from Malaysia and Indonesia is used for floor base and another 30% is used as concrete-forming panels (*Mokuzai Kenzai Weekly* 1 April 2013). Some concrete-forming panels are coated with polyurethane paint to make stripping easier and increase the panels' lifespan.

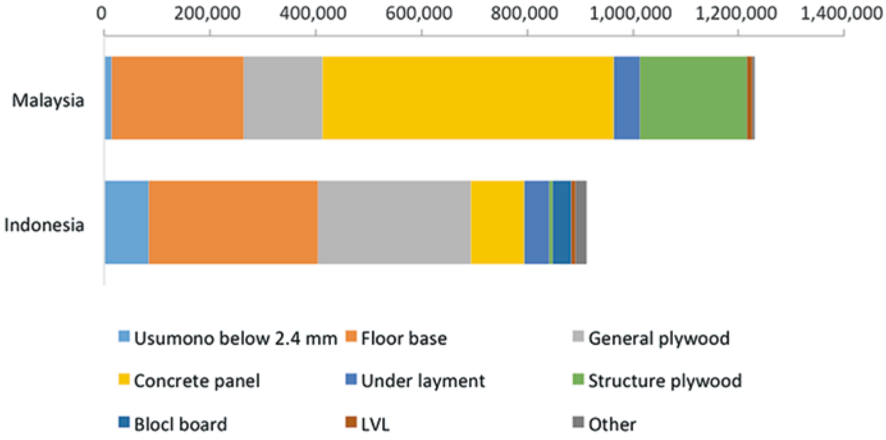


Fig. 25.11 Volume of imported hardwood plywood by item by Japan Lumber Importers' Association members, 2014 (million m^3)
Source: Ueda (2016)

There are some differences in the thickness between plywood imported from the major suppliers, Sarawak and Indonesia, to Japan. Sarawakian plywood producers are large enterprises and produce plywood at a low price, but the timber quality is not as high as Indonesian plywood in general. As a result, Malaysian (mostly Sarawakian) plywood dominates the middle thicknesses (6–12 mm) and much of it is used for concrete-forming panels. Indonesian plywood dominates thin plywood (<6 mm) and most is used for flooring base and general purposes (Fig. 25.11).

On the other hand, temperate tree species, including Japanese larch and cedar, can be the raw material for thick structural plywood. Following round log export bans or increases in export taxes imposed by Indonesia, Sabah and Sarawak, plywood factories in Japan shifted to importing softwood from Russia (mostly Siberian larch) during the 1990s and 2000s. After Russia also increased export taxes on round logs in 2007–2008, Japanese plywood factories shifted again to using domestic softwood and the self-sufficiency of raw material for plywood has increased significantly (Fig. 25.12). Innovations in plywood production equipment and the promotion of structural plywood for building materials (such as walls and floors), supported by the government, have facilitated these shifts.

25.3.2 Japan Agriculture Standard

The Japanese government introduced the Japan Agriculture Standard (JAS) in 1953 to standardise the quality of agricultural, forestry and fishery products. The Revised Building Standards Law 1971 regulates that main building structures should be constructed using JAS-certified materials. As of 2017, 48 timber-producing factories in

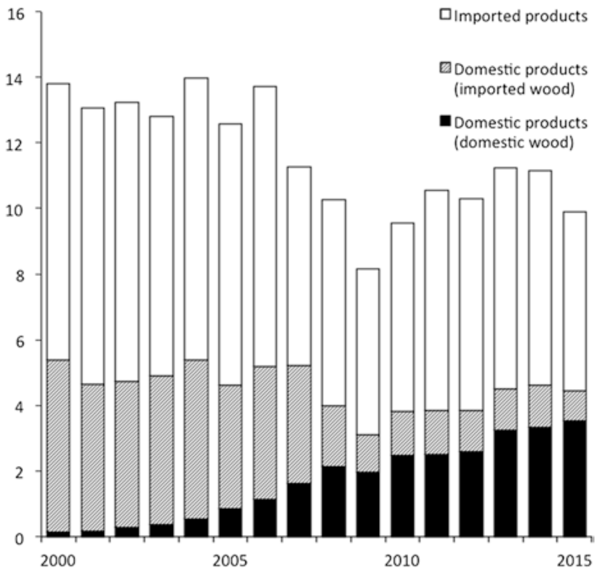


Fig. 25.12 Plywood supply in Japan (million m^3)
Source: Forestry Agency (2017)

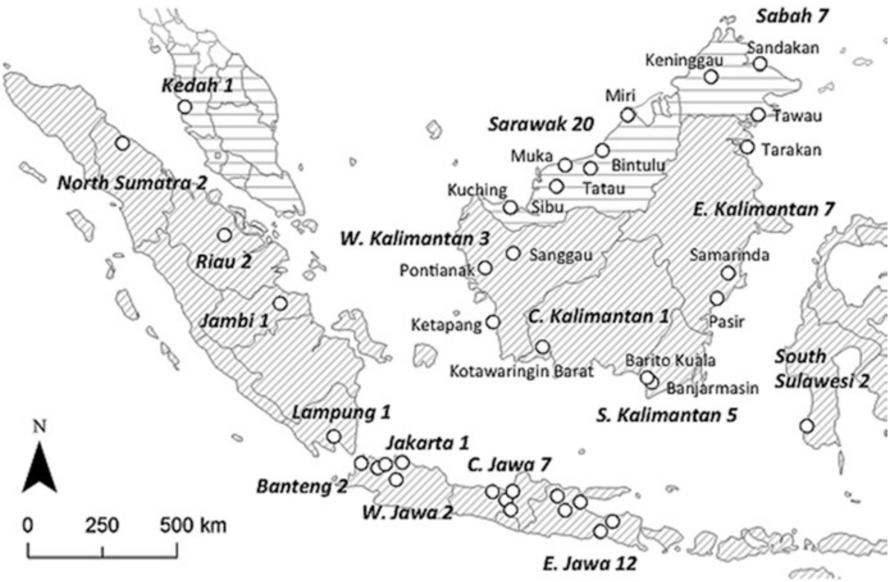


Fig. 25.13 Location of JAS-certified factories and the number in each state and province in Malaysia and Indonesia
Source: MAFF (2017)

Indonesia (Kalimantan: 16, Java: 24) and 28 factories in Malaysia (Sabah: 7, Sarawak: 20, peninsular Malaysia: 1) are certified by the JAS (Fig. 25.13; MAFF 2017). JAS-certified plywood is stamped with the name of the factories. It is therefore easy to know the source factories of most plywood used in building construction (including concrete-forming panels) in Japan. The number of JAS-certified factories is highest in Sarawak, followed by East Java where many plywood factories source round logs from various provinces of Kalimantan and also *Albizia*, a fast-growing tree widely planted by smallholders in Java.

25.3.3 Japanese Trading Companies

Exports of plywood from Malaysia and Indonesia to Japan are mostly conducted by Japanese trading companies, including Sumitomo Forestry (Timber and Building Materials Division), Itochu Kenzai, Sojitsu and Sojitsu Kenzai, SMB Kenzai (which came out of a merger between Marubeni Kenzai and Sumisho & Mitsuibussan Kenza in 2016) and Toyo Materia (Fig. 25.14). These trading companies sell the imported plywood to domestic timber wholesalers and flooring-producing companies. Sumitomo Forestry is the largest importer from Indonesia while SMB Kenzai was the largest importer from Malaysia in 2015. In addition to the trading companies, Japan Kenzai, the largest distributor and wholesaler of building materials in Japan, is also a major importer, buying 225,000 m^3 of plywood in 2015, mostly from Malaysia (*Mokuzai Kenzai Weekly* 11 April 2016). The trading relationships between Japanese trading companies and Malaysian and Indonesian plywood-producing companies are cross-cutting and flexible (Fig. 25.15).

25.4 Recent Changes

25.4.1 Anti-tropical Timber Campaign, 1980s–1990s

Rapid deforestation and forest degradation induced by commercial logging brought about severe environmental and social impacts in tropical countries, especially where local communities strongly depended on the ecosystem services. The movement against logging operations in Sarawak became active in the late 1980s. Indigenous peoples in the Baram and Limbang areas—Penan, Iban, Kayan, Kenyah, Kelabit and Lun Bawang—began to place barricades across logging roads in 1987 and succeeded in attracting international attention (World Rainforest Movement and Sahabat Alam Malaysia 1990). While the Sarawak state government pulled down the barricades and arrested numerous protesters, the blockades, mostly organised by the Penan, have continued at many logging roads in Baram and Belaga districts until recently.

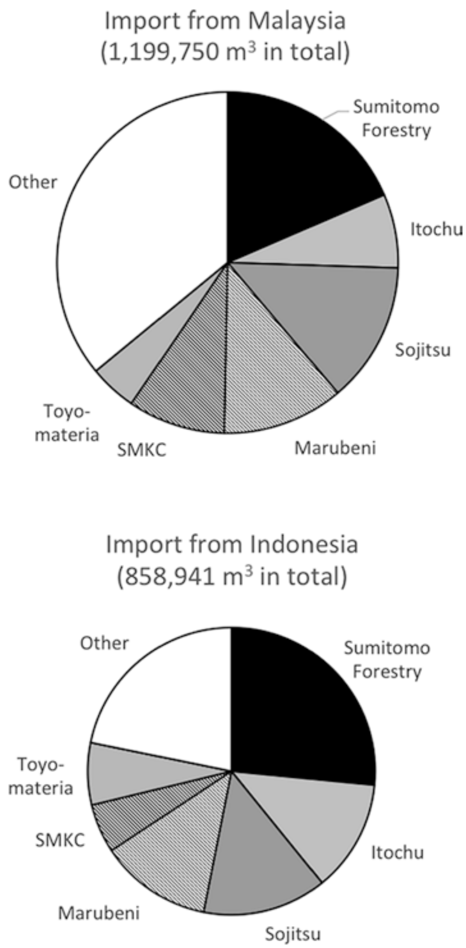


Fig. 25.14 Estimated volume of annual imported plywood from Malaysia and Indonesia by six major trading companies, 2015
Source: *Mokuzai Kenzai Weekly* (11 April 2016)
Note: Data for some companies were not available and are estimated from monthly records or value (¥) and average prices of other companies

The federal government of Malaysia invited the International Tropical Timber Organisation (ITTO) to Sarawak in 1989 and 1990 to undertake a study of forest management there. The ITTO published its report in 1990 and noted that hill dipterocarp forests were being overcut and that logging practices resulted in widespread environmental disruption and excessive damage to residual trees, with the result that then current levels of log production were not sustainable (Aiken and Leigh 1992).

25.4.2 Forest Certification

The anti-tropical timber movement targeted the setting up of a legally binding forest convention at the Rio Earth Summit in 1992. However, unlike the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), which became important international instruments, the

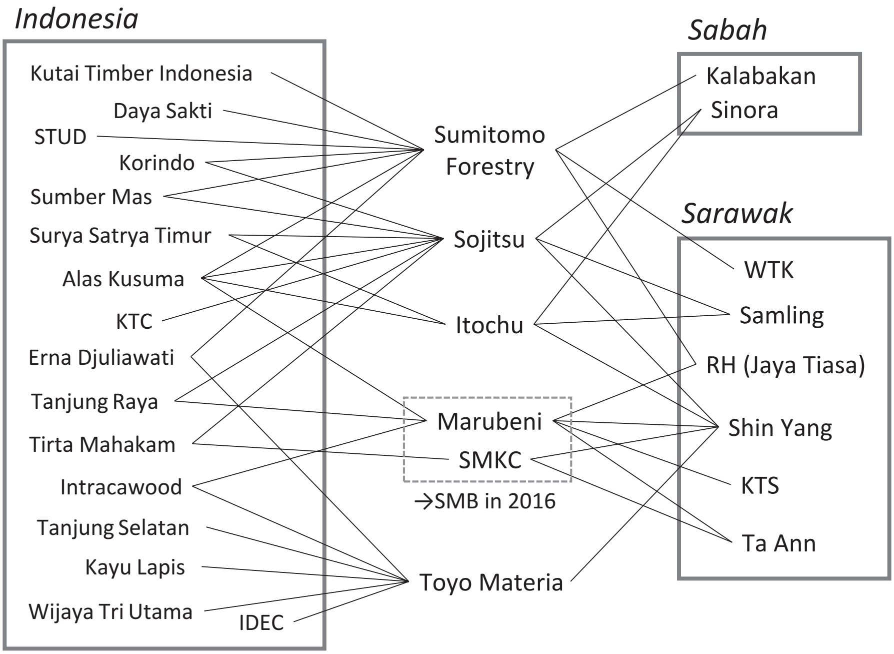


Fig. 25.15 Trading relationship of Japanese trading companies and Indonesian and Malaysian plywood-producing companies, 2010–2011
Source: Mokuzai-Kenzai Weekly (2011–2012)

forest convention failed to be agreed and only the non-binding Forest Principle was adopted. Thereafter, environmental non-governmental organisations (NGOs) worked to establish a global voluntary certification system of sustainable forest management, the Forest Stewardship Council (FSC) launched in 1993. The purpose of forest certification is to persuade consumers to choose timber produced sustainably and to provide economic incentives (price premiums) for logging companies to manage forests sustainably. On the other hand, forest landowners and timber producers in Europe established another global certification system, the Programme for the Endorsement of Forest Certification (PEFC) in 1999. The PEFC is a global umbrella scheme for the assessment and mutual recognition of national forest certification schemes.

Malaysia and Indonesia established their own certification systems. The Malaysian Timber Certification Council was established in 1998 and started operating the Malaysian Timber Certification Scheme (MTCS) in 2001. The MTCS was endorsed by the PEFC in 2009. In Indonesia, Lembaga Ekolabel Indonesia (LEI, Indonesian Ecolabelling Institute) was founded in 1994. LEI is cooperating with the FSC in an attempt to achieve mutual recognition of the two certification systems. The Indonesian government further introduced a national certification scheme, Pengelolaan Hutan Produksi Lestari (PHPL, Sustainable Production Forest Management) in 2002 for all logging concessions and industrial tree plantations (Ministerial Decree No. 4795/2002).

Forests certified by the FSC or PEFC have increased in the European Union (EU) and North America during the 2000s. However, forest certification has not been popular either in the Japan or in the tropical timber-producing countries and regions, especially Sarawak, until recently. In Japan, the government, notably the Forestry Agency, has as a principle mission the promotion of domestic forestry. Hayami Forestry was the first FSC-certified company in Japan (certified in 2000) and its well-managed planted forests became a model for certification. However, most Japanese forest owners have only small amounts of land and their income from forestry is very limited, so most do not have either an interest in or capacity to achieve all the criteria of certification by paying an additional cost. Because many timber producers in the EU and the United States obtained certification earlier, it has been difficult for the Japanese government until recently to adopt a policy to recommend certified wood products which could undermine the domestic forestry sector.

For Southeast Asian suppliers of round logs and plywood, market demand, especially in Japan, for certified timber products was very weak, and the shortness of logging licences and prevalence of illegal logging discouraged concession licence-holders from managing forests sustainably. In Malaysia, with support from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, German Agency for International Cooperation), the Sabah Forestry Department manages the Deramakot Forest Reserve (55,507 ha) directly as a model of sustainable forest management and achieved the first FSC certification for natural production forests in Southeast Asia in 1997. While most state forests in peninsular Malaysia are certified by the MTCS, the Anap-Muput Forest Management Unit in Bintulu, Sarawak (certified by the MTCS in 2006) has been the only certified logging concession in Sarawak up to 2017. In Indonesia, PT Diamond Raya Timber in Riau (90,956 ha) is the first FSC-certified concession (certified in 2001). However, any increase in these numbers has remained slow.

25.4.3 Legality Verification

While the promotion of sustainable forest management with forest certification has been not successful in Southeast Asia, more acceptable legality verification has been promoted since the 2000s to at least eliminate illegal logging against the laws of the timber-producing countries. The Japanese government endorsed the G8 Action Programme on Forests, which included measures against illegal logging taken at the G8 summit in Birmingham, Britain, in 1998. Japan further committed to addressing the issue of illegal logging at the Kyushu-Okinawa Summit in 2000 and issued a revised Green Purchasing Law in 2006 to ensure only legally sourced timber products are purchased by government entities in the country (Oberndorf 2013).

The EU also adopted the Forest Law Enforcement, Governance and Trade Action Plan (FLEGT) in 2003 and the EU Timber Regulation (EUTR) in 2010. The United States had the Lacey Act of 1900 to prohibit trade in wildlife, fish and plants that have been illegally taken, possessed, transported or sold, and amended the act in

2008 to expand its protection to a broader range of plants and plant products. The EUTR and amended Lacey Act are applied to all imported timber and timber products. Japan again issued the Act on Promotion of Use and Distribution of Legally Harvested Wood and Wood Products (Clean Wood Act) in 2016. While the Clean Wood Act does not prohibit the import of illegally harvested logs, it recommends timber business companies should check the source and legality of the timber imported. The law promotes the trade in legal timber by introducing a registration system of companies that trade only timber and timber products with legality verification, and also by mandating the government to identify the legality systems of timber-producing countries to provide the information to the timber businesses.

25.4.4 Indonesia

Indonesia established the mandatory Sistem Verifikasi Legalitas Kayu (SVLK, Timber Legality Verification System) in 2009 and the PHPL was integrated into the SVLK as the starting point of legality verification. The number of natural forest concessions certified by the PHPL has gradually increased. As of 2014, 146 of 274 logging concessions were certified by the PHPL (Fig. 25.16). The EU recognised

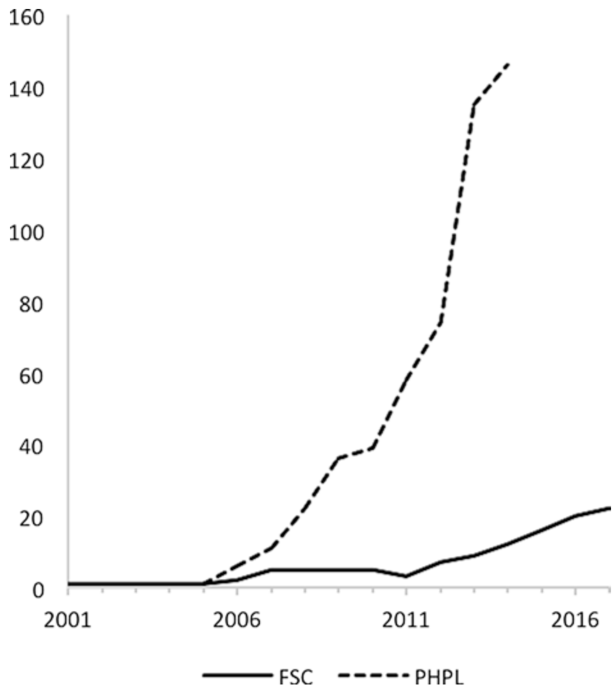


Fig. 25.16 Number of FSC- and PHPL-certified logging concessions in Indonesia

the SVLK as a legality verification system according to their EUTR, and allowed the importation of Indonesian timber without additional due diligence in 2016.

To promote the FSC, an NGO based in the Netherlands and Indonesia, the Borneo Initiative, was established in 2012 with support from Dutch housing companies. Collaborating with other NGOs, the Borneo Initiative has provided financial and technical support to logging companies to be certified by the FSC. It succeeded in increasing the number of FSC-certified concessions to 20 by the end of 2017.

25.4.5 Sabah

The Sabah state government, and especially the Forestry Department, introduced obligations towards reduced-impact logging and sustainable forest management in all logging concessions in the state in 1997 (Lintangah 2014). By May 2017, 746,564 ha of forest in Sabah were fully certified (*Daily Express* 2017). In recent years, the state government is enhancing the function of each land-use type. While the government has boosted intensive log production from the planted forests, it also increased the coverage of totally protected forests to 1.9 million ha, 26% of total state land, by 2016.

25.4.6 Sarawak

Forestry policy in Sarawak was changed significantly after Adenan Satem (in office 2014–2017) succeeded Taib Mahmud as chief minister. He declared controls over illegal logging (*Borneo Post* 2016) and strengthened the Sarawak Timber Legality Verification System (STLVS) by including independent third-party verification to ensure compliance with Sarawak's laws and regulations (*Borneo Post* 2015b; Ling 2017). The Sarawak government also established one-stop compliance centres along logging roads throughout the state to enforce compliance, particularly for assessment of royalties to the forest as close as possible to the felling sites (Forest Department Sarawak 2016), and also encouraged the big six logging companies to have their concessions certified as sustainable forest management. Adenan died of a heart attack in office in January 2017. His successor as chief minister, Abang Johari Openg (in office 2017–), is continuing his policies of not having any more large-scale oil palm plantations and also monitoring the timber industry, particularly logging (*Borneo Post* 2018). Following these policy changes, the volume of plywood imported to Japan from Malaysia decreased by 26% in 2014–2016 (*Mokuzai Kenzai Weekly* 13 February 2017). The volume of timber production in Sarawak is expected to fall continuously in the near future.

