R. B. Singh · Soumendu Chatterjee ·
Mukunda Mishra ·
Andrews José de Lucena *Editors*

Practices in Regional Science and Sustainable Regional Development

Experiences from the Global South

Springer

Practices in Regional Science and Sustainable Regional Development

R. B. Singh · Soumendu Chatterjee ·
Mukunda Mishra · Andrews José de Lucena
Editors

Practices in Regional Science and Sustainable Regional Development

Experiences from the Global South

Springer

Editors
R. B. Singh
Department of Geography
Delhi School of Economics
University of Delhi
Delhi, India

Mukunda Mishra
Department of Geography
Dr. Meghnad Saha College
Itahar, West Bengal, India

Soumendu Chatterjee
Department of Geography
Presidency University
Kolkata, West Bengal, India

Andrews José de Lucena
Department of Geography
Federal Rural University of Rio de Janeiro
Rio de Janeiro, Brazil

ISBN 978-981-16-2220-5 ISBN 978-981-16-2221-2 (eBook)
https://doi.org/10.1007/978-981-16-2221-2

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

Foreword

Regional Science has been developing as a science of the region, which enhances regional understanding and development along with the progress of its tools, methods, conceptual framework, and useful data/information. In recent years, it faces new challenges generated by the aggravation of climatic and other global problems and disasters related to them, which may widen the gaps between the haves and the have-nots globally, regionally, and locally. This book sheds light on the actual practices in Regional Science, which are intended to contribute to sustainable regional development, particularly in the Global South. It covers a wide range of contemporary hot issues related to Regional Science, including climatic and other environmental changes, human health, education, and the impact of COVID-19, in addition to more conventional themes such as regional imbalance, poverty, urbanization, and migration. The editors express their deep concern on the regional as well as a global climate change affecting regional society seriously in many parts of the world. They see the outbreak of COVID-19 not only as a health hazard but also as a long-term social, economic, and behavioral hazard. It is particularly notable that they emphasize the importance of the experiences in the Global South regions, which have difficult economic and societal situations to be overcome, and there is a lot to be learned from their experiences. I hope this book is read widely in the world by those who want to make regions more sustainable and contributes to the enhancement of global, regional, and local understanding for sustainability, with the aid of the evolving Regional Science.

Hokkaido, Japan
February 2021

Yukio Himiyama, Ph.D.
Emeritus Professor, Hokkaido University of Education;
Past President, International Geographical Union; Member, Science Council of Japan

Preface

Regional Science aims to foster the exchange of ideas and promote studies focusing on the region and utilizing tools, methods, and theoretical frameworks designed for regional analysis, as well as concepts, procedures, and analytical techniques of the various social and other sciences. The efforts of Professor Walter Isard set the foundation stone of Regional Science during the 1960s. However, the first two decades in this millennium has been witnessing a series of events that calls for a serious review of the tools and techniques that could reinstall the Regional Science at the center of development planning. The 2008s Global Economic Crisis was a severe alert to the policy researchers and policymakers to speculate that the regional crises are often more important than the national crisis. The scholarly world witnessed that some regions, lagging severely in terms of economic and societal developments, need to see their economic base renewed, which inevitably require to involve all actors—natural, economic, social, political, and education—to work together proactively.

The issues of climate change have stormed the laboratories of almost all fields of knowledge. A deep insight into the matter of how the regional version of 'deflected' climatic parameters is excerpting impacts on regional society or economy to shape the human development of that region has become a relevant academic discourse throughout the globe. Above all, the pandemic outbreak of the novel COVID-19, spreading violently in almost all parts of the globe, is not only a severe health hazard, but it also brings to fore the long-term social, economic, and behavioral implications that mankind will be facing during the decades to come. All these things have been emerging as the newer research dimensions under the purview of Regional Science.

Alongside the needs, the principle methodological changes incorporated in the Regional Science have a significant concern. The statistical models, the geographic information systems (GIS), and the even broader area of geoinformatics, and the applications of big data to Regional Science, have become instrumental in analyzing the region and imbricating the development plans.

The use of the phrase Global South marks a shift from a central focus on development or cultural difference toward an emphasis on geopolitical relations of power. However, the most common things about the Global South nations are that they are mostly (not all) low-income and often politically or culturally marginalized. Besides, there is clear evidence of the uneven spatial distribution of resources, economic activities, literacy, and health condition that make the regional scientists inquisitive.

This volume is an academic venture to integrate the practitioners working in the same channel of addressing the regional issues and striving for sustainable regional development through their innovative ideas. We have set a collection of scholarly works that will be an academic archive of the emerging trends and techniques incorporated in Regional Science, particularly during the first two decades of this millennium. The volume incorporates within its folds the systematic and analytical notes making scientific commentary on the innovative methods of regional development, measurement of the development, regional development models, and policy measures that are found instrumental for India and the other Global South countries.

Delhi, India R. B. Singh
Kolkata, India Soumendu Chatterjee
Itahar, India Mukunda Mishra
Rio de Janeiro, Brazil Andrews José de Lucena

Acknowledgments

This book is the outcome of collective efforts. Our heartfelt recognition goes collectively to all of our friends, colleagues, students, and all others without whose active support in different aspects this book would not have seen the light of day. Yes, they all have made it possible with their respective roles.

We express our deepest sense of indebtedness to Professor Yukio Himiyama, *Emeritus Professor, Hokkaido University of Education, Japan, and Past President, International Geographical Union (IGU),* for his kind bits of advice and for providing his valuable time to write the 'Foreword' for this volume.

In a contributory volume, authors are the key stakeholders. We convey our sincere thanks to all the contributors for offering us the opportunity to include their works in this volume. Their prompt response and active cooperation have made this volume successful by incorporating a total of sixteen chapters from three continents that belong to the Global South, i.e., South America, Africa, and Asia. We must mention the names of Professor Jerzy Bański of the Institute of Geography and Spatial Organization, Polish Academy of Sciences, Poland, and Dr. Iwona Kiniorska of Jan Kochanowski University in Kielce, Poland, for sharing their analysis on the role of local resources as factors of regional development.

We are grateful to the administrative authorities of our respective institutions for their administrative supports.

We also thank all the reviewers for their constructive comments and advice that led to substantial improvements to this volume's content and quality.

Constructive editorial advice and constant support from Ms. Nupoor Singh*, the Editor, Springer Singapore*, remain unparalleled. We acknowledge the support of the entire team of Springer Nature associated with the publishing process, disseminating their respective roles with utmost perfection.

R. B. Singh, Ph.D.
Soumendu Chatterjee, Ph.D.
Mukunda Mishra, Ph.D.
Andrews José de Lucena, Ph.D.

Contents

Regional Science and Sustainable Regional Development

Regional Science, Regional Planning, and the Global South 3
Mukunda Mishra and R. B. Singh

The Role of Local Resources as Factors of Regional Development 23
Jerzy Bański and Iwona Kiniorska

Livelihood Zonation Mapping: An Unplugged Sect of Regional Science 37
Somenath Halder and Rajesh Sarda

Sustainable Regional Development in South America

The Indigenous Territories and Local Sustainable Development in the Amazon Region 69
Melgris José Becerra, Jorge Adriàn Flores Rangel, Claudio Ubiratan Gonçalves, and Gabriel Ibrahin Tovar

Territorial Planning and Regionalization in Brazil: Empirical Consolidation and the Role of the National Development Bank 113
Pablo Ibanez, Gustavo Westmann, and Fabiola Lana Iozzi

Erosion and Coastal Structures in Brazilian Metropolises: The Case of Fortaleza and Its Inequalities 127
Eduardo Lacerda Barros, Davis Pereira de Paula, Renan Gonçalves Pinheiro Guerra, and Jader de Oliveira Santos