25.5 Conclusion

Timber trading from the Philippines, Malaysia, Indonesia and Papua New Guinea to Japan has been one of the main factors behind forest degradation and has also led to deforestation. Logging permits were issued repeatedly at a rate faster than the recovery capacity of the forests and were used as a tool to win political struggles by local politicians. Logging roads were extended in the far interior, allowing illegal loggers to enter these areas easily when government law enforcement became weak. Continuous primary forests in this region only remain in the deep interior where road or river access is too difficult for logging operations.

However, logging in natural forests is not the main cause of deforestation in these countries in recent years. Oil palm and industrial tree plantations owned both by large companies and smallholders are expanding rapidly in lowland areas of Malaysia and Indonesia, accelerating deforestation. In light of this it is necessary to guide the logging licence-holders in managing their natural forest concessions in a sustainable manner and to regulate the rampant conversion of the forest into oil palm and industrial tree plantations.

References

Aiken, S. Robert, and Colin H. Leigh. 1992. *Vanishing rain forests: The ecological transition in Malaysia*. New York: Oxford University Press.

Borneo Post. 2015a. Enforce improved Sarawak Legality Verification System immediately. 3 September.

———. 2015b. Chong blames 'big six' for deforestation. 29 May.

———. 2016. Sarawak state government is committed to combat illegal logging. 3 March.

———. 2018. The way forward. 13 January.

Caldecott, Julian. 1996. *Designing conservation projects: People and biodiversity in endangered tropical environments*. Cambridge: Cambridge University Press.

Center for Forestry Planning and Statistics, Ministry of Forestry. 2009. *Indonesia forestry outlook study*. Bangkok: FAO Regional Office for Asia and the Pacfic.

Chokkalingam, Unna, Antonio P. Carandang, Juan M. Pulhin, Rodel D. Lasco, Rose Jane J. Peras, and Takeshi Toma, eds. 2006. *One century of forest rehabilitation in the Philippines: Approaches, outcomes and lessons*. Jakarta: Center for International Forestry Research.

Cooke, Fadzilah M. 1999. *The challenge of sustainable forests: Forest resource policy in Malaysia, 1970–1995*. St Leonards: Allen and Unwin.

Cruz, Maria Concepcion, Carrie A. Meyer, Robert C. Repetto, and Richard Woodward. 1992. *Population growth, poverty and environmental stress: Frontier migration in the Philippines and Costa Rica*. Washington, DC: World Resources Institute.

Daily Express. 2017. Two more forest reserves in Sabah certified under FSC. 30 May.

Dauverge, Peter. 1997. *Shadows in the forest: Japan and the politics of timber in Southeast Asia*. Cambridge, MA: MIT Press.

De la Cruz, E. 1941. The socio-economic significance of the Philippine forest. *Philippine Journal of Forestry* 4: 141–160.

Faeh, Daniel. 2011. *Development of global timber tycoons in Sarawak, East Malaysia*. Basel: Bruno Manser Fund.

Food and Agriculture Organisation [FAO]. 2015. *Global forest resources assessment: How are the world's forests changing?* Rome: Food and Agriculture Organisation.

Forest Department Sarawak. 2016. Sarawak state government is committed to combat illegal logging. 3 March. http://www.forestry.sarawak.gov.my/modules/web/pages.php?mod=news&sub=news_view&nid=327. Accessed 20 Aug 2018.

Forest Management Bureau [FMB]. 2016. *2016 Philippine forestry statistics*. Manila: Department of Environment and Natural Resources, Republic of the Philippines.

Forest Trends, and Koalisi Anti-Mafia Hutan. 2015. *Indonesia's legal timber supply gap and implications for expansion of milling capacity: A review of the road map for the revitalization of the forest industry, phase 1*. Forest Trends.

Forestry Agency. 2016. *Shinrin ringyo hakusho* [Annual report on forest and forestry in Japan for the fiscal year 2015]. Tokyo: Forestry Agency.

———. 2017. *Shinrin ringyo hakusho* [Annual report on forest and forestry in Japan for the fiscal year 2016]. Tokyo: Forestry Agency.

Gaveau, David L.A., Douglas Sheil, Mohammad A. Salim Husnayaen, Sanjiwana Arjasakusuma, Marc Ancrenaz, Pablo Pacheco, and Erik Meijaard. 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific Reports* 6: 32017.

Hirsch, Philip, and Carol Warren, eds. 1998. *The politics of environment in Southeast Asia: Resources and resistance*. London: Routledge.

Japan Federation of Plywood Producing Factories' Association [JFPPFA]. 2008. *Goban hyakunenshi* [100 years of plywood]. Tokyo: JFPPFA.

Japan South Sea Lumber Council [Nihon nayo-zai kyogikai]. 1975. *Nanyozai shi* [History of South Sea wood]. Tokyo: Japan South Sea Lumber Council.

Kartasubrata, Junus. 1985. Forest policy, legislation and administration in Indonesia. *Nederlands Bosbouwtijdschrift* 57 (5/6): 167–175.

Lawson Sam, Art Blundell, Bruce Cabarle, Naomi Basik, Michael Jenkins, and Kerstin Canby. 2014. *Consumer goods and deforestation: An analysis of the extent and nature of illegality in forest conversion for agriculture and timber plantations*. Forest Trends.

Ling, Sharon. 2017. All timber concessions in Sarawak will need forest management certification. *The Star*, 7 November.

Lintangah, Walter. 2014. Stakeholder analysis in sustainable forest management in Sabah, Malaysia. PhD thesis, Technische Universität Dresden.

Malaysian Palm Oil Board. 2017. Production of crude palm oil for the month of December 2017. http://bepi.mpob.gov.my/index.php/en/statistics/production/177-production-2017/792-production-of-crude-oil-palm-2017.html. Accessed 19 Aug 2018.

Ministry of Agriculture, Forestry and Fisheries [MAFF]. 2017. *Rinsanbutsu gaikoku nintei koujyo itiran* [List of certified foregn factories of forestry products]. Tokyo: MAFF.

Ministry of Environment and Forestry, Indonesia. 2016. *Statistik lingkungan hidup dan kehutanan 2016* [Annual statistics of environment and forestry]. Jakarta: Ministry of Environment and Forestry, Indonesia.

Mokuzai Kenzai Weekly. 2016. 11 April.

Murashima, Yoshinao, and Akihiko Araya. 2000. *Sekaino mokuzai boueki kouzo—Kankyo no seikihe grobaruka-suru mokuzai sijyou* [International structure of timber trading—Globalised timber market towards the century of the envirionment]. Tokyo: Nihon ringto chosa-kai [Japan Forest Engineering Society].

Oberndorf, Robert B. 2013. *Combating illegal logging in Asia: A review of progress and the role of the Asia Forest Partnership 2002–2012*. Forest Trends.

Rebugio, Lucrecio L., Juan M. Pulhin, Antonio P. Carandang, Eleno O. Peralta, Leni D. Camacho, and Nathaniel C. Bantayan. 2007. Forest restoration and rehabilitation in the Philippines. In *Keep Asia green*, Southeast Asia, ed. D.K. Lee, vol. 1, 125–169. Vienna: IUFRO.

Ross, Michael L. 2001. *Timber booms and institutional breakdown in Southeast Asia*. Cambridge: Cambridge University Press.

Roth, Dennis M. 1983. Philippine forests and forestry: 1565–1920. In *Global deforestation and the nineteenth-century world economy*, ed. Richard Philip Tucker and John F. Richards, 30–49. Durham: Duke University Press.

Sabah Forestry Department. 2003. *Annual report 2003*. Sandakan: Sabah Forestry Department.

———. 2004. *Annual report 2004*. Sandakan: Sabah Forestry Department.

———. 2005. *Annual report 2005*. Sandakan: Sabah Forestry Department.

———. 2006. *Annual report 2006*. Sandakan: Sabah Forestry Department.

———. 2007. *Annual report 2007*. Sandakan: Sabah Forestry Department.

———. 2008. *Annual report 2008*. Sandakan: Sabah Forestry Department.

———. 2009. *Annual report 2009*. Sandakan: Sabah Forestry Department.

———. 2010. *Annual report 2010*. Sandakan: Sabah Forestry Department.

———. 2011. *Annual report 2011*. Sandakan: Sabah Forestry Department.

———. 2012. *Annual report 2012*. Sandakan: Sabah Forestry Department.

———. 2013. *Annual report 2013*. Sandakan: Sabah Forestry Department.

———. 2014. *Annual report 2014*. Sandakan: Sabah Forestry Department.

———. 2015. *Annual report 2015*. Sandakan: Sabah Forestry Department.

———. 2016. *Annual report 2016*. Sandakan: Sabah Forestry Department.

———. 2017. *Annual report 2017*. Sandakan: Sabah Forestry Department.

Sarawak Forest Department. 2017. Log production and forest revenue, 2000–2018. Kuching. http://www.forestry.sarawak.gov.my/page-0-287-1030-Log-Production-And-Forest-Revenue-2000-2018-August.html. 18 Sept 2018.

Sarawak Timber Association. 2017. *STA review* 291, December.

Sarawak Timber Industry Development Corporation [STIDC]. 2006. *Annual report*. Sarawak: Sarawak Timber Industry Development Corporation [STIDC].

———. 2009. *Annual report*. Sarawak: Sarawak Timber Industry Development Corporation [STIDC].

———. 2016. *Annual report*. Sarawak: Sarawak Timber Industry Development Corporation [STIDC].

———. 2017. *Annual report*. Sarawak: Sarawak Timber Industry Development Corporation [STIDC].

Shinohara, Takeo. 1981. *Tonanajia oseania no ringyo* [Forestry in Southeast Asia and Oceania]. Tokyo: Chikyu-sha.

Shiotani, Tsutomu. 1969. *Tonanajia ringyo no tenkai—Nanyo-zai no seisan ryutsu kouzou* [Development of forestry in Southeast Asia—Production and trading structures of South Sea wood]. Tokyo: Chikyu shuppan.

Ta Ann Group. 2018. Business activities. http://www.taann.com.my/. 19 Sept 2018.

Ueda, Yoshiki. 2016. Goban, tokuni katawaku-goban (concrete panel) no genjyo to konngo no kokusanzai siyou no kanusei [Current status of plywood especially concrete-forming panels and future potential to use domestic wood]. http://www.rinkeikyo.jp/documents/20160113ueda.pdf. Accessed 19 Aug 2018.

World Rainforest Movement, and Sahabat Alam Malaysia. 1990. *The battle for Sarawak's forests*. Penang: World Rainforest Movement and Sahabat Alam Malaysia.

Chapter 26
Certifying Borneo's Forest Landscape: Implementation Processes of Forest Certification in Sarawak

Daisuke Naito and Noboru Ishikawa

Abstract Sarawak has a history of imposing political constraints on natural resource governance. Forest certification is expected to bring important changes to forestry in Sarawak, heralding a new era of forest management. However, the effects of a new environmental regulatory system have yet to be adequately examined, particularly the social consequences of certification which vary depending on the standards employed, audit procedures and the levels of stakeholder participation. This chapter examines experiences to date with forest certification in Malaysia, specifically certification by the Malaysian Timber Certification Council (MTCC) in Sarawak, to investigate the effects of certification on both forest management and rural communities. It is therefore important to focus attention on issues related to both indigenous peoples' land and natural resources use. The example of Malaysia and the divergent experiences in different states illustrates that the situation on the ground can vary greatly, even with the same forest certification scheme and within the same country.

Keywords Sarawak · Forest certification · Environmental management · Deforestation · Land-use change · Indigenous people

D. Naito (✉)
Graduate School of Agriculture, Kyoto University, Kyoto, Japan

Center for International Forestry Research, Bogor, Indonesia
e-mail: dnaito@cseas.kyoto-u.ac.jp

N. Ishikawa
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_26

26.1 Introduction

Sarawak has a history of imposing political constraints on natural resource governance. In 2014 the former Sarawak chief minister Adenan Satem announced what appeared to be a new direction by stating that at least six logging concessions within the state needed to achieve Malaysian Timber Certification Council (MTCC) certification by 2020. Forest certification is expected to bring important changes to forestry in Sarawak, heralding a new era of forest management. However, the effects of the new environmental regulatory system have yet to be adequately examined, particularly the social consequences of certification which vary depending on the standards employed, audit procedures and level of stakeholder participation. It is thus essential to thoroughly examine the effects of the forest certification systems in order to determine their efficiency and consequences on the global, national and local levels. This chapter describes the background of forest certification schemes as well the framework, implementation processes and experiences involved with forest certification in Malaysia, in particular Sarawak's role in obtaining certification by the MTCC. The discussion also analyses the effects of these certification schemes on forest management and on rural communities that are often marginalised and highly dependent on natural forest resources.

Forest certification systems emerged in the 1980s out of an environmental movement against massive deforestation in the tropics. Commercial logging—one of the main causes of deforestation during that period—has had serious effects on the subsistence activities and cultural practices of rural communities as well as on forest ecosystems and global biodiversity. A number of scholars have documented how logging has drastically altered rural communities' livelihoods (Brosius 1997; Dentan et al. 1997; Cooke 1999; Nicholas 2000). Many observers became first cognisant of these issues when indigenous protesters blockaded logging roads in East Malaysia to bring wider attention to their struggle (Hong 1987; Brosius 1999). In response, European non-governmental organisations (NGOs) created campaigns to boycott tropical timber and governments introduced procurement policies to avoid importing tropical timber. Many other countries followed suit with similar regulations (Vogt et al. 1999). However, tropical timber-producing countries complained that the regulations erected unfair trade barriers. Others argued that boycotts were ineffective in stopping deforestation and, instead, promoted further forest conversion. Hence, some European governments changed their policies to emphasise the promotion of timber produced in environmentally and socially sustainable forests. Forest certification systems thus emerged to verify this type of sustainability.

Among the several forest certification systems in the world, the Forest Stewardship Council (FSC) is particularly well known for its strict adherence to rigorous social and environmental standards (Bass et al. 2001; Klooster 2006).[1] The

[1] The FSC was established by interested business representatives, social groups and environmental organisations to improve forest management as environmentally appropriate, socially beneficial and economically viable (Romero et al. 2013).

FSC was officially established in 1994 as an independent, non-governmental and non-profit organisation. Its purpose was to promote responsible management of the world's forests by setting certification standards, trademark assurances and accreditation services for companies and organisations interested in responsible forestry (FSC 2018a). Its certified forests are spread across 86 countries, totalling 200.8 million ha (FSC 2018b). The FSC Principles and Criteria (FSC P&C) comprise 10 principles and 56 criteria that certify forest management with the tripartite goal of economic viability, biodiversity conservation and respect for indigenous peoples' rights (Nussbaum and Simula 2005).[2] As of 2016, the global area of certified forest is estimated at 462 million ha (UNECE/FAO 2016). The total expanse of certified forests worldwide amounts to an estimated 11% of global forest areas. Although forest certification was created to deal with the decline of tropical forests, it has so far had limited acceptance and response in tropical areas.

This chapter begins by examining the process of implementing forest certification in Malaysia. It describes the background, progress and present status of forest certification schemes. It then compares Malaysia's two certification schemes, the processes by which these forest certification schemes were introduced and stakeholder participation in these processes, including how stakeholders influenced the establishment of the schemes. Sarawak and Sabah serve as case studies for an explanation and analysis of the problems that have arisen with Malaysia's forest certification systems.

26.2 Forest Certification in Malaysia

Two forest certification organisations and schemes operate in Malaysia: the MTCC and the FSC.[3] The MTCC (reviewed at greater length below) was established in October 1998 to develop and operate a Malaysian national forest certification scheme. It is an independent organisation, incorporated under the Companies Act 1965. It is governed by a board of trustees, although it is strongly influenced by the Malaysian government and funded through revenue from the Malaysian timber trade.

Under the constitution of the Malaysia, land, forests and resources lie under the jurisdiction of the states (Cooke 1999). For the MTCC, certification is given to a forest management unit (FMU) which is responsible for forest management in the

[2] The FSC P&C are global standards of forest management that apply to all FSC-certified forests in the world. For the purposes of this chapter, the most relevant principles are principle 1: compliance with all applicable laws and international treaties; principle 2: tenure and use rights and responsibilities; principle 3: recognition and respect of indigenous peoples' rights; and principle 4: maintenance or enhancement of the long-term social and economic wellbeing of forest workers and local communities and respect of workers' rights. For this chapter, the FSC P&C are FSC-STD-01-001 V4-0 since the new V5-2 has not yet been implemented on the ground.

[3] Formerly known as the National Timber Certification Council (NTCC), which was established in 1998 (*Malaysiakini* 2001).

area, but states differ in how each FMU is constituted. In each state of peninsular Malaysia there is only one FMU and it comprises that state's forest reserve. On the other hand, in both Sabah and Sarawak there are multiple FMUs with each FMU comprising a different concession area. In 2018 the total area of MTCC-certified forest was 4.35 million ha. Most state forests in peninsular Malaysia and two timber concessions in Sabah and Sarawak have met the Malaysian Criteria, Indicators, Activities and Standards of Performance for Forest Management Certification (MC&I) (MTCC 2018).

The second forest certification scheme was introduced in 1994: FSC certification. As noted above, the FSC is an international non-profit NGO which aims to promote forest management that is appropriate from an environmental perspective to benefit society while also being economically sustainable. The FSC, with its 10 principles and 56 criteria to evaluate sustainable forest management, does not actually issue certificates; it accredits certification bodies to conduct the certification process. Forest managers select a specific certification body accredited to do such FSC audits. These certification bodies currently include the Rainforest Alliance, Société générale de surveillance (SGS) and SCS Global Services, among others.[4]

The FSC also approves national standards that conform to FSC principles and criteria, while incorporating more local concerns and issues. In Malaysia, the national standard has just been approved by the FSC. However, before approval the certification body that does the audits must create an interim standard on a case-by-case basis. In order to achieve certification, forest managers usually have to obtain lengthy logging concession licences from the state government to show their commitment to long-term forest management. The state governments cooperate with private companies to provide support to the forest managers. Donor and foreign development aid or other funding agencies also provide monetary and technical support. When independent auditors approve forestry management practices as meeting FSC standards, an FSC certification is granted. For example, the Sabah Forestry Department was awarded FSC certification in 1997 for an area in Kinabatangan known as the Deramakot Forest Reserve with a sustainable management plan that was developed in collaboration with Gesellschaft für Internationale Zusammenarbeit (GIZ, formerly Gesellschaft für Technische Zusammenarbeit, GTZ) since 1989. In peninsular Malaysia, the Perak Integrated Timber Complex was issued FSC certification for its natural forests in 2002, having collaborated with the Tropical Forest Trust, an organisation that supports work toward obtaining certification. Table 26.1 presents the list of MTCC- and FSC-certified forest areas in Malaysia.

[4] The FSC does not directly certify, but sets credible standards. Certification bodies that are accredited can be found online at the Accreditation Services International website (ASI 2018). SGS is a certification body that conducts audits, with headquarters in Switzerland. The SGS Qualifor is a forest certification programme accredited by Accreditation Services International. The regional branch, SGS-Malaysia, also conducts MTCC certifications and other certification audits.

Table 26.1 Forest management area certified in Malaysia (natural forest), 2018

Forest	Certificate-holder/FMU management	Certified area (ha)
MTCC-certified forests		
FMU 11 (Sabah)	Bornion Timber Sdn Bhd	40,645.50
Kedah FMU	Kedah State Forestry Department	334,983.00
Segaliud Lokan FMU (Sabah)	KTS Plantation Sdn Bhd	57,247.00
Negeri Sembilan FMU	Negeri Sembilan State Forestry Department	155,825.00
Pahang FMU	Pahang State Forestry Department	1,504,407.35
Perak FMU	Perak State Forestry Department	998,306.02
Ravenscourt FMU (Sarawak)	Ravenscourt Sdn Bhd	117,941.00
FMU 14 (Sabah)	Sapulut Forest Development Sdn Bhd	54,643.00
Selangor FMU	Selangor State Forestry Department	238,748.83
Kapit FMU (Sarawak)	Tanjong Manis Holdings Sdn Bhd	149,756.00
Terengganu FMU	Terengganu State Forestry Department	544,936.58
Anap-Muput FMU (Sarawak)	Zedtee Sdn Bhd	83,535.00
Linau FMU (Sarawak)	Shin Yang Trading Sdn Bhd	72,685.00
	Total	4,353,659.28
FSC-certified forests		
Deramakot Forest Reserve	Sabah Forestry Department	55,139.00
Trusan Sugut Forest Reserve	Sabah Forestry Department	8,680.00
Tangkulap and Sungai Talibu Forest Reserves	Sabah Forestry Department	48,431.00
Ulu Segama-Malua FMU	Sabah Forestry Department	242,884.00
Northern Gunung Rara Forest Reserve	Sabah Forestry Department	61,330.00
Pin-Supu Forest Reserve	Sabah Forestry Department	4,696.00
Timimbang-Botitian FMU	Sabah Forestry Department	13,610.00
Nuluhon Trusmadi & Sungai Kiluyu FMU	Sabah Forestry Department	88,045.00
Ulu Kalumpang-Wullersdorf FMU	Sabah Forestry Department	64,953.74
KPKKT FMU (Terengganu)	Kumpulan Pengurusan Kayu Kayan Terengganu Sdn Bhd	106,877.00
Cherul Forest Reserve (Terengganu)	Pesama Timber Corporation Sdn Bhd	20,243.00
Total		714,888.74

Sources: MTCC (2018), Sabah Forestry Department (2017a, b, 2018a, b, c, d, e, f, g) and FSC (2018b)

26.3 The MTCC Implementation Process

26.3.1 The National Consultation Process

As noted above, in the 1980s the Malaysian timber industry was severely damaged and timber exports decreased due to boycotts by European countries that prohibited the importation and use of tropical timber. In order to re-enter European markets, establishing an internationally credible independent forest certification scheme became politically and economically vital for the Malaysian timber sector. The National Forestry Council decided to establish an independent national forest certification scheme based on the criteria and indicators of the International Tropical Timber Organisation (ITTO) (Ng 2000).[5] However, the processes of establishing and operating the scheme were lengthy and complex. Table 26.2 reviews the timeline of the main steps in the MTCC and MC&I processes.

Malaysia joined the ITTO as a tropical timber-producing country in 1994, and ratified the International Trade Timber Agreement (ITTA) including ITTO Objective 2000, the purpose of which was to move rapidly towards an international trade in tropical timber from sustainably managed forests. Member countries were requested to work towards achieving sustainable forest management.

In 1994 the National Committee of Sustainable Forest Management (NCSFM) was established, comprising representatives of the Ministry of Primary Industries, the Forestry Department (peninsular Malaysia, Sabah and Sarawak), the Forest

Table 26.2 Timeline of the MTCC and MC&I implementation process

Year	Activity
1994	Establishment of the National Committee of Sustainable Forest Management (NCSFM)
1996	Establishment of the Malaysia-Netherlands Joint Working Group on Forestry (M-NJWG); launch of a pilot project to evaluate Malaysian forestry practices
1998	Establishment of the MTCC
1999	National public consultation held, introduction and proposal of the Malaysian Criteria and Indicators (MC&I) system
2000	Revision of MC&I
2001	Adoption of MC&I (2001); exit of NGO/CSOs from the MTCC; certification of FMUs in Pahang, Terengganu and Selangor
2002	The MTCC joined PEFC to begin mutual recognition of certification
2005	Adoption of MC&I (2002)
2009	The MTCS endorsed by the PEFC
2011	Adoption of MC&I (Natural Forest)
2013	Anap-Muput FMU awarded PEFC certification

Sources: Sandom and Simula (2001) and MTCC (2018)

[5] The National Forestry Council coordinates the work of the forestry department of each state of peninsular Malaysia, Sabah and Sarawak and considers the direction of the national forestry policy.

Research Institute of Malaysia, the Malaysian Timber Industry Board (MTIB), the Malaysia Timber Council (MTC) and Universiti Putra Malaysia's Faculty of Forestry. The committee was established to elaborate and put into operation both the ITTO's guidelines for the sustainable management of natural tropical forests and its criteria for the measurement of sustainable tropical forest management to ensure Malaysian forests would be more sustainably managed.

In order to achieve better market access to European countries, Malaysia started cooperating with the Netherlands, which at the time was the largest importer of timber from peninsular Malaysia. In mid-1996 the MTIB and the Netherlands Timber Trade Association (NTTA) created a partnership focusing on timber certification known as the Malaysia-Netherlands Joint Working Group on Forestry (M-NJWG). The partnership launched a pilot project to evaluate Malaysian forestry practices in light of the Netherlands's timber procurement policy. The goal was to export certified timber to the Netherlands. In 1997 the National Forestry Council appointed the NCSFM to formulate a set of MC&I based on the ITTO's criteria and indicators. The MC&I were formulated to be specifically consistent with the Netherlands's timber procurement policy.

In peninsular Malaysia, the entire area of each state's forested zones was considered one forest management unit which then became the unit for certification. Each state's forestry department was responsible for obtaining certification as the forest manager. In Sabah and Sarawak, either logging companies or forestry departments were the forest managers to be certified. The NCSFM stipulated that revenue from timber exports was to be used for operating a forest certification scheme in Malaysia.

In 1998 the MTCC was established to operate the forest certification scheme. The MTCC board of trustees, which formulated its goals, included environmental NGOs such as World Wildlife Fund-Malaysia (WWF-Malaysia) and aimed for balanced decision-making among the stakeholders. The MTCC led the formulation of the MC&I and Sabah and Sarawak held regional consultation meetings to discuss the contents of the certification scheme. In October 1999 a national public consultation was held and proposed the Malaysian Criteria and Indicators (seven criteria and 53 indicators). The M-NJWG formulated the MC&I based on a simplified version of the Netherlands's timber certification. SGS-Malaysia conducted audits for the Pahang, Terengganu and Selangor forestry departments using the MC&I, and issued a list of areas of non-compliance. These forestry departments then improved the practices that had been deemed non-compliant, passed the reassessment and were awarded MTCC certification. However, the Netherlands requested additional supplementary audits concerning indigenous issues and thus a higher standard for their timber import requirements. Consequently, the MTCC-certified timber still did not qualify for export to the Netherlands (MTIB 1998). The MTCC decided not proceed with joint certification with the Netherlands because of the additional changes the latter made.

In October 2001 the MTCC adopted the MC&I for MTCC certification. The MC&I adopted were a revised version with six criteria and 29 indicators (MC&I 1999). The MTCC primarily adopted the revised version and launched forest certification with the intention of implementing a stepwise approach to achieving more demanding levels of certification. In December 2001 the accredited certification body, SGS-Malaysia, certified the FMUs in Pahang, Terengganu and Selangor based on the 1999 MC&I.

The adoption of the MC&I 1999 by the MTCC was not supported by WWF-Malaysia, a member of the original MTCC board of trustees. WWF-Malaysia announced its objection to the decision and resigned from the board, stating that the results of the consultation process were not reflected in these MC&I.[6] An NGO representing indigenous peoples' groups also resigned from the MC&I consultation process (Ng et al. 2002; JOANGOHutan 2002).

26.3.2 Efforts Towards Mutual MTCC and FSC Recognition

The MC&I that were adopted did not meet the Netherlands's timber regulations and the price premium could not be realised as long as the MC&I standards were not compliant. The MTCC therefore decided to continue towards obtaining mutual recognition with the FSC. In 2000 they co-hosted a forest certification workshop and conducted a comparative study of the standards. The results confirmed that the MC&I 1999 needed to be revised in order to conform to both the environmental and social aspects of the FSC principles and criteria. A national steering committee was established and started a multi-stakeholder consultation process for progressing towards mutual recognition of two certification systems, essentially revising the MC&I 1999. Beginning in April 2001, the national steering committee held five meetings and established a technical working group in peninsular Malaysia, Sabah and Sarawak to formulate indicators and verifiers for the revised MC&I.

In October 2002, at the national-level consultation meeting with relevant stakeholders, it was agreed that the new MC&I 2002 based on the FSC P&C would be field-tested in each of the three regions (Sabah, Sarawak and peninsular Malaysia) (MTCC 2002a). In 2004 the certification bodies and stakeholders participated in and conducted MC&I 2002 field tests in peninsular Malaysia, Sabah and Sarawak (MTCC 2004), including in Perak FMU, Deramakot Forest Reserve and Ulu Balui, Kapit, in the three regions, respectively. However, the NGO that represented the indigenous peoples' groups did not participate in the technical working group and national steering committee consultation process since issues of customary rights were still not taken into account.

Compared to the MC&I 1999, the MC&I 2002 appeared slightly stricter, although certain criteria relating to environmental conservation and indigenous customary rights issues remained unresolved. When the previous certificate-holders renewed their certification, the MTCC applied the MC&I 2002. Table 26.3 presents a comparison of the basic contents of the FSC P&C, the MC&I 1999 and the MC&I 2002.

[6] Members of labour groups from the timber industry and the Malay Forest Officers Union, West Malaysia, replaced WWF-Malaysia on the board of trustees.

Table 26.3 Comparison of the criteria for the FSC and MC&I

	FSC P&C	MC&I 2002	MC&I 1999
Compliance framework	National legislation[a]	National legislation	National legislation
	Convention on International Trade in Endangered Species of Wild Fauna and Flora	Convention on International Trade in Endangered Species of Wild Fauna and Flora	
	International Labour Organisation Treaty	International Labour Organisation Treaty	
	International Tropical Timber Agreement	International Tropical Timber Agreement	
	Convention on Biological Diversity	Convention on Biological Diversity	
Indigenous rights security	Respect for traditional and legal rights to possess, use and manage land, territory and resources	Assure indigenous resources and tenure rights prescribed by both indigenous law and national law	Interested parties document opinions on indigenous law and guarantee status of customary rights
Biodiversity conservation	Conservation of endangered species	Practice environmental impact assessment and create wildlife corridors in areas greater than 500 ha	Identify rare and endangered species and conserve their habitat
	Protection of mother-tree nesting areas, habitats and unusual species	Conserve genetic diversity, wildlife and biodiversity in FMUs	
	Preservation of high conservation value forests	Prohibit improper hunting, gathering, fishing and trapping	
		Preservation of high conservation value forests	
Environmental considerations	Prohibit the use of toxic chemicals	Prohibit the use of toxic chemicals	Documentation of guidelines for low-impact logging
	Prohibit genetic modification	Practise low-impact logging	
	Prohibit the diverted use of plantation forests and other land	Possible to redirect land use for alternative uses	

Sources: Scientific Certification Systems (2010), MTCC (2002b) and NTCC (1999)
Note: [a]National legislation includes the federal constitution, national forestry policy, national policy on biological diversity, National Forestry Act, state forest enactments, state forestry policy, state forest rules, state ordinances related to protection of wildlife, and so on

In order to achieve mutual recognition with the FSC, the MTCC reorganised the technical working group and the national steering committee to establish the national working group to reformulate the MC&I. The MTCC wanted the national working group to be recognised by the FSC and the MC&I 2002 to be endorsed as the FSC's national standards by FSC International. In August 2003 a technical working group was established as the national working group, and in 2004 conferences were held in peninsular Malaysia, Sabah, and Sarawak (MTCC 2004). However, the FSC was not satisfied with the established national working group because the NGO representatives of the indigenous peoples did not participate in the consultation processes.

26.3.3 Mutual Recognition with the PEFC

Without the participation of indigenous groups in the consultation process, it was near impossible to achieve the mutual recognition of the MTCC by the FSC. The MTCC therefore decided to look beyond the FSC and seek mutual recognition with the PEFC, another international forestry certification scheme. The PEFC was established in 1999 by governmental organisations, timber companies and stakeholders in the paper industry to carry out certification schemes for sustainably managed forests. Initially, the PEFC was named the Pan-European Forest Certification and targeted European forests. However, it is now a globally recognised forest certification scheme. Principally, the PEFC assesses member countries' certification initiatives to arrive at a mutual recognition of certification. In 2002 the MTCC joined the PEFC and the mutual recognition process began.

In order to achieve mutual recognition, there were several conditions the MTCC had to improve. Among these conditions, certification audits and accreditation had to be conducted by an external independent organisation. The MTCC had certified the certification bodies; now, the new accreditation body was to accredit certification bodies. The Department of Standards Malaysia was given that responsibility (Indufor 2009). The MTCC implemented several changes that allowed them to meet PEFC standards and its timber certification programme was approved by the PEFC. The MTCC thus achieved mutual recognition and was endorsed by the PEFC in 2009. When approving the mutual recognition, the PEFC did not request a substantial revision of the MC&I. The PEFC respected the MTCC position on ensuring indigenous rights within Malaysian domestic law. PEFC-certified products were first exported from Malaysia in 2010 following this mutual recognition and 2510.73 m^3 of PEFC-certified products were exported in the first year (MTCC 2010).

26.4 Comparison of the Certification Schemes

While the MTCC was successfully endorsed by the PEFC and has thus achieved a degree of acceptance in the global market, mutual recognition between the MTCC and the FSC has proved remarkably challenging. Table 26.4 presents a summary of the differences between the present MTCC and FSC certification standards.

Table 26.4 Comparison of selected MTCC and FSC principles

Principle	MC&I natural forest	FSC principles and criteria
Compliance with laws and standards	Forest management shall comply with all applicable laws of Malaysia and respect international treaties.	Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.
Tenure and use rights and responsibilities	Availability of documentation, if any, of legal or customary tenure or use rights of local communities within relevant federal, state and local laws in the FMU.	Local communities with legal or customary tenure or use rights shall maintain control, to the extent necessary to protect their rights or resources, over forest operations unless they delegate control with free and informed consent to other agencies.
Indigenous peoples' rights	Forest management practices in indigenous people's lands recognised within relevant federal, state and local laws shall not threaten or diminish, either directly or indirectly, their resources or tenure rights.	Forest management shall not threaten or diminish, either directly or indirectly, the resources or tenure rights of indigenous peoples.
Environmental impacts	Environmental impact assessments are carried out, including landscape level considerations, as well as the impacts of on-site processing facilities, appropriate to the scale and intensity of forest management, prior to commencement of forest operations in the FMU.	Assessment of environmental impacts shall be completed—appropriate to the scale, intensity of forest management and the uniqueness of the affected resources—and adequately integrated into management systems. Assessments shall include landscape level considerations as well as the impacts of on-site processing facilities. Environmental impacts shall be assessed prior to commencement of site disturbing.
Maintenance of high conservation value forests impacts	Forest managers shall determine the presence of HCVF attributes in the FMU in accordance with relevant federal, state and local laws, appropriate to scale and intensity of forest management operations in the FMU, and in consultation with relevant stakeholders.	Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.

Sources: MC&I Natural Forest (MTCC 2012a, b); FSC-STD-01-001 V4-0

26.4.1 MTCC-Certified Forests

In this section we examine the process of implementing MTCC forest management certification in Sarawak.

26.4.1.1 The Anap-Muput FMU

The Anap-Muput FMU (AMFMU) is first natural forest certified by the MTCC/PEFC in Sarawak, having been certified under the MC&I 2002 in 2005. The area is part of a former ITTO model forest management area (MFMA) and is located in the Tatau region of Bintulu. The ITTO initiated the MFMA project in 1993 as a sustainable forest management pilot project. The current area of the AMFMU is 83,535 ha and it is classified as permanent forest estate comprising the Mukah Hills Protected Forests (6600 ha) that was gazetted in 1956 and the Anap Protected Forests (76,935 ha) which was gazetted in 1958. Initially, the Sarawak Timber Industry Development Corporation (STIDC) held the forest concession, but in 1998 the concession was transferred to Shin Yang Trading Sdn Bhd until 2024 (Zedtee Sdn Bhd 2006). Zedtee Sdn Bhd (a subsidiary of Shin Yang Trading) has been responsible for forest management of the AMFMU since 1989.

The ITTO project was carried out from 1993 to 2006 and consisted of three phases. In the first phase, the ITTO project team conducted a selection of the forest management sites for the project and began the development of the MFMA plan. In the second phase, they drafted a forest management plan for the MFMA, conducted training and capacity-building of staff and logging workers, and developed reduced-impact logging and road construction in the field site. The achievements of the ITTO project have become fundamental resources in the region for meeting forest certification requirements.

In the AMFMU, one measure of the sustainability of timber harvests is the limiting of the annual allowable cut according to the current growth rate of the forest. This tree growth is calculated from simulations of a growth model based on permanent sample plots that were designated in the MFMA project phases. For 2015 the annual allowable cut was set at 12,000 m^3. In terms of environmental guidelines and concerns, an environmental impact assessment has been carried out. To determine the biological diversity of the area, the Wildlife Conservation Society Malaysia conducted a survey in 2006. A research team from Kyoto University also conducted camera trapping of wild animals in the AMFMU (Samejima and Hon, Chap. 8; Hon et al., Chap. 9). Given the size of the AMFMU and its location, it is unsurprising that parts of it have been identified as high conservation value forests, including vital areas such as water catchments, virgin forests, natural salt lick sites (Hon et al., Chap. 9) as well as culturally and religiously important places.

In terms of the social aspects of the AMFMU management, 17 longhouses within and around it have been identified. They are mostly Iban communities and engaged in swidden agriculture for their subsistence and livelihood. Satellite images showed that the total area of swidden agriculture was 7842 ha in 1996 and 8590 ha in 2005. These areas for swidden agriculture are mostly located along the northern and southern stretches of the Ulu Anap River. Migration from longhouses along the river banks to the sides of logging roads has been observed (AMFMU 2006) similar to that discussed by Ryoji Soda et al. (2015, Chap. 15). The AMFMU management raised concerns about their migration patterns and swidden practices as they may be a threat to the forest management. The ITTO conducted community development projects to mitigate the impact of swidden activities and transition these communities to a variety of alternative livelihoods (ITTO 2007).

Currently, six longhouses are located within the FMU and 11 longhouses are located adjacent to the AMFMU (AMFMU 2006). Regarding the relationship with these communities, Zedtee has been engaging with communities such as providing donations to the Gawai festival, the installation of aquaculture ponds, gravity-fed water systems, and performing services such as levelling the land for longhouses and improving road access for villagers. The Anap Sustainable Development Unit Liaison Committee along with the Conservation and Community Development Committee Anap-Muput were established to improve the channels of communication between the forest managers and the local communities, especially with regard to issues concerning legal and customary rights issues to land and resources. These committee frameworks are also responsible for documenting conflicts and complaints about forest operations and noting locations within the AMFMU that are culturally and religiously important, such as for the purpose of resolving disputes. Originally the northern and southeastern parts of the MFMA project zone were areas with a Licence for Planted Forest (LPF) and were licensed to Zedtee. The company has converted the original vegetation of this zone to plantations of oil palm and fast-growing trees. Although some dividend from these plantations is distributed to the adjacent communities, the village headman of one longhouse raised the issue of the limited access to natural resources within the area. As the area is no longer part of the AMFMU, this issue was not in the scope of the surveillance audit (SIRIM 2015).

Anap-Muput FMU was first area certified under the MC&I (2002) in 2005 by the MTCC. By then the MTCC had achieved mutual recognition with the PEFC. The main audit was made in April 2013 in a subsequent new standard certificate for forest management using the MC&I (natural forest), with three observations and six noncompliances being issued. Anap-Muput submitted collective action plans to solve these noncompliances in May 2013; an audit team leader approved these plans and Anap-Muput FMU has been awarded certification (SIRIM 2013).

Subsequently, the first surveillance visit was conducted by the two auditors on 23–29 June 2014. Five noncompliances and seven observations were issued. Noncompliances included logging roads, worker health and safety issues, an increase in logging accidents and sewage effluence from the workers' houses, as well as issues regarding the conservation of biodiversity and high conservation value forests.

Auditors stated that local communities' customary rights over *pulau* (communally reserved forests, see Takeuchi et al., Chap. 21) within the AMFMU had been recognised by the management (SIRIM 2013). *Pulau* (literally 'islands' in Iban) are stands of forest usually preserved when cutting forest for farming. There are many kinds of *pulau*, and some are created specifically to preserve water catchments, fruit trees or important timber trees for use in building at a later date. Others are considered locations where spirits reside or where important events occurred in the past (Takeuchi et al., Chap. 21). In 2013, in a case of the logging of *pulau*, Zedtee consulted with local communities and compensated them by performing requested tasks such as levelling the ground for the construction of a longhouse and by providing logs for building a 16-door longhouse (SIRIM 2015). Zedtee also facilitated the participation of local communities in rubber plantation development programmes conducted by the Rubber Industry Smallholders Development Authority.

The second surveillance visit with three auditors took place on 24–28 August 2015. At that time, one major noncompliance and seven minor noncompliances were recorded. Auditors learned that one of workers was paid less than the legal minimum wage, which is a major concern in terms of fair working conditions. This noncompliance was settled with the immediate payment of a minimum wage to the worker. An incident of the illegal logging of 'mother' or seed source trees within the AMFMU was also reported. A villager claimed that this damage was done within his *pulau*; however, Zedtee invited the district officer to confirm the legal status of the land and found that the area was part of the forest reserve (SIRIM 2013). Another minor noncompliance was regarding the lack of procedures to preserve culturally and religiously important sites within the AMFMU. An auditor also noted a minor noncompliance regarding the local communities not receiving the report of the social impact assessment and the lack of a monitoring system for mitigating social impacts.

The MFMA project provided the foundation for achieving certification. Regarding social matters, the AMFMU has been implementing community development programmes with local Iban communities to replace their traditional swidden activities with alternative livelihoods by using some of the revenue from newly established oil palm and tree plantations. However, this land-use conversion to plantations has perplexed local communities. Although the forest and the plantation areas are managed by the same company, the LPF area was excised from the MTCC-certified forests so MTCC standards are no longer relevant in these areas.

26.4.2 FSC Certification

As noted above, FSC certification has a reputation for using strict standards in respect of social aspects of local communities affected by forest management. The FSC's principles 3 and 4 are dedicated to these concerns:

> Principle 3: The Organisation shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.
> Principle 4: The Organisation shall contribute to maintaining or enhancing the social and economic wellbeing of local communities. (FSC 2015)

While Sarawak has no areas certified by the FSC, the introduction of FSC certification has had an important effect on local people in a certified forest in the neighbouring state of Sabah, the Deramakot Forest Reserve (DFR). After intense commercial logging in 1980s, Sabah began to pursue forest certification as an alternative to unsustainable practices. In 1989 the Sabah Forestry Department started implementing a sustainable forestry management project in partnership with GTZ, a German development agency, and the DFR was chosen as its project site (Mannan et al. 2003). In September 1997 the reserve was awarded the first forest certification in Southeast Asia by the FSC; it remains to this day the longest-standing certified rainforest. The DFR was selected because it was the only natural forest that had been previously logged and no communities existed within the forest reserve. Moreover, at the time it was chosen no logging licences had been issued in the proposed forest reserve (Mannan et al. 2002). When the German Federal Ministry for Economic Cooperation and Development offered to fund the project, its policy prohibited logging in virgin forests; thus, the DFR's disturbed forest from earlier logging activities presented the potential for ecosystem rehabilitation and recovery to the original condition of the forest and led to its selection. After the certification of the DFR, the Sabah Forestry Department also obtained FSC certification for several other forest reserves (Table 26.1).

The project goal at the DFR was to develop a sustainable forest management model for logged secondary forests. The project strengthened the research capabilities of Sabah Forestry Department staff and developed a forest management plan. Facilities were constructed, including buildings for officers, conference rooms, employee accommodation and training areas. Comprehensive forest resource inventories were conducted to determine the forest resources present and trained staff for the implementation of reduced-impact logging. The reduced-impact logging system was based on a growth model of Dipterocarpaceae species; the forest reserve consists primarily of mixed dipterocarp forest. The annual allowable cut at the DFR was limited to 20,000 m^3 per year and forest restoration and rehabilitation were mandated with a required reforestation of 200 ha per year (Mannan et al. 2002). Short-term socioeconomic research was also conducted in two villages located near the forest reserve.

As mentioned earlier, the FSC itself does not directly certify but delegates the certification process to accredited certification bodies. These organisations are in charge of monitoring a certified forest. For SGS, an accredited certification body, a major assessment at the beginning of the process is usually conducted; if a forest passes the initial assessment there will be surveillance visits at least once a year and a reassessment of the entire forest operation every 5 years. During surveillance visits auditors are required to ensure that compliance with FSC standards is still being maintained. If noncompliance with FSC standards is identified, SGS issues a corrective action request (CAR). A major CAR must either be dealt with immediately or the management team must provide a detailed outline indicating how it intends to address the situation. FSC certification is withdrawn if the forest management (the certificate-holder) does not show willingness to act on the CAR and improve its practices. A minor CAR must be dealt with by a specified deadline date. If a correction is not implemented before the next inspection the minor CAR may be upgraded to a major CAR. SGS assessment reports provide details of CARs, indicating points for corrective behaviour and improved practices specified by the auditor and how the forestry department responded in each case.

SGS conducted the first major assessment of the DFR in 1997. In a major assessment, the auditors began by assessing documents and field surveys. After the major assessment, SGS issued one major CAR and seven minor CARs. The major CAR concerned the Sabah Forestry Department's lack of management of its logging contractor, stating: 'Incidence of non-compliance with conditions of service contract, in absence of Forestry Department supervision' (SGS 1997). The Sabah Forestry Department worked to solve the problem and SGS revisited and approved the correction of the CARs. On 23 July 1997 the reserve was certified under FSC forest certification. No CARs were issued for social concerns in the first major assessment. The basic understanding of the auditors was that villagers did not depend on the forest reserve for a living, which would imply that their impact on the forest was small at that time.

The Sabah Forestry Department still finds that illegal timber extraction represents the biggest threat to the reserve (Mannan et al. 2002). These incidents were also mentioned during surveillance visits and the department decided to implement boundary demarcation activities. Then there are some complaints from local communities regarding the effects of these activities. The resulting stricter controls may raise some issues with local communities.

The SGS audit team did request that a committee be formed to encourage better communications between local indigenous peoples and NGOs in forest management (SGS 2002). And in 2000 the Deramakot Forest Reserve Social Forestry Committee was established, which aimed to promote social forestry and create opportunities through which local communities and the state's forestry department could work together (Sabah Forestry Department 2016). Structurally, the committee was led by the head of the DFR staff as the chairperson with the Sabah Forestry Department playing a major role. Local village representatives (two representatives from each village located around the DFR) served as committee members. Initially, meetings were held four times per year. After each meeting and before the next meeting, the Sabah Forestry Department staff documented and distributed minutes. The meetings were directed by the head of the DFR and, at the end of the meetings, there were question and answer periods. In the meetings, the Sabah Forestry Department provided information regarding ongoing forestry practices. The department also shared part-time job opportunities for planting seedlings and fruit trees within the DFR. While the committee discussed many matters, concerns over access to the DFR for local inhabitants and land-tenure issues could not be resolved within this committee.

The audit team also pointed out the need for development programmes among local communities and requested the involvement of a local NGO, which had an office in Kota Kinabalu. Initially, the Sabah Forestry Department provided financial support to the NGO for building a gravity-fed portable water system and a kindergarten. Furthermore, when major problems emerged, the local people could ask for support from the NGO. However, financial support to conduct these dialogues was not sufficient for the NGO to continue its support on the ground.

26.5 Conclusion

In this chapter, several implementation processes of the forest certification systems in Malaysia were reviewed. There are two such systems: the MTCC and the FSC. MTCC-certified forest now covers 4.35 million ha, with many of the state forests in peninsular Malaysia already certified by the MTCC. In Sarawak, there are few MTCC-certified natural forests and no FSC-certified natural forests.

After a massive boycott of tropical timber in the 1980s and 1990s, Malaysia needed its forest management to be internationally recognised as sustainable. First, it targeted getting FSC certification; however, the FSC's requirement for assurances of indigenous peoples' rights and the conservation of biodiversity proved to be difficult within the scheme. The MTCC took what they considered to be a stepwise approach to achieving sustainable forest management instead by complying with current laws and administrative systems. The MTCC worked to obtain mutual recognition with the PEFC, another internationally recognised forest certification system. Substituting a new scheme resolved some of the problems. In 2009 mutual recognition was achieved between the MTCC and the PEFC and subsequently most MTCC-certified timber could be exported with PEFC endorsement.

On the other hand, some FSC-certified forests are found in Malaysia, where they cover approximately 714,000 ha, mostly in Sabah. FSC certification offers a price premium on certified timber and international credibility for sustainable forest management and this reputation is important for the Sabah Forestry Department. The FSC has stricter standards for biodiversity and indigenous rights and the Sabah Forestry Department respects these rights within state laws and regulations. Areas in Sabah are still searching for better methods to conduct effective social impact assessments and benefit-sharing with communities.

Recognition of indigenous people's rights is one of the long-standing difficulties in achieving forest certification. In both Sarawak and Sabah, committees were established with the participation of local communities in order to discuss these issues related to forest management. It is clearly very important to enable these committees to work effectively in order to have better communication between local communities and forest management systems.

Forest certification can look to involve key stakeholders engaged in management with the support of a broader audience. In Japan, the government is promoting sustainable sourcing, such as through the implementation of the Clean Wood Act 2017. The 2020 Tokyo Olympics committee has also introduced sustainable procurement guidelines for building materials and sources. Timber import companies must also ensure that their products are produced sustainably without risking human rights and/or leaving a negative impact on the natural environment. Several Japanese companies announced that they would increase their purchases of certified timber. This rising demand for certified timber and timber products will compel timber production to be undertaken in a sustainable manner. These trends will continue if more companies become committed to making their value chains more sustainable. The example of Malaysia, and the diverse experiences in different states, illustrates that the situation on the ground can vary greatly, even with the same forest certification scheme and within the same country. It is important to examine how these certified forests are achieving responsible forest management, particularly in terms of the rights of indigenous peoples and natural resources issues.

Acknowledgements We thank all the stakeholders who participated in this research. We would like to thank Dr Christine Padoch and Dr Masahiro Ichikawa for comments on earlier versions of this chapter. The research was supported by the Japan Society for the Promotion of Science, the Research Institute for Humanity and Nature, Center for Southeast Asian Studies at Kyoto University, the ASEAN Research Platform and the government of Japan's contribution to the Centre for International Forestry Research. We are grateful to editors for their feedback.

References

Accreditation Services International [ASI]. 2018. Conformity assessment bodies database. http://www.accreditation-services.com/s/find-a-cab. Accessed 10 Aug 2018.

Anap Muput. 2006. Forest Management Plan for Anap Muput (Year 2006–2025).

Bass, Stephen, Kirsti Thornber, Matthew Markopoulos, Sarah Roberts, and Maryanne Grieg-Gran. 2001. *Certification's impacts on forests, stakeholders, and supply chains*, Instruments for Sustainable Private Sector Forestry Series. London: International Institute for Environment and Development.

Brosius, J. Peter. 1997. Endangered forest, endangered people: Environmentalist representations of indigenous knowledge. *Human Ecology* 2 (1): 47–69.

———. 1999. Green dots, pink hearts: Displacing politics from the Malaysian rainforest. *American Anthropologist* 101 (1): 36–57.

Cooke, Fadzilah Majid. 1999. *The challenge of sustainable forests: Forest resource policy in Malaysia, 1970–1995*, ASAA Southeast Asia Publications Series. Honolulu: University of Hawaii Press.

Dentan, Robert Knox, Kirk Endicott, Alberto Gomes, and M.B. Hooker. 1997. *Malaysia and the original people: Case study of the impact of development on indigenous peoples*. Needham Heights: Allyn and Bacon.

Forest Stewardship Council [FSC]. 2006. *FSC principles 2 and 3: Guidance on interpretation*. Bonn: Forest Stewardship Council.

———. 2015. The 10 FSC principles. https://ic.fsc.org/en/what-is-fsc-certification/principles-criteria/fscs-10-principles. Accessed 10 Aug 2018.

———. 2018a. What is FSC? https://ic.fsc.org/en/what-is-fsc. Accessed 7 Sept 2018.

———. 2018b. Public certificate search. https://info.fsc.org/details.php?id=a0240000005sSxGAAU&type=certificate&return=certificate.php. Accessed 13 Sept 2018.

Hong, Evelyne. 1987. *Natives of Sarawak: Survival in Borneo's vanishing forests*. Penang: Institut Masyarakat.

Indufor. 2009. *PEFC council and MTCC conformity assessment of Malaysian timber certification scheme to PEFC requirements—Final report*. Helsinki: Indufor.

ITTO. 2007. Model Forest Management Area (MFMA) -Phase III Project completion report. http://www.itto.int/files/user/pdf/publications/PD%2012%2099/pd12-99-2%20rev4(F)%20e.pdf

JOANGOHutan. 2002. Malaysian timber certification scheme ignores concerns of forest peoples. Press statement. Kuching, 30 January.

Klooster, Dan. 2006. Environmental certification of forests in Mexico: The political ecology of a nongovernmental market intervention. *Annals of the Association of American Geographers* 96 (3): 541–565.

Malaysiakini. 2001. Timber certification process ignores natives. 18 November.

Malaysian Timber Certification Council [MTCC]. 2000. *Annual report 2000*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2002a. *Annual report 2002*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2002b. *Summary of FMU audit*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2004. *Annual report 2004*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2006. *Annual report 2006*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2010. *Annual report 2010*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2012a. Use of MC&I (Natural forest) for certification of natural forest in Malaysia. https://mtcc.com.my/use-of-mci-natural-forest-for-certification-of-natural-forest-in-malaysia/. Accessed 15 Aug 2018.

———. 2012b. *Malaysian criteria and indicators for forest management certification (Natural forest)*. Kuala Lumpur: Malaysian Timber Certification Council.

———. 2018. Certified forests. http://mtcc.com.my/certified-forests. Accessed 16 Aug 2018.

Malaysian Timber Industry Board [MTIB]. 1998. *Proceedings of the seminar on pilot study on timber certification*. Kuala Lumpur: Malaysian Timber Industry Board.

Mannan, Sam, Yahya Awang, Albert Radin, Andurus Abi, and Peter Lagan. 2002. The Sabah Forestry Department experience from Deramakot Forest Reserve: Five years of practical experience in certified forest management. Paper presented at the Seminar on Practising Sustainable Forest Management: Lessons Learned and Future Challenges, Kota Kinabalu, Sabah, 20–22 August.

Mannan, Sam, Yahya Awang, Albert Radin, Andurus Abi, Subari Hj Suparlan, and Peter Lagan. 2003. Conservation of the orangutan and forest management units: The Deramakot model. Paper presented at the Workshop on Orangutan Conservation in Sabah, Kota Kinabalu, Sabah, 25–27 August.

National Timber Certification Council, Malaysia [NTCC]. 1999. *Malaysian criteria, indicators, activities and standards of performance (MC&I) for forest management certification (Forest Management Unit level)*. Kuala Lumpur: NTCC.

Ng, Ginny. 2000. The certification process in Malaysia: A case study. Pilot project submitted in partial fulfilment for the certificate for the International Training Programme on Forest Certification, Sweden, 14 May–2 June, and South Africa, 14 May–24 November.

Ng, Ginny, Tong Pei Sin, and Lim Hin Fui. 2002. Environment impact and social components in forest certification: 'Thorny issues in Malaysia?' Paper presented at the Seminar on Practising Sustainable Forest Management: Lessons Learned and Future Challenges, Kota Kinabalu, Sabah, 20–22 August.

Nicholas, Colin. 2000. *The Orang Asli and the contest for resources: Indigenous politics, development and identity in Peninsular Malaysia*. Subang Jaya: Center for Orang Asli Concerns.

Nussbaum, Ruth, and Markku Simula. 2005. *The forest certification handbook*. 2nd ed. London: Earthscan.

Romero, Claudia, Francis E. Putz, Manuel R. Guariguata, Erin O. Sills, Paolo O. Cerutti, and Guillaume Lescuyer. 2013. *An overview of current knowledge about the impacts of forest management*, CIFOR Occasional Paper No. 91. Bogor: Centre for International Forestry Research (CIFOR).

Sabah Forestry Department. 2016. Deramakot forest operations. In *Annual report 2016*, 259–276. Sandakan: Sabah Forestry Department.

———. 2017a. Northern Gunung Rara Forest Reserve. http://www.forest.sabah.gov.my/GunungRara/. Accessed 15 Aug 2018.

———. 2017b. Ulu Segama-Malua Sustainable Forest Management Project. http://www.forest.sabah.gov.my/usm/. Accessed 15 Aug 2018.

———. 2018a. Deramakot Forest Reserve. http://www.deramakot.sabah.gov.my. Accessed 15 Aug 2018.

———. 2018b. Pin-Supu Forest Reserve. http://www.forest.sabah.gov.my/PinSupu/. Accessed 15 Aug 2018.

———. 2018c. Tangkulap Forest Reserve and Sungai Talibu Forest Reserve. http://www.forest.sabah.gov.my/tangkulap/. Accessed 15 Aug 2018.

———. 2018d. Timimbang-Botitian FMU. http://www.forest.sabah.gov.my/Timimbangbotitian/. Accessed 15 Aug 2018.

———. 2018e. Trusan Sugut Forest Reserve. http://www.forest.sabah.gov.my/sugut/. Accessed 15 Aug 2018.

———. 2018f. Ulu Kalumpang-Wullersdorf Sustainable Forest Management Project. http://www.forest.sabah.gov.my/ulukalumpang. Accessed 15 Aug 2018.

———. 2018g. Nuluhon Trusmadi (Extension) Forest Reserve. http://www.forest.sabah.gov.my/fmu10/component/content/article/39-profile/114-public-statement. Accessed 15 Aug 2018.

Sandom, James, and Markku Simula. 2001. *Assessment of compatibility of Malaysian criteria and indicators for forest certification with FSC requirements*. Kuala Lumpur: National Timber Certification Council, Malaysia.

Scientific Certification Systems. 2010. Forest management and stump-to-forest gate chain-of-custody certification re evaluation report for the Perak Integrated Timber Complex (Perak ITC). Certificate Number: SCS-FM/COC-00046N, February.

SIRIM QAS International [SIRIM]. 2013. Public summary of stage 2 audit of Anap Muput Forest Management Unit for forest management certification. http://www.sirim-qas.com.my/sirim/core-files/uploads/2017/05/Public-Summary-FMC-of-Anap-Muput-Forest-Management-Unit-Main-Assessment.pdf. Accessed 15 Aug 2018.

———. 2015. Public summary surveillance 1 on Anap Muput FMU for forest management certification. http://www.sirim-qas.com.my/core-files/uploads/2016/08/Public-Summary-Zedtee-Sdn-Bhd_Anap-Muput-FMU_SA1_2014_Final1.pdf. Accessed 15 Aug 2018.

Société générale de surveillance [SGS]. 1997. *Forest management certification report 1997*. Société générale de surveillance.

———. 2002. *Forest management certification report 2002*. Société générale de surveillance.

Soda, Ryoji, Yumi Kato, and Jason Hon. 2015. The diversity of small-scale oil palm cultivation in Sarawak, Malaysia. *The Geographical Journal*. https://doi.org/10.1111/geoj.12152

United Nations Economic Commission for Europe/Food and Agriculture Organisation of the United Nations [UNECE/FAO]. 2016. *Forest products annual market review, 2015–2016*. New York/Geneva: United Nations.

Vogt, Kristiina A., Bruce C. Larson, John C. Gordon, Daniel J. Vogt, and Anna Fanzeres. 1999. *Forest certification: Roots, issues, challenges, and benefits*. Boca Raton: CRC Press.

Chapter 27
Changing Patterns of Sarawak's Exports, *c.*1870–2013

Atsushi Kobayashi and Kaoru Sugihara

Abstract This chapter describes the changing patterns of Sarawak's export trade from the late nineteenth century to the present, and discusses their implications for the fate of a high biomass society. Its main contribution is to collect trade statistics in and beyond Sarawak in order to identify the long-term trends and changes from the perspective of global economic history. From the 1870s to 1913 Sarawak became integrated into the Singapore-centred network of Southeast Asian export economies, largely by exporting primary products for local and regional consumption. From *c.*1914 to 1940 the composition shifted towards international commodities, especially rubber and oil. From 1946 to 2013 new commodities, such as timber, natural gas and oil palm, were added. Sarawak's postwar trade growth became progressively dependent on the growth of East and Southeast Asian economies, especially Japan and Malaysia. While acknowledging the successful export performance, the chapter also sketches the process of progressive disarticulation between the export sector and the local economy and society, with an increasing dependence on oil and natural gas. It suggests that such a tendency was a likely outcome for the resource-rich periphery, especially if the economy was not administered by a state intent on linking resource revenues to the improvement of the welfare of local society.

Keywords Sarawak · Economy · Exports · Natural resources · Oil and gas · Trading networks

A. Kobayashi (✉)
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: akoba@cseas.kyoto-u.ac.jp

K. Sugihara
Research Institute for Humanity and Nature, Kyoto, Japan

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_27

27.1 Introduction

Established in 1841 as a kingdom ruled by the Brookes, Sarawak has been a producer and exporter of primary products for over a century and a half. Local communities and the society as a whole adapted to external stimuli and global markets by producing a series of internationally competitive export commodities. This chapter describes the changing patterns of export trade and discusses their implications for the fate of a high biomass society. Its main contribution is to collect trade statistics in and beyond Sarawak in order to identify the long-term trends and changes from the perspective of global economic history.

While acknowledging the generally successful export performance of the state, the discussion also sketches the process of progressive disarticulation between the export sector and the local economy and society, with an increasing dependence on oil and natural gas. It suggests that such a tendency was a likely outcome for the resource-rich periphery, especially if the economy was not administered by a state intent on linking resource revenues to the improvement of the welfare of local society.

In order to show the region's changing relationships with the outside world, it is useful to focus on the trading networks of Sarawak at the initial stage of their development. Existing studies have shown that the trade of Sarawak grew with the establishment of networks connecting Singapore to Kuching, then from Kuching to riverside bazaars, and finally from the bazaars to rural longhouses in the forests (Chew 1990; Ooi 1997). Merchants from Kuching, Chinese middlemen and peddlers, and local indigenous villagers thus formed a chain of intermediaries to trade forest and agricultural products; the local economy became integrated into intraregional trade centred on Singapore, which in turn also grew as an entrepot of long-distance trade. However, beyond this, the ways in which Sarawak was linked to the international economy and how they changed over time have not been closely examined.

The next section discusses available trade statistics, clarifying the territorial coverage in addition to the geographical and commodity composition of exports and imports, mainly from the 1870s to 1913. It argues that Sarawak became integrated into the Singapore-centred network of Southeast Asian export economies, largely by exporting primary products for both local and regional consumption. The more Southeast Asia's regional economy became integrated into long-distance trade, the greater its purchasing power became; the demand for sago and other forest products (including many non-timber products) from Sarawak subsequently grew. The local economy was incorporated into this network through both export trade and coasting trade.

The second section deals with the period from *c.*1914 to 1940. The commodity composition of exports shifted towards international commodities, that is, rubber and oil replaced traditional primary products for regional consumption. They were shipped, directly or through the depot of Singapore harbour, to the West as well as to the rest of the world. As a result, there was a decline in the dependence on traditional local trading networks. However, while direct exports flourished during the boom period, in times of economic depression local and regional demands helped sustain exports. Given that both rubber and oil were produced near ports, traditional linkages of foreign trade with coasting trade became relatively weaker. The growth of foreign trade was no longer accompanied by the growth of linkages between foreign trade and internal commerce, which was characteristic of the previous period.

In contrast to the interwar period, postwar Sarawak exports were much more clearly dependent on the strong growth of Southeast and East Asian countries, especially Japan and Malaysia. The commodity composition of exports changed even more drastically towards mineral fuels, as well as to raw materials for industrial uses. The third section thus deals with the period from 1946 to around 2013 and traces the rapid growth of exports of oil, timber and natural gas to Japan and other parts of East and Southeast Asia.

Through these stages, Sarawak was progressively integrated into the world economy. This is clear from the very impressive growth of the volume and value of exports as well as its massive contribution to the local gross domestic product (GDP). In the third economic period described here, this impact was particularly large as products from the state were in high demand, reflecting the diffusion of industrialisation and the growth of modern consumption patterns in many parts of Asia. As the centre of the world economy moved from the Atlantic to the Pacific, Sarawak's locational advantage was greatly enhanced as well. At the same time, Sarawak's local economy was relatively slow to benefit from the effects of oil and natural gas exploration, and the state remained firmly an exporter of primary products. Thus the disarticulation between the export sector and the local economy (set out in the second period) persisted. The massive increase of exports of oil and natural gas meant that this trend intensified after the Second World War. The result was the emergence of a relatively affluent economy in terms of GDP (and per capita GDP if GDP is simply divided by population) and export volume, with remarkably little impact on the livelihoods of ordinary people. As this book suggests (Kato and Soda, Chap. 16; Soda and Kato, Chap. 17; Ubukata and Sadamichi, Chap. 24), the growth of smallholder oil palm production in the most recent period involves the utilisation of the more traditional and path-dependent methods of resource use and the human–nature interface enmeshed in the process. The response of this kind, however, had not been activated for many years. The current development in the region is also threatened by corruption, weak enforcement of official policies and fragile governance of the tropical biosphere.

In the last section, we attempt to place the case of Sarawak in a larger framework of the history of the world economy and trade patterns. In so doing, we suggest the nature of the developmental path of the high biomass society of Sarawak under global capitalism.

27.2 At the Margin of the Export Economy, *c.*1870–1913

We begin with a general observation of Sarawak trade statistics for the prewar period. For the period from 1870 to 1917, the most comprehensive annual trade statistics of Sarawak are available in the *Sarawak Gazette*. No data are available for 1918. After 1919 the Department of Trade and Customs began to publish annual trade statistics until 1940 when publication was interrupted by the Japanese invasion of Borneo. Throughout the prewar period, these trade statistics record the total volume of foreign trade and coasting trade in Straits dollars, as well as the commodity composition (value and quantity of foreign trade items).[1] However, there are two shortcomings in these statistics. First, the statistics do not explicitly show the territorial coverage, despite the fact that the territory of Sarawak, ruled by the Brooke administration, expanded gradually in the late nineteenth century (Kaur 1998: 4). More specifically, it is necessary to clarify whether these trade statistics provided by the administration are confined only to Kuching or include the entire territory of Sarawak.

Figure 27.1 shows foreign imports and exports in Sarawak from 1870 to 1940. Here foreign imports and exports from 1870 until 1917 are defined as trade of Kuching, while after 1919 they are identified as trade of the whole of Sarawak. Overall, the state's trade grew during this period. An increase of both exports and imports was particularly rapid after the 1920s, owing to the development of the oil

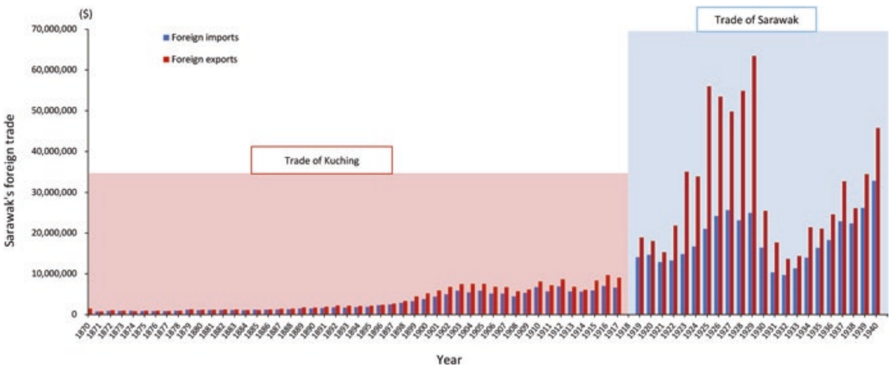


Fig. 27.1 Sarawak's foreign trade, 1870–1940 (Straits $)
Sources: *Sarawak Gazette* (Sarawak trade returns for the year 1870–1907); *Sarawak Government Gazette* (Sarawak trade returns for the year 1908–1917), *Sarawak Annual Report of the Department of Trade and Customs* (1919–1940)

[1] The Straits dollar was a silver coin circulated in Southeast Asia (mainly the Straits Settlements, the Malay Peninsula and Borneo) as legal tender of the Straits Settlements in the nineteenth century. After 1899 the Straits dollar came to be issued as paper currency and its value was pegged to the pound sterling by the Straits Settlements government in the shift to the gold exchange standard.

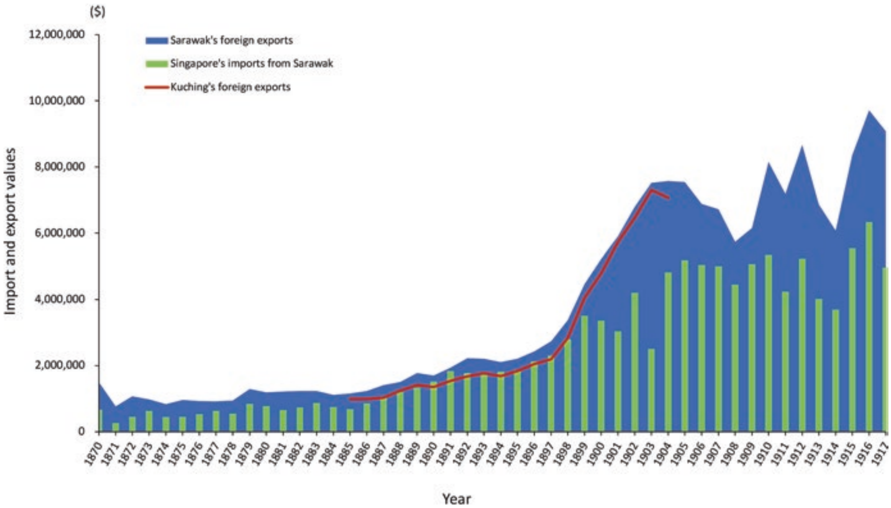


Fig. 27.2 Sarawak's foreign exports, Kuching's foreign exports and Singapore's imports from Sarawak, 1870–1917 (Straits $)
Sources: *Sarawak Gazette* (Sarawak trade returns for the year 1870–1907); *Sarawak Government Gazette* (Sarawak trade returns for the year 1908–1917), Colony of Straits Settlements (1870–1917), *Sarawak Gazette* (Kuching monthly trade returns 1885–1904)

industry in Miri and rubber cultivation. The volume of exports was larger than that of imports, giving Sarawak a persistent trade surplus.

How can we ensure that the foreign trade data up to 1918 included only trade of Kuching? Figure 27.2 compares foreign exports from Sarawak (represented by the blue area of the graph) and Kuching's foreign exports (represented by the red line on the graph) calculated from monthly trade reports of Kuching published in the *Sarawak Gazette* from 1883 to 1904. Here, it is obvious that their volumes more or less correspond with each other. Therefore, we can interpret that the trade statistics of Sarawak from 1870 to 1917 represented only the trade of Kuching and represented the whole of Sarawak for the following years.

The second issue is that these sources do not show the geographical composition (origin and destination) of Sarawak's foreign trade. Previous studies have argued that Singapore played a significant role as an international entrepot, connecting Sarawak with foreign countries throughout the nineteenth and first half of the twentieth centuries (Chew 1990; Ooi 1997; Kaur 1998). However, the importance of Singapore for Sarawak's external trade has not been explored from a statistical standpoint. Therefore, we attempt to estimate the share of Singapore in Sarawak's foreign trade from 1870 to 1917 by comparing Singapore's imports from Sarawak (represented by green bars) with foreign exports from Sarawak (represented by the blue area of the graph) in Fig. 27.2. We can confirm that Singapore accounted for the most significant share of foreign exports from Sarawak throughout this period. More precisely, the average share of Singapore for Sarawak's foreign trade during 1870–1917 was 66%. The average share for each decade changed from 53% in the

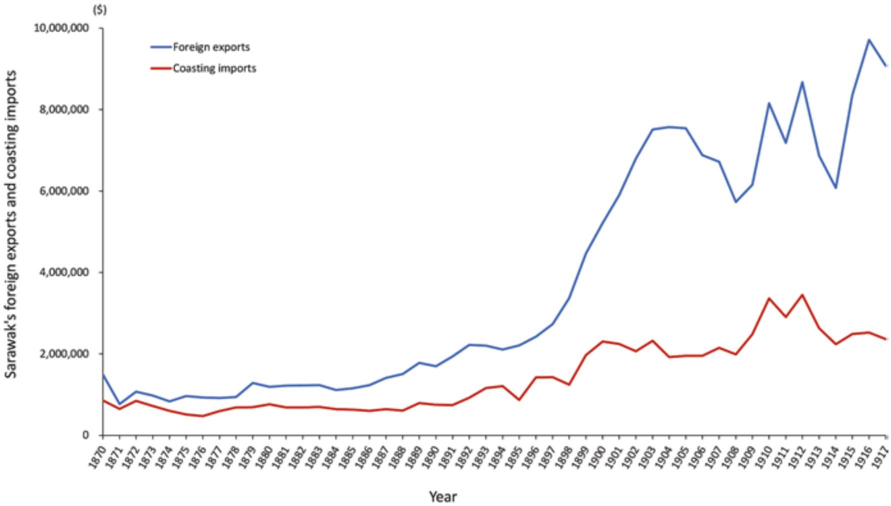


Fig. 27.3 Foreign exports and coasting imports of Sarawak, 1870–1917 (Straits $)
Sources: *Sarawak Gazette* (Sarawak trade returns for the year 1870–1907); *Sarawak Government Gazette* (Sarawak trade returns for the year 1908–1917)

1870s to 67% in the 1880s, 85% in the 1890s, 65% in the 1900s and to 61% in the 1910s. In other words, while the trade connections with Singapore became progressively stronger between the 1870s and 1890s, Sarawak's export destinations diversified into locations other than Singapore after the 1900s.

Figure 27.3 shows the volumes of foreign exports and coasting imports of Sarawak, centred on Kuching during 1870–1917. As noted above, previous studies have suggested that local products carried by riverine trade to bazaars at coastal towns were imported into Kuching by coasting trade, and these items were re-exported from Kuching to overseas markets. We assume therefore that the trends of coasting imports and foreign exports would have a strong correlation. In Fig. 27.3 their volumes and trends were at approximately the same level until the mid-1880s, although foreign exports were always slightly larger than coasting imports. We assume that this gap was caused by the transaction costs arising from intermediation and transport. Because most of the commodities and trade items imported into Kuching via coasting trade were re-exported to Singapore, when coasting imports increased, foreign exports was also likely to increase. Thus, for this period foreign trade and coasting trade were closely connected with each other.

However, while foreign exports increased steadily after the mid-1880s, the volume of coasting imports grew slowly until the end of the century and the gap between them became gradually wider in the early twentieth century. Therefore, while the significance of coasting trade for domestic commerce lasted to a certain degree, the growth of Sarawak's foreign trade after the early twentieth century did not rely on internal trading networks with multiethnic transactions.

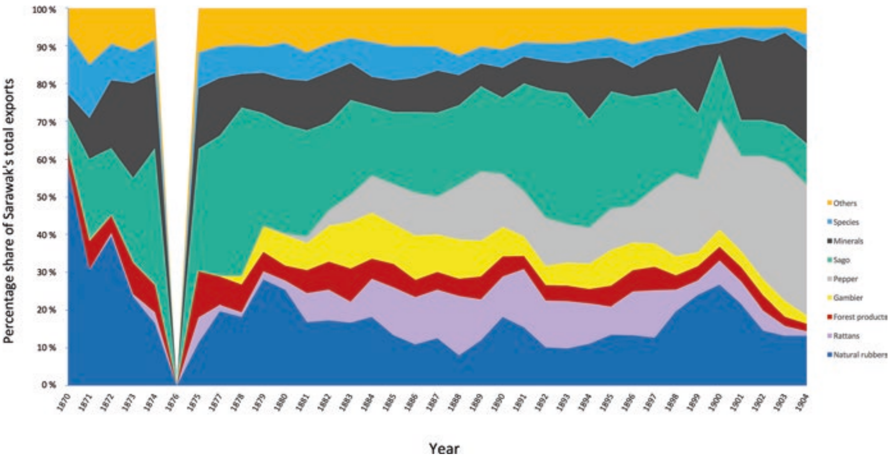


Fig. 27.4 Commodity composition of Sarawak exports, 1870–1904
Sources: *Sarawak Gazette* (Sarawak trade returns for the year 1870–1904)
Note 1: Calculated from dollar values
Note 2: Data for 1876 is missing

We now turn to the changing trends of exported items in the development of Sarawak's trade. Figure 27.4 shows the composition of commodities as foreign exports from Sarawak from 1870 to 1904. Since the list of merchandise in trade statistics after 1905 changed greatly, this figure only covers the years up to 1904. During this period, a total of 119 items were listed in trade statistics and they are classified into eight main categories. Natural rubbers include natural resins (such as gutta-percha, jelutong and dammar). The category of rattans consists of two species of rattan and rattan canes. Forest products include local commodities derived from tropical forests. In contrast to those forest-derived produces, gambier and pepper are classified as agricultural products. Sago (the traditional staple for indigenous people in insular Southeast Asia) includes three types of product: raw sago, sago flour and sago pearls. The category of minerals comprises gold dust, tin and antimony excavated from the mines in the hinterland.

According to Fig. 27.4, forest products (such as natural rubbers, rattans and sago) accounted for a large part of foreign exports until the 1890s. However, from the late 1890s pepper and minerals increased their share of the exported commodities and became leading exports for the growth of foreign trade in the early twentieth century. After the 1890s the gold mine at Bau (in the hinterland of Kuching) began to produce a large amount of gold dust under the management of the Borneo Company Limited. This led Chinese miners who worked there to turn to pepper and gambier cultivation (Kaur 1998: 46). This shift thus brought about an increase in exports of pepper and minerals after the 1890s. In other words, the driving force of Sarawak's exports shifted from forest products delivered by local indigenous inhabitants to minerals and agricultural products largely produced by Chinese farmers and controlled by Western enterprise. Furthermore, Sarawak also saw the emergence

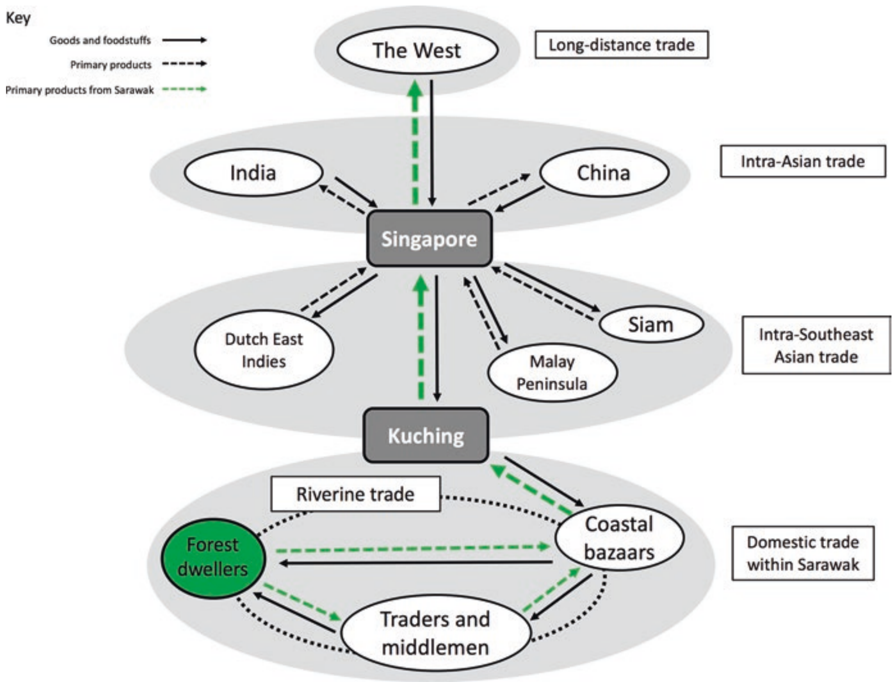


Fig. 27.5 Patterns of Sarawak's integration into the world economy in the late nineteenth century

of new commodities and the reorganisation of trading networks after the 1910s (discussed in the next section).

We can summarise the pattern of Sarawak's integration into the international economy in the late nineteenth century. Figure 27.5 depicts the linkages between the internal domestic commerce of Sarawak and the multilateral international trading networks centred on Singapore, based on a study by Daniel Chew (1990) and studies on Singaporean trade in the nineteenth century (Wong 1978; Kobayashi 2013). The lower part of the figure indicates the structure of foreign and coasting trade in Sarawak. Here 'foreign trade' indicates trade between Kuching and Singapore, while 'coasting trade' represents trade between Kuching and other coastal ports in Sarawak, such as Sibu, Bintulu and Miri. In this figure, coasting trade further connects with the internal riverine trade via commercial networks from bazaar merchants to indigenous dwellers living in the forests. However, we do not have sufficient data or information on the volume and trends of these internal trade networks.

Figure 27.5 also shows that Sarawak joined the international division of labour through the intraregional trade networks centred on Singapore. Since its establishment as a trading outpost in 1819, Singapore grew as a transit hub of trade between neighbouring lands in Southeast Asia and other foreign regions, such as Europe, India and China (Wong 1978; Sugihara 2005, 2009; Kobayashi 2013). In Singapore, primary goods were gathered from a wide range of surrounding countries and were exchanged for manufactured goods and necessities for local Southeast Asian populations. In the course of development of intraregional trade with Singapore at the centre, after the 1870s in particular, foodstuffs such as rice, salted fish and livestock started to circulate within the region on a larger scale through such trade. For example, Siamese rice was exchanged with forest products produced in Sarawak via Singapore. Sarawak, which was incorporated into this trading network from the 1840s, became much more profoundly involved in both international and regional markets after the 1870s.

27.3 Riding on Global Turbulence, 1913–1940

After the early twentieth century, the Miri oilfields in northern Sarawak developed under the management of Western enterprises (British colonial powers and the Shell oil company) and exports of rubber increased greatly under the promotion measures of the Brooke government. This section explores the transition of Sarawak's exports in this period, focusing on the changes in the trading networks and the patterns of integration into the world economy.

Figure 27.6 illustrates Singapore's share of Sarawak's foreign exports from 1910 to 1930. Sarawak's foreign exports (taken from the sources used in the previous

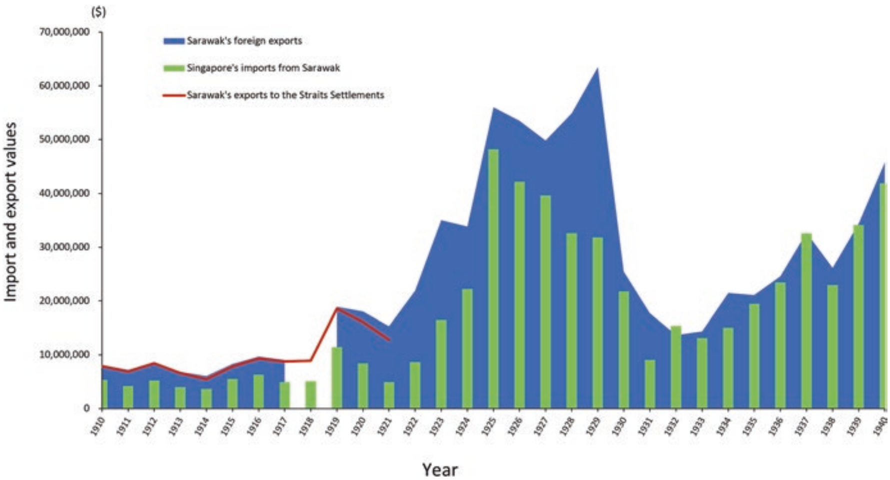


Fig. 27.6 Sarawak's foreign exports and Singapore's imports from Sarawak, 1910–1940 (Straits $)

Sources: *Sarawak Government Gazette* (Sarawak trade returns for the year 1910–1917), *Sarawak Annual Report of the Department of Trade and Customs* (1919–1940), Colony of Straits Settlements (1910–1917), Statistical Department, Board of Trade (1926)

Note: Original trade values in *Statistical abstracts* were in pounds sterling and were converted into Straits dollars at the rate of two shillings and four pence section) are shown in blue, while the red line represents the value of Sarawak's exports to the Straits Settlements, extracted from the *Statistical abstract for the several British overseas dominions and protectorates in each year from 1909 to 1923* (Statistical Department, Board of Trade 1926). The comparison between Sarawak's foreign exports and its exports to the Straits Settlements suggests that almost all of its foreign exports during the 1910s went to the Straits Settlements, probably mainly to Singapore. However, the value of Singapore's imports from Sarawak (extracted from trade statistics of Singapore and shown as green bars in Fig. 27.6) does not correspond with them. It is noticeably lower in certain periods and this was most probably caused by the difference in the definition of trade statistics between the two regions. In Singapore's statistical records, imported commodities that were re-exported without any transaction or consumption within the colony were not counted as imports. In contrast, Sarawak's trade statistics do include transit exports. For example, oil exports from Sarawak to Europe that were transshipped via Singapore would be included in Sarawak's statistics as exports to Singapore, while they would be excluded from Singapore's statistics.

The bulk of Sarawak's foreign exports were still bound for Singapore after the 1920s, using the well-developed harbour infrastructure and steamship lines that were available (Huff 1994: 236–240). In other words, a part of Sarawak's foreign exports, and oil exports in particular, bypassed conventional trading links and were carried out through a network of advanced infrastructure instead. The divergence of Sarawak's trade structure from the Singapore-centred trading network began after 1900 and fuelled a further growth of Sarawak's exports.

We now turn to the composition of commodities in foreign exports from Sarawak after 1905, as illustrated in Fig. 27.7. In the early twentieth century, new export commodities (rubber and mineral fuels) appeared. After the 1910s those two products began to occupy a commanding share in overall exports and they drove the expansion of Sarawak's trade until 1940. In Sarawak, rubber was cultivated by both indigenous people and Chinese immigrants. The Brooke administration encouraged rubber smallholding rather than large-scale plantations (Ishikawa 2010: 73) and implemented a promotion plan for rubber exports after 1917 (Chew 1990: 152–157; Ooi 1997: 104, 235). In addition, after the discovery of oilfields in Miri at the beginning of the twentieth century, the oil industry developed rapidly by the Anglo-Saxon Petroleum Company (which was part of the Shell/Royal Dutch group of companies) and by Sarawak Oilfields Limited under the initiative of the Brooke government after 1921 (Kaur 1998: 26–27). According to Fig. 27.7, the shares of oil and gas as part of Sarawak's total exports seemed to increase considerably after 1920 as trade statistics after this period began to include exports from Miri. Rubber and mineral fuels, which were produced under the investment of labour, capital and government assistance, became the driving force of the growth of exports after 1900. On the other hand, conventional local products (such as forest products, agricultural products and minerals) did not possess such a large share of exports, even though the actual volume of these exports kept increasing.

If we return to Fig. 27.1 to analyse the general trend of the value of Sarawak's exports in this period, we see that performance clearly reflected the Great Depression

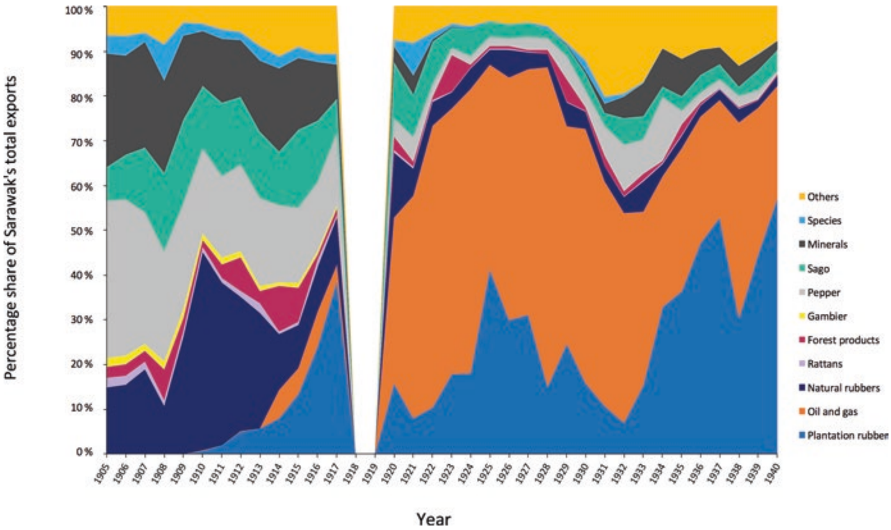


Fig. 27.7 Commodity composition of Sarawak's exports, 1905–1940
Sources: *Sarawak Gazette* (Sarawak trade returns for the year 1905–1907); *Sarawak Government Gazette* (Sarawak trade returns for the year 1908–1917); *Sarawak Annual Report of the Department of Trade and Customs* (1920–1940)
Note 1: Calculated from dollar values
Note 2: Data for 1918 and 1919 are missing

of 1929–1933 that began in the United States and a partial recovery in the mid-1930s. It was important that Sarawak was not dependent on the exports of a single commodity. Sometimes relatively more conventional commodities (such as pepper, sago and minerals) returned to take up a larger market share of exports, while the value of oil and rubber exports fluctuated.

Figure 27.8 illustrates the patterns of integration in the second period. Reflecting the change of commodity composition, the trading networks of Sarawak shifted from being Singapore-centred to a pattern of multiple linkages including a direct route to the outside world. The figure shows that Miri oilfields were connected to Europe not just through Singapore but also directly. In addition, exports of oil via the depot of Singapore were also no longer entirely in the hands of conventional merchants' networks, even though the transport of mineral fuels remained dependent on Singapore's sophisticated infrastructure. The importance of Singapore as an international entrepot serving as the main port to and from Sarawak to both international and regional markets thus declined in relative terms after 1900.

Meanwhile, in the course of the expansion of rubber exports, the rubber economy developed around cities such as Kuching and Sibu (see Fig. 27.8). As a result, the linkage between foreign trade and domestic coasting trade was losing its significance for the growth of Sarawak's total economy and trade. In the nineteenth century, Sarawak's exports mostly consisted of forest produces and sago delivered from hinterland through the riverine and coasting trades. These commercial networks

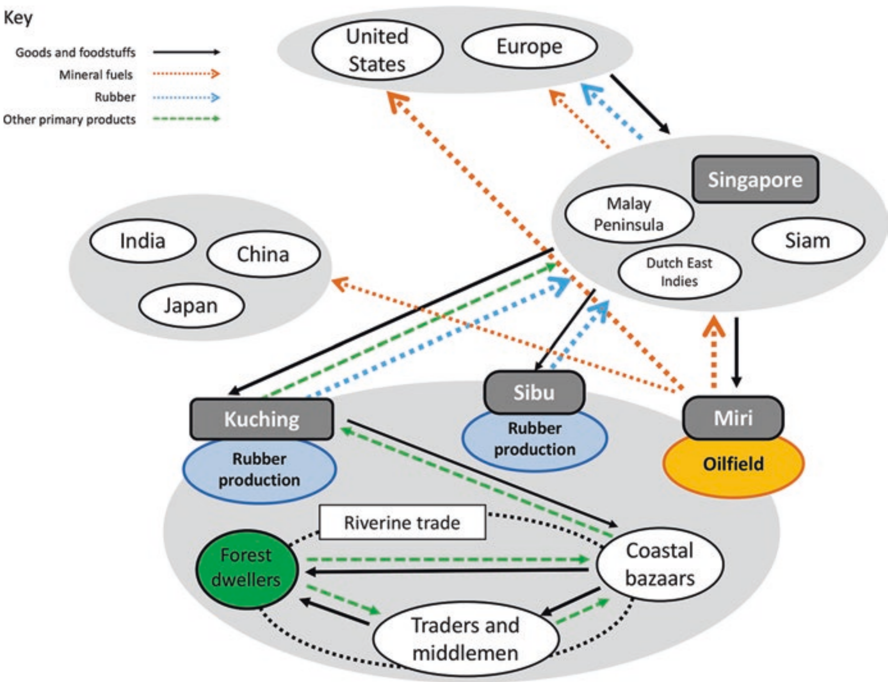


Fig. 27.8 Patterns of Sarawak's integration into the world economy, *c.*1920

were based on a chain of credit sales from Singapore merchants to Kuching merchants and finally to indigenous ethnic groups (Chew 1990), so that foreign trade was closely connected with coasting trade. However, as agricultural products (such as pepper, gambier and rubber) began to account for a commanding share of foreign exports, trade growth became more independent from the connection with coasting trade. Those products were primarily produced by Chinese immigrants who came to Sarawak and bought new land around Kuching and Sibu, such as the Fuzhou (Ishikawa and Ishikawa, Chap. 6), and by indigenous people who began to cultivate rubber on their own native land. The rubber economy developed in the neighbouring areas of each port, such as Kuching, Sibu and Bintulu, so that their products were directly exported from the ports by steamship lines and not via coasting trade towards Kuching as was done previously. For example, since a new steamship company launched a direct service line between Sibu and Singapore in the 1910s (Kaur 1998: 78), the bulk of rubber produced in the hinterland was likely to be directly exported to Singapore from Sibu itself. Thus, in changing the composition of exported commodities and the development of new shipping lines, the link between foreign exports and coasting imports in Sarawak became weaker (see Fig. 27.3).

In sum, the changes of Sarawak's trading system in the second period which are reflected in the trade statistics suggest a tendency towards a more direct integration of local society into the world economy. This were expressed in three ways: (1) the decline of traditional trading networks; (2) the diversification of export commodities, including mineral fuels; and (3) an increasing detachment of export production from the high biomass society.

27.4 In the Shadow of the East Asian Miracle, 1945–2013

After 1945 (or perhaps more visibly from the 1950s), the growth of the world economy, driven by the strong growth of the United States and the emergence of the Asia-Pacific economy, fundamentally changed the nature of Sarawak's exports. First and foremost, oil became a major international commodity, which supported postwar economic development and industrialisation programmes in developed countries and newly independent states. By 1948 oil consisted of 64% of Sarawak's exports. After recovering from the Second World War, Miri's share of Sarawak's total exports for that year was already 66%, Kuching had 18% and Sibu had 10%. Between 1948 and 1970 oil was exported to the Malay Peninsula via Singapore, to Singapore itself along with Australia, Japan and the Philippines.[2] At this point, however, Sarawak was not fully integrated into the regional economy in a way that the local region would benefit directly from the emergence of the Asia-Pacific economy. The value of total exports increased from $374 million in 1950 to $660 million in 1970.[3] It grew by 50% for the period from 1950 to 1970 in terms of US dollars. This rate of growth was much lower than that of world trade which grew 5.5 times. It was also lower than that of the trade of 10 major Asian countries which grew 4.1 times.[4]

Major political changes only slowly resulted in policy responses to changing international demand. In 1946 Sarawak became a British Crown colony, and in September 1963 the state became part of Malaysia. The end of the Brooke empire did not immediately induce policy change; the Revised Sarawak Development Plan 1951–1957 highlighted a strategy of industrialisation, resulting in relatively slow diversification and industrialisation of Sarawak's economy, driven by export growth

[2] It is not easy to know exactly where Sarawak's exports to Singapore eventually went and what proportion was consumed in Singapore, especially during the period from the Second World War to its independence in 1965, as the country went through several political changes. The Direction of Trade Statistics complied by the International Monetary Fund treats Singapore (along with Sarawak and the Federation of Malaya) as an entity of 'foreign trade', so trade between Singapore and the Federation of Malaya (and between Sarawak and Singapore and between Sarawak and the Federation of Malaya) was recorded from 1958 to 1962 (IMF and IBRD 1962). The notes contained in Chief Statistician at Singapore (1951) *Malayan statistics*, on the other hand, describe the gradual development of Malayan statistics since 1946, and offer statistics of trade between Sarawak and Malaya (including the figures for Sarawak's oil exports to Malaya) in 1950. However, trade between Singapore and the Federation of Malaya is not included in this document.

[3] While sources are not always explicit, 'dollars' refer to the Sarawak dollar to 1953, the Malaya and British Borneo dollar from then to 1967, and the Malaysian dollar (ringgit) after that. The Sarawak dollar was equivalent to 2s.4d. (sterling), thus the same value as the Malayan dollar.

[4] For a brief description of the sources and methods of calculation of figures for world trade, Asia's trade and intra-Asian trade, see Sugihara (2017: 130).

(for details on British policies in the region and funding, see Kaur 1998; Porritt 1997: 179–182). The integration of Sarawak into the Commonwealth and Southeast Asian economic frameworks did help accelerate the growth of exports in one sense, but with a heavy bias towards the sterling area, which recorded a rather slow rate of growth compared to the emergence of a rapidly growing Pacific economy led by the United States and Japan.

The political shift from being a British colony to becoming part of Malaysia in 1963 did not mark a clear economic policy change either. Instead, it rather reinforced the direction of Sarawak's integration into the regional Malaysian economy and later Southeast Asian economies, which served for more independence from the British-led economic framework but not necessarily for deeper export orientation. After independence, import-substitution, export-orientation and heavy industrialisation policies were tried; rapid industrial development was achieved and exports of the electronics industries increased (Jomo 2007: xiii–xxv, 1–34), without significant direct impacts on the nature of the Sarawakian economy.

As far as Sarawak was concerned, the more significant economic change came with the establishment of Petroliam Nasional Berhad (Petronas), a nationally owned Malaysian petroleum corporation, first proposed in 1971 and effected in 1974. In the middle of the growing dissent of the Organisation of the Petroleum Exporting Countries (OPEC) against the oil majors from the late 1960s, Malaysia had to decide whether or not to continue its dependence on foreign oil companies (mainly Shell but also Exxon and Esso in other parts of Malaysia) (PricewaterhouseCoopers 2016). Malaysia chose to create a state company, with supervisory powers over the majors and production activities of its own (for general background on the oil trade, see Sugihara and Allan 1993; Sugihara 2008).

Figure 27.9 shows that Sarawak's total exports for this period went primarily to Southeast Asia (mainly Singapore and the Federation of Malaya which later became Malaysia) and East Asia (Japan). Singapore was the dominant destination for early exports, followed by Indonesia. Oil, the most important of Sarawak's exports, consisted of both crude and refined petroleum beginning from the prewar years (Hepburn 1949).[5] In 1953 motor spirits consisted of $30 million, diesel oil $81 million and crude oil $180 million.[6] The early exports of oil from Sarawak to Singapore must have been refined petroleum, while Sarawak's exports to Japan, Australia and Britain must have consisted of crude petroleum. In 1958 Singapore's trade in oil was overwhelmingly made up of petroleum products with very little consisting of crude petroleum. About half the petroleum that was imported into Singapore was either consumed in Singapore or the Federation of Malaya (for example, for use in motor vehicles).[7]

[5] This source states that all the oil produced in Brunei and Sarawak was refined at Lutong, near Miri. A substantial amount of crude petroleum may have been imported from Brunei, refined at Lutong and exported as refined petroleum from Sarawak, at least for an early period of time (Porritt 1997: 234, 242).

[6] These figures are denominated in Sarawak dollars.

[7] In 1958, $611 million of petroleum products were imported into Singapore; $299 million of petroleum products were then exported from Singapore to other foreign countries with about

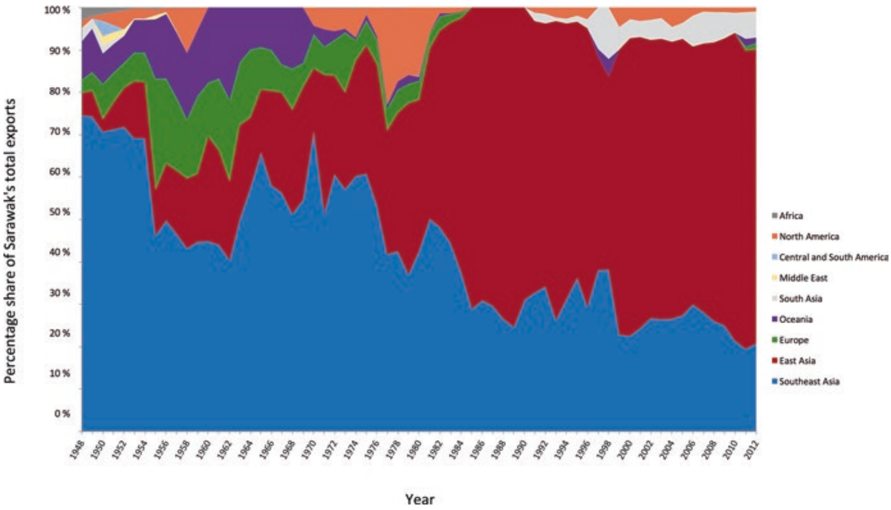


Fig. 27.9 Geographical distribution of Sarawak's exports, 1948–2013
Sources: *Sarawak Government Gazette* (Supplement/extraordinary 1948–1953); Department of Trade and Customs, Colony of Sarawak (1955–1961); Sarawak Central Statistics Bureau (1961–1963); Department of Statistics Malaysia, Sarawak Branch (1964–1996); Department of Statistics Malaysia, Sarawak Branch (1996–2013)
Note: Values were calculated in Sarawak dollars and Malaya and British Borneo dollars from 1948, and calculated in Malaysian ringgit from *c.*1967

After 1970 the export destination of oil from Sarawak shifted definitively to East Asia, especially Japan. In 1970 almost all petroleum and petroleum products were exported from Miri, but export destinations were diverse; of the total petroleum and petroleum products exported, 43% was to Singapore, 22% to the Philippines, 12% to Australia, 4% each to Thailand and peninsular Malaysia, and 3% each to Japan and Burma (Myanmar) in terms of volume. By 1985 Bintulu was exporting more than Miri, largely as a result of successful oil exploration: of the export destinations for crude petroleum, 28% went to Japan, 24% to South Korea, 16% to peninsular Malaysia, 12% to the Philippines and 7% to Singapore. The growth of Sarawak's exports from then on was closely linked to the emergence of the Asia-Pacific economy.

Returning the international performance of Sarawak's exports, the value of total exports increased from RM660 million in 1970 to RM108,398 in 2013. The increase was on a qualitatively different scale from the earlier period and marks a fundamental shift of Sarawak's position in the world economy, from the peripheral role in the sterling area and Malaysia, to a direct participant in the dynamism of the Asia-

$66 million being exported to the Federation of Malaya. The remaining amount (approximately $246 million) must have been consumed in Singapore (Singapore Department of Statistics 1958). These figures are denominated in Malayan dollars.

Pacific economy. In terms of US dollars, Sarawak's exports grew by 160 times between 1970 and 2013, a rate which was much higher than that of world trade, which grew 63 times in the same period, and about the same as that of the trade of 10 major Asian countries, which grew 164 times (see Sugihara 2017).

The background behind this change took place between 1950 and 1980 when oil-fuelled (and later liquefied natural gas-fuelled) industrialisation took root in the western side of the Pacific rim, first in Japan and gradually spreading to other coastal regions of East Asia. This industrialisation trend eventually reached Southeast Asia and Malaysia. The postwar recovery of Japan and East Asia initially began with the development of labour-intensive industries such as the production of textiles and sundries, but soon began to include relatively labour-intensive segments of capital-intensive industries such as consumer electronics and transport machinery.[8] In the 1960s the Japanese steel industry and electricity generating sector made conscious efforts to create an energy-efficient path of development.

At the same time, a series of seafront industrial complexes was created to develop resource-intensive industries such as oil refineries, petrochemical plants, the manufacture of heavy machinery, shipbuilding (including of large tankers), and electricity and power generation. Foreign (largely American) capital and technology, private entrepreneurship and local and municipal governments were all involved in the construction of sites close to coastal industrial ports that were easily accessible to ships transporting mineral fuels, iron ore and containers along the Pacific side of the archipelago (Kobori 2010). From the late 1960s to the 1970s South Korea and Taiwan made similar efforts.

Imports of cheap oil (mainly from the Middle East) and mineral resources were for the first time systematically combined with the Japanese and East Asian comparative advantages (such as the availability of cheap labour of good quality, water, food and biomass energy) through this development (Sugihara 2018). Sarawak's oil exports were part of this development.

After the 1973 oil crisis Japan continued to import a massive amount of oil, despite very high prices. These oil imports were mostly from the Middle East but included imports from all over the world, including Sarawak. The main destination of Sarawak's oil exports thus shifted decisively from Singapore (and Southeast Asia) to Japan (and East Asia) in the 1970s. The petroleum sector long dominated Sarawak's economy and from 1963 onwards formed the largest source of state revenue (Kaur 1998: 180).

High oil prices encouraged the development of energy-saving technology. Not only Japan but also the United States and Western Europe (who traditionally followed more resource- and energy-intensive paths) redirected their efforts to energy-saving paths. Even so, the demand for energy kept increasing, as East and Southeast

---

[8] 'Sundries' is an established category in trade statistics. It is an unusual category in that the contents change rapidly over the years. It usually refers to various traditional, modern and hybrid manufactured goods ranging from straw mats to European umbrellas, cheap toys, matches, tooth brushes and medicine. But these categories began to include lots of electrical goods and plastic products in the 1950s and 1960s, some of them rather sophisticated and high value added.

Asia continued to sustain very high rates of growth. Many East and Southeast Asian countries exhausted local natural resources and increased imports, especially for mineral fuels.

By 1995 the destination of Sarawak's crude petroleum exports shifted back to Southeast Asia, with 39% of these exports going to the Philippines, 17% to Japan and 15% to South Korea, reflecting the collapse of Japan's economic bubble and the changing growth rates of East and Southeast Asian countries. Peak production in Sarawak was reached in 1976 when a total of 42.4 million barrels of oil were produced.

Around this time, a more serious attempt to make use of oil-related development for the local economy began. Transport facilities, employment and access to more modern urban infrastructure were among the more important nexuses. This did have an impact on the export potential of forest areas as well. Petronas also initiated a degree of downstream activities, such as the production of fertilisers; however, these efforts hardly transformed the local economy into an industrial one.

Meanwhile, Sarawak's strong involvement in East Asia continued with the emergence of new export commodities. Returning to Fig. 27.9, the overall geographical destination of Sarawak's exports remained in favour of East Asia, in spite of the changing destination of oil. From 1976 to 2013 Japan was the largest destination of Sarawak's exports (except for 1997 and 1998), followed by Singapore, the rest of Malaysia, South Korea, Taiwan and occasionally the United States. The rise of new commodities, especially a large increase of liquefied natural gas (LNG), replaced oil and sustained exports. Exports of sawlogs and plywood also increased.

LNG now occupies the largest share of Sarawak's exports. In 1971 substantial gas reserves were found offshore at Bintulu. Initially gas was used as fuel for a refinery at Lutong (near Miri) and for generating electricity. Malaysia LNG Sdn Bhd, a joint venture between Shell Gas BV, Mitsubishi Corporation, the state government of Sarawak and Petronas, was formed in June 1978 (Ahmad and Regterschot 2001; Malaysia LNG 2012). Since then, exports of LNG to Japan have soared (Kaur 1998: 180, 254).

In 1969 major gas companies in Japan decided to shift their supply source from coal and oil to LNG. Tokyo Gas completed the planned shift between 1972 and 1985, while Osaka Gas did so between 1975 and 1990 (Inoue 2007). LNG also began to be used for electricity generation stations around the same time, which in due course became more important as the source of demand. The introduction of LNG as the chief source of electricity generation by Tokyo Gas in the 1960s and 1970s was a major innovation, largely motivated by the need to reduce the amount of sulphur oxide being discharged into the air by coal- and oil-fired plants and causing serious pollution in the region. In addition to price considerations (as the price of oil had remained high from the 1970s), LNG was identified as a cleaner fossil fuel and became the main source of supply for power generation in Japan (Ito 2016: 44–54, 65–66). Unlike in the United States and Canada, LNG was not used in Japan as an important material in the petrochemical industry (Hirano 2016: 182, 192).

Imports of LNG to Japan steadily increased from the 1980s. Indonesia, Malaysia and more recently Australia were the leading exporters to Japan. In 2001 Japan imported 15 billion m^3 of LNG from Malaysia, comprising 15% of total LNG imports. From the Malaysian perspective, 73% of LNG exports went to Japan. In 2016 Japan imported 16 billion m^3 of LNG from Malaysia, comprising 19% of total LNG imports. However, reflecting much higher prices of LNG, the value of imports soared. 56% of Malaysia's LNG exports went to Japan in that year (data are mainly from British Petroleum 2002, 2017). A large portion of imports from Malaysia were from Bintulu.

Another major export was timber. The government's forest policy encouraged logging, which resulted in widespread deforestation that drew much international criticism. By the early 1980s Sarawak was the only major exporter of timber (mainly logs) in Malaysia. Despite the restriction of imports set out by Western countries, timber from Sarawak continued to be exported to Japan and other East Asian countries (Kaur 1998: 191–198). By the late 1980s exports of wooden products and plywood exceeded those of timber and held an important place in the composition of Sarawak's exports until relatively recently. The development of the timber industry benefited the state of Sarawak (through the large amounts of revenue that were generated) and local elites, but not the vast majority of local indigenous inhabitants who lost much of their customary land and space for livelihoods. There was also a growth of pulp industries, though not as rapid as observed in other parts of Southeast Asia.

Along with timber, oil palm plantations emerged as a major export sector. Production has accelerated since the 1990s, increasing both Malaysian and foreign capital and entrepreneurship. Many plantations extended their operations to milling and other downstream activities that provided additional revenue. Oil palm is a fairly labour-intensive industry and, unlike the timber industry, it was concentrated in swaths of peatland located relatively close to the coast. By 2010, 37% of Sarawak's peatland was converted into oil palm plantations (Miettinen 2012: 21). The rapid expansion and changes in land use have raised many concerns for environmental sustainability including deforestation, biodiversity loss, pollution and cultural effects on communities still engaged in traditional livelihoods. Some indigenous villagers and dispossessed farmers have since become workers for the timber industry and oil palm plantations. In response to the concerns of Western countries over sustainability and human rights, plantations and stakeholders took measures such as the issuance of internationally recognised certification (Kato and Soda, Chap. 16; Naito and Ishikawa, Chap. 26). Smallholder palm oil production has developed in recent years but it remains peripheral to the plantation-dominated development of infrastructure and commercial networks (Fig. 27.10).

Figure 27.11 shows the ways in which Sarawak was incorporated into the rapid increase of demand for oil and natural gas by growing economies in East and Southeast Asia. Western countries no longer acted as a major export destination and, compared to other branches of intra-Asian trade, Sarawak's exports focused more on Japan, newly industrialised economies and Southeast Asian countries rather than on China, mainly as a result of the state's commodity composition and path dependencies. However, Sarawak has still clearly benefited from the rapid growth of the Asian regional economy which is centred on China. In terms of the relative signifi-

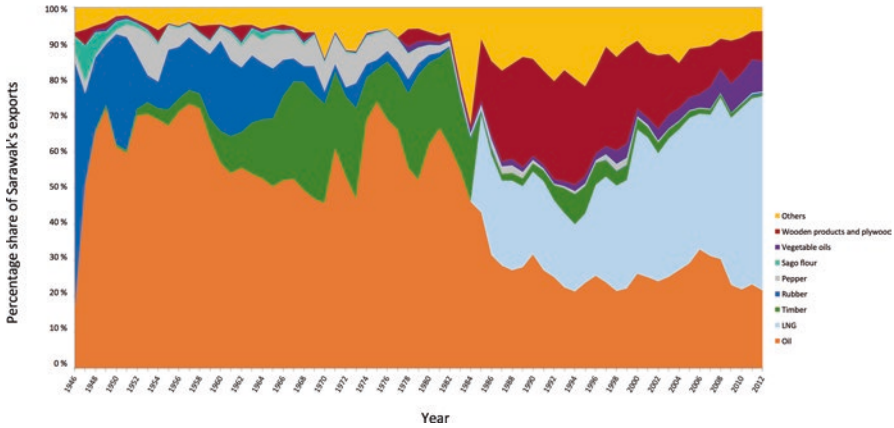


Fig. 27.10 Commodity composition of Sarawak's exports, 1946–2012
Sources: *Sarawak Government Gazette* (*Supplement/extraordinary* 1946–1947); Department of Trade and Customs, Colony of Sarawak (1955–1961); Sarawak Central Statistics Bureau (1961–1963); Department of Statistics Malaysia, Sarawak Branch (1964–1996); Department of Statistics Malaysia, Sarawak Branch (1996–2013)

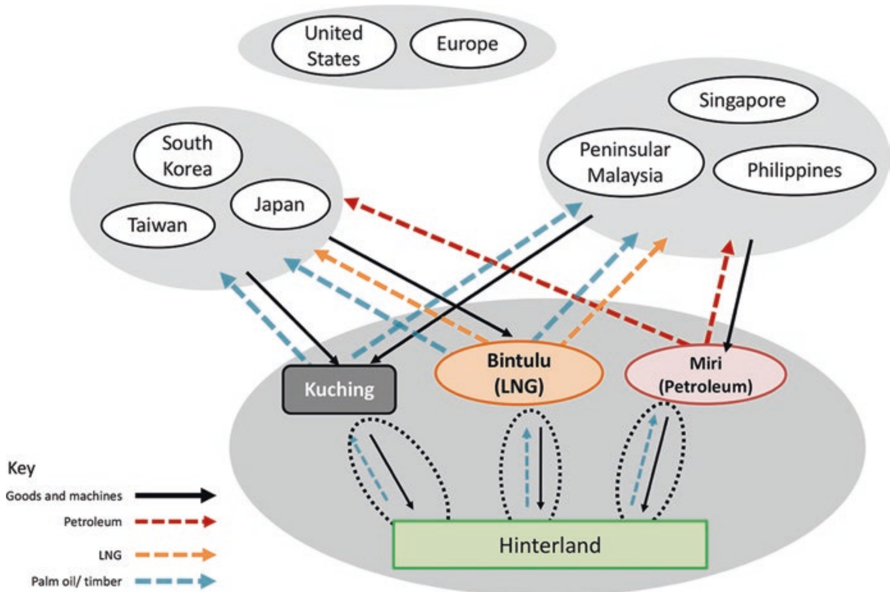


Fig. 27.11 Patterns of Sarawak's integration into the world economy, *c*.2010

cance of main ports, Bintulu became by far the largest, followed by Miri and Kuching, reflecting the relative decline of exports coming from the natural biosphere. Nevertheless, the total amount of exports of wood products, plywood and palm oil has rapidly increased since the 1990s, which exposed the local community, land and forests to the forces of economic globalisation. Urban-centred development resulted in considerable economic and political inequalities (Soda 2007: 21), and so-called ‘development politics’, with its promise of infrastructural projects and federal grants, still features significantly in nonurban and less-developed parts of Sarawak to this day (Weiss and Puyok 2017: 4).

27.5 Conclusion

It has been noted that, while international trade was not a dominant factor for the growth of non-Western economies during the nineteenth century (Hanson 1980: 131–132), the development of Southeast Asian economies was clearly export led (Cowan 1964; Drabble 2000). Between 1870 and 1913 Southeast Asia’s GDP increased at about 2.6 times, a little faster than world GDP (Maddison 2009). Between 1883 and 1913 the value of the region’s trade increased four times; in 1910 its share in world trade was 3.4% (Sugihara 2005: 6–7; Sugihara 2015: 48–51).

In Southeast Asia, a large part of the local economies was commercialised before economic integration in the late nineteenth century (Reid 1997; Sugihara 2009). Western colonisation accelerated this tendency. Through the improvement of transport infrastructure and the enforcement of free trade under Western domination, both Western and Asian merchants activated their commerce in both long-distance trade and intra-Asian trade (Lindblad 2002). Their trading linkages, which spread from major ports like Singapore across the region, transmitted demand from industrialising countries to the hinterlands and jungles of Sarawak and fuelled the growth of exports of primary goods in colonial Southeast Asia. The share of intra-Asian trade (including intra-Southeast Asian trade) in Southeast Asia’s trade held up very well (Sugihara 1996; Kobayashi 2013: 443–474). Sarawak fits into this general picture, although the impact of international trade was partially checked by conservative government policies towards investment and poor transport facilities (Kaur 1998; Drabble 2000).

After the 1970s the trade of Sarawak came to be much more closely linked to the Asia-Pacific economy, which grew faster than any other region in the world. East Asia (represented by Japan) and Southeast Asia (represented by Malaysia) offered the Asian and Southeast Asian regional markets for primary products, to which Sarawak was able to respond, with American and Malaysian investment and the support of the Malaysian government. Sarawak’s direct involvement with the growth of demand for mineral fuels, timber and oil palm in the Asia-Pacific sustained its very high economic growth.

Sarawak’s biomass society in the nineteenth century was directly linked to the outside world through the intermediation of local and regional merchants. Local society was highly responsive to new commercial opportunities for this reason. In most of the subsequent periods, however, the linkages between the biomass society and the world economy became more distant for two reasons: one was the increase of exports of oil and natural gas; and the second was the growth of the timber industry and expansion of plantations. The changing prosperity of the main export sectors was accompanied by the decline of traditional ports and commercial networks. The local biomass society was progressively integrated into the world economy through more direct linkages between foreign demand, the state and entrepreneurs. Timber exports led to increasingly rampant deforestation and the construction of roads and other transport networks, drastically affecting the human–nature interface. In the more recent period, a portion of local communities has actively engaged in oil palm production, along with plantation economies. However, it remains unclear if the current society (especially more rural indigenous inhabitants) is strong enough to withstand the forces of globalisation, and to articulate local initiatives in the more internally generated path of economic development.

References

Ahmad, Adzha Kasmuni, and Jannes Regterschot. 2001. The Malaysia LNG complex—Sustainable growth. Paper presented at the Thirteenth International Conference and Exhibition on Liquefied Natural Gas, Seoul, South Korea, 14–17 May.

British Petroleum. 2002. *BP statistical review of world energy June 2002*. London: British Petroleum Company.

———. 2017. *BP statistical review of world energy June 2017*. London: British Petroleum Company.

Chew, Daniel. 1990. *Chinese pioneers on the Sarawak frontier 1841–1941*. Singapore: Oxford University Press.

Chief Statistician at Singapore. 1951. *Malayan statistics: Monthly digest of economic and social statistics relating to the Colony of Singapore and the Federation of Malaya*. Singapore: Government Printing Office.

Colony of the Straits Settlements. 1868–1927. *Blue book for the year 1868–1927*. Singapore: Government Printing Office.

Cowan, C.D., ed. 1964. *The economic development of Southeast Asia: Studies in economic history and political economy*. London: George Allen and Unwin.

Department of Statistics Malaysia, Sarawak Branch. 1964–2013. *Statistics of external trade for the year 1964–2013*. Kuching: Department of Statistics Malaysia, Sarawak Branch.

Department of Trade and Customs, Colony of Sarawak. 1955–61. *Annual statistics for the year 1954–60*. Kuching: Government Printing Office.

Drabble, John H. 2000. *An economic history of Malaysia, c.1800–1990: The transition to modern economic growth*. London: Macmillan.

Hanson, John R. 1980. *Trade in transition: Exports from the Third World, 1840–1900*. New York: Academic.

Hepburn, B.A. 1949. *Handbook of Sarawak: Comprising historical, statistical and general information concerning the colony obtained from official and other reliable records*. Singapore: Government of Sarawak. Malaya Publishing House for the Government of Sarawak.

Hirano, So. 2016. *Nihon no sekiyu kagaku sangyo: bokko, kozo hukyo kara saiseichoe* [The petrochemical industry in Japan: From the emergence and structural depression to the renewed growth phase]. Nagoya: Nagoya Daigaku Shuppankai.

Huff, W.G. 1994. *The economic growth of Singapore: Trade and development in the twentieth century*. Cambridge: Cambridge University Press.

Inoue, Hisato. 2007. Development of an LNG receiving terminal process simulator and construction of an education/training system. Paper presented at the Fifteenth International Conference and Exhibition on Liquefied Natural Gas, Barcelona, Spain, 24–27 April.

International Monetary Fund [IMF] and International Bank for Reconstruction and Development [IBRD]. 1962. *Direction of trade: A supplement to international financial statistics 1958–1962*. Washington, DC: IMF and IBRD.

Ishikawa, Noboru. 2010. *Between frontiers: Nation and identity in a Southeast Asian borderland*. Singapore: NUS Press.

Ito, Yasushi. 2016. *Kankyo seisaku to inobeshon: kodo seicho-ki Nihon no iousankabutsu taisaku no jirei kenkyu* [Environmental policy and innovation: A case study of policy measures against the discharge of sulphur oxide in Japan during the period of high economic growth]. Tokyo: Chuo Keizaisha.

Jomo, K.S., ed. 2007. *Malaysian industrial policy*. Singapore: NUS Press.

Kaur, Amarjit. 1998. *Economic change in East Malaysia: Sabah and Sarawak since 1850*. London: Palgrave Macmillan.

Kobayashi, Atsushi. 2013. The role of Singapore in the growth of intra-Southeast Asian trade, *c.*1820s–1852. *Southeast Asian Studies* 2 (3): 443–474.

Kobori, Satoru. 2010. *Nihon no energi kakumei: shigen shokoku no kingendai* [The energy revolution in Japan: The modern and contemporary history of a resource-poor country]. Nagoya: Nagoya Daigaku Shuppankai.

Lindblad, J. Thomas. 2002. The outer islands in the 19th century: Contest for the periphery. In *The emergence of a national economy: An economic history of Indonesia, 1800–2000*, ed. Howard Dick, Vincent J.H. Houben, J. Thomas Lindblad, and Thee Kian Wie, 82–110. Honolulu: University of Hawaii Press.

Maddison, Angus. 2009. Statistics on world population, GDP and per capita GDP, 1–2008 AD. http://www.ggdc.net/maddison/. Accessed 15 Aug 2018.

Malaysia LNG Sdn Bhd. 2012. About us. http://www.mlng.com.my. Accessed 15 Aug 2018.

Miettinen, Jukka, Al Hooijer, Daniel Tollenaar, Sue Page, Chris Malins, Ronald Vernimmen, Chenghua Shi, and Soo Chin Liew. 2012. *Historical analysis and projection of oil palm plantation expansion on peatland in Southeast Asia*, White Paper No. 17. Washington, DC: International Council on Clean Transportation.

Ooi, Keat Gin. 1997. *Of free trade and native interests: The Brookes and the economic development of Sarawak, 1841–1941*. Oxford: Oxford University Press.

Porritt, Vernon L. 1997. *British colonial rule in Sarawak, 1946–1963*. Kuala Lumpur: Oxford University Press.

Pricewaterhouse Coopers. 2016. *The Malaysian oil and gas industry: Challenging times, but fundamentals intact*. Kuala Lumpur: Pricewaterhouse Coopers.

Reid, Anthony. 1997. A new phase of commercial expansion in Southeast Asia, 1760–1840. In *The last stand of Asian autonomies: Responses to modernity in the diverse states of Southeast Asia and Korea, 1750–1900*, ed. Anthony Reid, 57–81. London: Macmillan.

Sarawak Central Statistics Bureau. 1961–1963. *Statistics of external trade for the year 1961–63*. Kuching: Sarawak Central Statistics Bureau.

Sarawak annual report of the Department of Trade and Customs for the year, 1920–1940, 1946–1953. Sarawak, Kuching.

Sarawak Gazette. 1870–1907. *Sarawak trade returns for the year 1870–1907*. Kuching: Government Printing Office.

———. 1885–1904. *Kuching monthly trade returns, 1885–1904*. Kuching: Government Printing Office.

Sarawak Government Gazette. 1908–1917. *Sarawak trade returns for the year 1908–1917*. Kuching: Government Printing Office.

———. 1946–1958. *Supplement/extraordinary 1946–1958*. Kuching: Government Printing Office.

Soda, Ryoji. 2007. *People on the move: Rural–urban interactions in Sarawak*. Kyoto: Kyoto University Press.

Statistical Department, Board of Trade. 1926. *Statistical abstract for the several British overseas dominions and protectorates in each year from 1909 to 1923*. London: House of Commons.

Sugihara, Kaoru. 1996. *Asiakan boeki no keisei to kozo* [Formation and structure of intra-Asian trade]. Kyoto: Minerva Shobou.

———. 2005. An introduction. In *Japan, China and the growth of the Asian international economy, 1850–1949*, ed. Kaoru Sugihara, 1–19. Oxford: Oxford University Press.

———. 2008. East Asia, Middle East and the world economy: The oil triangle under strain. In *Proceedings of the Third Afrasian International Symposium 'Resources under stress: Sustainability of the local community in Asia and Africa'*, ed. Yoshio Kawamura, Hisashi Nakamura, Shiro Sato, Aysun Uya, and Shinya Ishizaka, 213–237. Kyoto: Afrasian Centre for Peace and Development Studies, Ryukoku University and Centre for Southeast Asian Studies, Kyoto University.

———. 2009. The resurgence of intra-Asian trade, 1800–1850. In *How India clothed the world: The world of South Asian textiles, 1500–1850*, ed. Giorgio Riello, and Tirthankar Roy (with the collaboration of Om Prakash and Kaoru Sugihara), 139–169. Leiden: Brill.

———. 2015. Asia in the growth of world trade: A re-interpretation of the 'long nineteenth century'. In *Commodities, ports and Asian maritime trade since 1750*, ed. Ulbe Bosma and Anthony Webster, 17–58. Basingstoke: Palgrave Macmillan.

———. 2017. Monsoon Asia, intra-regional trade and fossil-fuel-driven industrialization. In *Economic development and environmental history in the Anthropocene: Perspectives on Asia and Africa*, ed. Gareth Austin, 119–144. London: Bloomsbury Academic.

———. 2018. Varieties of industrialization: An Asian regional perspective. In *Global economic history*, ed. Giorgio Riello and Tirthankar Roy. London: Bloomsbury Academic.

Sugihara, Kaoru, and John Anthony Allan, eds. 1993. *Japan in the contemporary Middle East*. London: Routledge.

Weiss, Meredith L., and Arnold Puyok, eds. 2017. *Electoral dynamics in Sarawak: Contesting developmentalism and rights*. Petaling Jaya: Strategic Information and Research Development Centre.

Wong, Lin Ken. 1978. Singapore: Its growth as an entrepot port, 1819–1941. *Journal of Southeast Asian Studies* 15 (1): 50–84.

Part V
Coda

Chapter 28
Into a New Epoch: Capitalist Nature in the Plantationocene

Noboru Ishikawa

Abstract This chapter delineates the characteristics of impacts and changes brought by the expansion of oil palm plantations to the biomass-rich interior region of Sarawak, Malaysia. It argues that many of the changes, both social and ecological, and the combination of the two, are derived from interfaces being formed when different and often distant landscapes, peoples, institutions and networks come into contact and are abruptly juxtaposed. Such new encounters have led to the temporal compression of succession—the transplanting, mobilisation, proliferation, reduction and extirpation of fauna, flora and human communities in a relatively short time. What emerges is a mixed landscape consisting of first nature and capitalist nature, where habitat fragmentation, biodiversity loss and multifaceted displacements proceed. Spatial compression brought by infrastructure development also connects the local community, both human and non-human, with distant people and markets, leading to a new kind of rural–urban continuum as well as the commodification of nature and labour. Along newly created commodity chains, there emerge numerous cultural encounters of individuals and social groups, adding a new social amalgam to the local community.

Keywords Sarawak · Anthropocene · Capitalocene · Plantationocene · Plantation frontier · *Oikoumene*

28.1 The Anthropocene and the Capitalocene

We have now entered the Anthropocene, a new geo-historical period in which humans are the most powerful agent of change, according to some scholars. If they are correct, we are no longer in the Holocene geological epoch. In light of this, urgent actions

The original version of this chapter was revised: This chapter was previously published as non-open access. It has now been changed to open access under a CC BY NC ND 4.0 license. The correction to this chapter is available at https://doi.org/10.1007/978-981-13-7513-2_29

N. Ishikawa (✉)
Center for Southeast Asian Studies, Kyoto University, Kyoto, Japan
e-mail: ishikawa@cseas.kyoto-u.ac.jp

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_28

are needed to respond to climate change and other human-induced environmental changes, if humans are the primary agents for change for the future trajectory of the Earth. Theories abound about just when this human influence became paramount, but many see the use of fossil fuels to support the Industrial Revolution as a crucial inflection point. The impact of humans is thus about the exploitation of buried organisms containing energy from photosynthesis and a result of millions of years of the natural anaerobic decomposition of buried organisms. In other words, biomass altered by heat and pressure over geological time lies at the heart of the Anthropocene's development, prosperity, and now crisis (Lewis and Maslin 2018).

Yet there are a variety of approaches in our search for a new epoch. 'Capitalocene' is one such example. The term pays more attention to the system of capitalism, governance as well as the mobilisation of labour and utilisation of natural resources that have led to global transformations. The notion of the Capitalocene has the advantage of attending to society, culture, history and power without restricting human influence only to the realm of scientific and technological inventions such as fire, steam engines and atomic bombs (Haraway 2015; cf. Moor 2017; Bonneuil and Fressoz 2017). On the one hand, natural scientists search for hints of change in natural phenomena such as 'golden spikes' left in a geological stratum, and look into conditions of climate, atmospheric chemistry, and the density and distribution of plant and animal species (Lewis and Maslin 2015: 174). On the other hand, social scientists examine changes in social formations, structure and governance as well as connections, networks, flows and the movement of things, labour and people under capitalism. In other words, while natural science Anthropocenologists employ large data sets on a global scale in search of an inflection point in the geological record and atmospheric change, social science Anthropocenologists present a civilisational critique that combines histories of the Earth system and world systems.

28.2 Into the Plantationocene

In lieu of a conclusion, I wish to introduce yet another historical periodisation, the 'Plantationocene', as a subcategory of the Anthropocene. In doing so, our research in this volume is located in the current debate. While the Anthropocene is defined in connection with the fossil fuel era, the Plantationocene is an epoch characterised by the emergence of a large-scale, monocropping production system across the surface of the Earth.[1] Each constituent of this production system—plant, land, labour, technology and infrastructure—is mutually dependent and thus presumed to be essential to the operation of the whole (cf. Mintz 1959: 44). The emergent system is 'the model and motor for the carbon-greedy machine-based factory system that is often cited as an inflection point for the Anthropocene'(Haraway 2015: 162; cf.

[1] The term Plantationocene was generated and extensively discussed in a dialogue on the Anthropocene in a recorded conversation for *Ethnos* at the University of Aarhus, Denmark, in October 2014. The discussion was transcribed and published as 'Anthropologists are talking about the Anthropocene' in *Ethnos* (see Haraway et al. 2016).

Haraway et al. 2016). In the course of human history, the monoculture plantation has transformed 'diverse kinds of human-tended farms, pastures, and forests into extractive and enclosed plantations' (Haraway 2015: 162). With the advent of the Plantationocene, multispecies forests and the remaining refugia are being wiped out (Tsing 2015b).

In the course of our research from 2010 to 2014, we have come to realise the salience of the Plantationocene's features, and we capture its latest and emerging moments in maritime Southeast Asia. Compared to the Malay Peninsula, which has experienced a century of oil palm cultivation and more than 30 years of downstream industrial sector development, what we witness in the riverine society of Sarawak is the formative stage of plantation expansion to upstream regions. Among many resource frontiers in Southeast Asia, Sarawak occupies a peculiar historical niche. Logging activity and the expansion of oil palm, both by the plantation system and on a smallholding basis, have proceeded concurrently. More importantly, people's livelihoods in Sarawak are still highly dependent on biomass-rich environs. In the course of our project, we had an opportunity to examine the very early stages of transformation from a biomass to land regime as well as subsistence and trade to market-orientated production. In other words, the crucial moment of the coming of the Plantationocene was unfolding in front our eyes during the study.[2]

Since 1492 the plantation mode of production has expanded to high biomass societies in the tropics.[3] The arrival of Europeans in the Caribbean in that year, and the subsequent colonisation of the Americas, initiated a global process known as the Columbian Exchange in which the transoceanic movements of plants, populations and capital fundamentally changed the way agricultural commodities were produced. These cross-continental movements have resulted in the 'radical reorganization of a web of life on and beneath the soil without geological precedent' (Lewis and Maslin 2015: 174). The main characteristics of the Plantationocene reflect this reorganisation. The impacts of the meeting of Old World and New World human populations and plants led to the reorganisation and homogenisation of the Earth's biota and served to mark the beginning of a new geological epoch. In terms of stratigraphy, the plant species deracinated and cultivated as plantation crops in the sediments of the tropics may provide a common marker of the Plantationocene across many deposits because pollen is often well preserved in marine, lake sediments and peatland (Lewis and Maslin 2015: 175).

---

[2] By 1800, when Alexander von Humboldt reached colonial plantations in Venezuela, the Plantationocene was already well under way. He witnessed the transformation of nature and described it as an interconnected living web. For him nature was a 'living whole' where organisms were bound together in a net-like intricate fabric (Wulf 2015).

[3] What distinguishes our research among pioneering studies on plantations (cf. Steward et al. 1956; Wolf 1982; Mintz 1985) is our multidisciplinary and multispecies approach. Through empirical research on site, we are able to add our findings to those of previous studies. For instance, for Steward's pioneering attempt to understand the Puerto Rican plantation society with a focus on local communities, sub-communities, and the level of social integration (Steward et al. 1956), we examine the social dynamics beyond plantation society, and to Wolf's attention to 'people without history', we add greater focus on more than human perspectives as well as histories of non-humans (cf. Tsing 2016).

28.3 Juxtaposition and New Interfaces

Here I wish to delineate some of the socio-ecological characteristics of the Plantationocene through our study of one small area of the central Sarawak frontier. Many of the changes, social and ecological, and the combination of the two, are derived from interfaces formed when different and often distant landscapes, people and things come into contact. Such new encounters or spatial juxtapositions have led to the temporal compression of succession—the transplanting and mobilisation, proliferation, reduction and extirpation of plants, flora and people in a relatively short period of time. We have found that this compression of both space and time is an important feature of the plantation frontier. The landscapes are juxtaposed by force, for instance when remnant communal forests of *pulau* and plantations meet. This leads to the coexistence of nature and non-nature or the encounter of 'first nature' with 'capitalist nature' (Tsing 2015a). The juxtaposed landscape consisting of first nature and second nature brings about both ecological and social changes. As we have seen in the plantation frontier of central Sarawak, the juxtaposition of peat swamp forests, secondary forests, culturally preserved communal forests, swidden fields, reduced-impact logging sites, logged-over forests, acacia planted forests and oil palm plantations leads to habitat fragmentation where a habitat is being increasingly divided into more isolated pieces (Haddad et al. 2015). This fragmentation process increases forest edges where wind damage and changes in temperature and humidity may make the environment along the edges unsuitable for certain species, resulting in the available habitat becoming even smaller (Turner 1996; Laurance et al. 2016).[4]

Yet there may be a chance for the coexistence of first nature and capitalist nature on the plantation frontier. Our study has shown that reduced-impact logging practices are one effective way to prevent biodiversity loss.[5] In addition, the initiative and conscious effort on the part of local peasants would contribute to the maintenance of a well-balanced, high-quality mixed landscape consisting of remnant forest, swidden fields, secondary forest and oil palm cultivation fields.

Spatial compression not only brings changes to ecological communities but also to humans. In the maritime frontier of Sarawak, profound changes have occurred both at the levels of the macro landscape and the micro household. Through the construction of road networks that link upriver and downriver supply chains, distant people are reconnected in a new manner distinctively different from relationships of the past. The landscape changes when people migrate to the roadside from the

---

[4] Due to fragmentation, more than 70% of the world's forests are now within 1 km of a forest edge, impacting on rainforest ecosystems across the globe (Haddad et al. 2015).

[5] An effective forest sustainability mechanism—ecosystem service certification—has been initiated by the Forest Stewardship Council, where management entities who wish to be certified for the maintenance of ecosystem services (carbon, biodiversity, watershed, soil and recreational services) must verify that their activities have no net negative impacts on selected ecosystem service(s). For a robust and cost-effective measurement method to evaluate a bundle of ecosystem services, see Kanehiro Kitayama (2013).

riverside in order to plant their own oil palm. The social ties previously maintained along maritime riverine lines are now giving way to terrestrial ones. At the household level, families are spatially extended and consist of urban wage earners as well as those who stay close to cultivated oil palm forests inland. Labour as well as remittances from urban family members often support senior members of the community who engage in oil palm smallholding in rural areas. Spatial compression leads to a new kind of rural–urban continuum, while peri-urban space is functionally diminishing.

The transformation from a biomass to land regime, as well as from subsistence to market-orientated production, has resulted in an increase in the value of local land. In such a situation, although we foresee the coexistence of oil palm smallholders and plantations in close proximity, more intense competition is expected between the two. If the history of rubber expansion to maritime Southeast Asia in the inter-war period is indicative, it may not take long for smallholders to upscale their production capacity to collectively match some of the large-scale plantations. What we currently see is the trend towards an enlarged oil palm peasantry in Sarawak. As a result, the competition for both land and labour is becoming acute between the plantation sector and smallholders. Under these circumstances, two modes of labour mobilisation for oil palm cultivation are likely to become more intense: the labour of local peasants at the fringe of corporate plantations is mobilised by the corporate sector, while local smallholders also mobilise extra-household labour to expand their farmland operations.

Along commodity chains that link production sites and consumption sites, there exist numerous cultural encounters of distant people. Take an encounter between the corporate sector and local communities as an example. Local people meet and interact with Bugis and Timorese plantation workers as well as Fuzhou Chinese in timber camps and Japanese businessmen procuring timber to be used as concrete-forming plywood in Tokyo. Such is a typical social field on the resource frontier under study. During our research, we often witnessed heated cockfights enjoyed both by local Ibans and Bugis migrants from Sulawesi. This kind of quotidian cultural encounter along commodity chains may add a new social amalgam to the multiethnic Kemena–Tatau basin.

The ecological, social and cultural compression that takes place along extended commodity chains is a characteristic of the Plantationocene. Since Sidney Mintz first discussed the Caribbean region as '*Oikoumene*', the plantation frontier throughout the world has been repopulated by people, fauna and flora from elsewhere. They mixed together and formed a distinctive niche in world history. Such Plantationocene space, however, was 'only laggardly assimilated into social science' (Mintz 1996: 289). Belatedly, we add a new page to the examination from the perspective of multidisciplinary research that combines social and natural sciences. The findings are nevertheless place-specific. Despite such limitations, we hope some relevance is to be found for further empirical examinations in this frontier or elsewhere in other tropical biomass societies. Our research may simply offer a snapshot of what is happening on the plantation frontier. Further research in another time and space would yield comparable data and ethnographic accounts to enable us to understand the specificity of the human-centred epoch of which we are all a part.

References

Bonneuil, Christophe, and Jean-Baptiste Fressoz. 2017. *The shock of the Anthropocene: The Earth, history and us*. London: Verso.

Haddad, Nick M., Lars A. Brudvig, Jean Clobert, Kendi F. Davies, Andrew Gonzalez, Robert D. Holt, Thomas E. Lovejoy, Joseph O. Sexton, Mike P. Austin, Cathy D. Collins, William M. Cook, Ellen I. Damschen, Robert M. Ewers, Bryan L. Foster, Clinton N. Jenkins, Andrew J. King, William F. Laurance, Douglas J. Levey, Chris R. Margules, Brett A. Melbourne, A.O. Nicholls, John L. Orrock, Dan-Xia Song, and John R. Townshend. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances* 1 (2): 1–9.

Haraway, Donna. 2015. Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making kin. *Environmental Humanities* 6 (1): 159–165.

Haraway, Donna, Noboru Ishikawa, Scott F. Gilbert, Kenneth Olwig, Anna L. Tsing, and Nils Bubant. 2016. Anthropologists are talking—About the Anthropocene. *Ethnos* 81 (3): 535–564.

Kitayama, Kanehiro, ed. 2013. *Co-benefits of sustainable forestry: Ecological studies of a certified Bornean rain forest*. Tokyo: Springer.

Laurance, William F., Jose L.C. Camargo, Philip M. Fearnside, Thomas E. Lovejoy, G. Bruce Williamson, Rita C.G. Mesquita, Christoph F.J. Meyer, Paulo E.D. Bobrowiec, and Susan G.W. Laurance. 2016. An Amazonian forest and its fragments as a laboratory of global change. In *Interactions between biosphere, atmosphere and human land use in the Amazon basin*, ed. Laszlo Nagy, Bruce R. Forsberg, and Paulo Artaxo, 407–440. Berlin: Springer.

Lewis, Simon L., and Mark A. Maslin. 2015. Defining the Anthropocene. *Nature* 519: 171–180.

———. 2018. *The human planet: How we created the Anthropocene*. London: Penguin.

Mintz, Sidney W. 1959. The plantation as a socio-cultural type. In *Plantation systems of the New World*, ed. Research Institute for the Study of Man and Pan American Union, 42–50. Washington, DC: Pan American Union.

———. 1985. *Sweetness and power: The place of sugar in modern history*. New York: Penguin.

———. 1996. Enduring substances, trying theories: The Caribbean region as Oikoumene. *Journal of the Royal Anthropological Institute* 2 (2): 289–311.

Moor, James. 2017. The Capitalocene, Part I: On the nature and origins of our ecological crisis. *Journal of Peasant Studies* 44 (3): 594–630.

Steward, Julian H. [and others]. 1956. *The people of Puerto Rico: A study in social anthropology*. Urbana: University of Illinois Press.

Tsing, Anna Lowenhaupt. 2015a. *The mushroom at the end of the world: On the possibility of life in capitalist ruins*. Princeton: Princeton University Press.

———. 2015b. Feral geographies: Life in capitalist ruins. Paper at RGS-IBG annual international conference, University of Exeter, 2 September.

———. 2016. Others without history: Organisms as agility-shifting actors in the trajectory of capital. 11th Eric Wolf Lecture, Vienna, 17 October.

Turner, I.M. 1996. Species loss in fragments of tropical rain forest: A review of the evidence. *Journal of Applied Ecology* 33 (2): 200–209.

Wolf, Eric. 1982. *Europe and the people without history*. Berkeley: University of California Press.

Wulf, Andrea. 2015. *The invention of nature: Alexander von Humboldt's New World*. New York: Penguin.

Correction to: Anthropogenic Tropical Forests

Correction to:
N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2

Correction to Chapter 01: Commodification of Nature on the Plantation Frontier
Noboru Ishikawa and Ryoji Soda

Correction to Chapter 28: Into a New Epoch: Capitalist Nature in the Plantationocene
Noboru Ishikawa

The above-mentioned chapters 01 and 28 were originally published as non-Open Access chapters. Later, the sponsoring university have opted for Open Access. The chapters have been reposted as Open Access chapters under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (http://creativecommons.org/licenses/by-nc-nd/4.0/).

The updated versions of the chapters can be found at
https://doi.org/10.1007/978-981-13-7513-2_1
https://doi.org/10.1007/978-981-13-7513-2_28

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2_29

Glossary of Non-English Terms

a liko' people of a river, a district or a village
adat custom
angkis long-tailed porcupine
apan salt lick
attap belian ironwood roofing
baka storage basket
bakor basket
bangkat carrying basket
batu landak porcupine bezoar
batu monyet leaf monkey bezoar
beduruk labour exchange system
bejalai (trading) journey away from the village
belacan prawn paste
belian ironwood
bilik household unit of a longhouse
biru type of leaf
bubu fish trap
bubung box trap
bulu gumi lit. body hair of the earth
bung raft, canoe
chapan winnowing basket
daleh puu' ancestral home
engkabang illipe nut
fen Chinese unit of weight (0.378 g)
fěn zǎo luxury-grade porcupine bezoar (powdered date)
gaharu agarwood
garam apong nipah salt
gawai harvest festival
gedung walet swiftlet house

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2

geronggang species of flowering plant
guanxi personalised relationship
gula apong nipah sugar
guliga landak porcupine bezoar
guliga monyet leaf monkey bezoar
hutan rakyat private forest
ikan masin salted fish
imam prayer leader of a mosque
jabon fast-growing timber tree
jerenang red
jiàn zhū zǎo porcupine bezoar (lit. porcupine date)
kapur tree of the Dipterocarpaceae family
kayu rakyat wood from smallholders
keladan tree of the Dipterocarpaceae family
keruing tree of the Dipterocarpaceae family
ketepe wild rubber
kliering burial pole, mortuary post
konsep baru new concept
landak porcupine
langkau temporary huts
lanji rice-carrying basket
liang Chinese unit of weight (3.78 g)
lilik type of leaf
malat dop ceremony of presenting the customary knife
man han quan xi (满汉全席) Manchu Han Imperial Feast
maren aristocrat
menggaris tree of the Fabaceae family
menua area surrounding a village
nakodah Malay and Bugis sea captain, trader
nanas silas' variety of pineapple
nanyozai South Sea log
nungkun api ritual lighting of a fire in a longhouse
nyuru tray for fish
panjuk snare
parang machete, large heavy knife
pemansai fish basket
pengerang old-growth secondary forest
penghulu area chief
Pengiran Brunei noble title, those who fulfilled the role of bureaucrat or tax collector
peselai (trading) journey away from the village
pukat net (for hunting)
pulau communally reserved forest, island of wood and cane
pulau mali sacred grove, taboo forest
pulau umai private reserved forest

raga seed basket
ringka dish, bowl and pot holder
rotan rattan
rumah longhouse or house
rumah munyit monkey house
salong burial pole
sangkuh spear
sarang burung edible swiftlet nest
selabit burden basket
selangan batu type of *Shorea* tree
seluk sowing basket
sengon fast-growing timber tree
shinra banshō (森羅万象) lit. intertwined forests of the cosmos that form the universe
sintung reaping basket
tangi hat
tangkuplauk food cover
taukay, towkay boss, businessman
temuda fallow/secondary forest
tikai mattress
timpa tray
tuai rumah headman
uyut seed basket
wi rattan
xuè zǎo high-priced kind of porcupine bezoar
yan wo (燕窝) edible swiftlet nest
yan wu (燕屋) swiftlet house

Index

N. Ishikawa, R. Soda (eds.), *Anthropogenic Tropical Forests*, Advances in Asian Human-Environmental Research, https://doi.org/10.1007/978-981-13-7513-2

C

G

M