Sustaining Port Activities Through Nature Conservation: The Case of Paraná Coast in Southern Brazil 151
Eduardo Vedor de Paula, Otacílio Lopes de Souza da Paz, Maíra Oneda Dal Pai, and Marianne de Oliveira

Urban Environmental Changes in South America: A Study on Air Pollution and Urban Heat Island over Rio de Janeiro 171
Heitor Soares de Farias, Andrews José de Lucena, and Vitor Fonseca Vieira Vasconcelos de Miranda

Assessment of Climatic Guidelines and Urban Planning in North-Eastern Coast of Brazil 199
Max Anjos, António Lopes, Elis Alves, Ezequiel Correia, and Francisco Mendonça

Experiences from Africa

Aerotropolis and Urban and Regional Impacts: The Case of the King Shaka International Airport in Durban, South Africa 223
Meghan Crosby and Brij Maharaj

Drivers of Socioeconomic Development and Underdevelopment in Moroccan Sahara 239
Suresh Kumar and Deepak Kumar

Experiences from Africa

An Overview of Climate Change Over South Asia: Observations, Projections, and Recent Advances 263
Bhupendra Bahadur Singh, Manmeet Singh, and Dharmaveer Singh

Environmental Vulnerability and Women Trafficking: Exploring the Bengal Sundarban Deltaic Region of India 279
Priyanka Biswas and Nilanjana Das Chatterjee

Women Beyond the Politics of Presence in Urban Local Governance: Exemplifying Purulia in West Bengal, India 297
Anindya Basu and Asha Bauri

Spatial Analysis of the Intra-urban Quality of Life: A Study in the Darjeeling Town in India 317
Bishal Chhetri and Kabita Lepcha

Three Decades of Urban Dynamics in India: Exemplifying Haora Sadar Subdivision 339
Monalisa Patra and Koel Roy Chowdhury

Editors and Contributors

About the Editors

Dr. R. B. Singh is a professor of geography at the Delhi School of Economics, University of Delhi; the secretary general and treasurer of the International Geographical Union (IGU); the chair of Council for Scientific and Industrial Research (CSIR)–Central Food Technological Research Institute of the Government of India, and a member of the International Council for Science (ICSU) and the scientific committee Urban Health and Well-Being. He was awarded the prestigious Japan Society for the Promotion of Scientific Research Fellowship and has presented papers and chaired sessions in more than 40 countries. He has published 14 books, 35 edited research volumes, and more than 215 research papers. He has supervised 34 Ph.D. and 79 M.Phil. students. In 1988 the Unesco/the International Social Science Council awarded him research and study grants in social and human sciences.

Dr. Soumendu Chatterjee is a Professor and Head of the Department of Geography at Presidency University in Kolkata, India. He has been teaching Geographical Science at the undergraduate and graduate levels for more than twenty years. His primary research interest is in creating scientific models for predicting complex physical and human processes on the Earth’s surface. He has more than 100 publications in national and international journals of repute to his credit, and has headed several research projects funded by the University Grants Commission (of India), Department of Science & Technology (GoI), Indian Council of Social Science Research (ICSSR) and other respected agencies in India and abroad.

Dr. Mukunda Mishra is an Assistant Professor, Department of Geography and designated Vice Principal of Dr. Meghnad Saha College in West Bengal, India. The college is affiliated to the University of Gour Banga. Dr. Mishra completed his postgraduate studies in Geography and Environmental Management at Vidyasagar University (receiving top rank in both the B.Sc. and M.Sc. panels of merit) and holds a Ph.D. in Geography from the same University. He was selected for the prestigious National Merit Scholarship by the Ministry of Human Resource Development, Government of India. His research chiefly focuses on\ analyzing unequal human development, and on creating multi-criteria predictive models. He has more than ten years of hands-on experience in dealing with development issues at the ground level in various districts of eastern India.

Dr. Andrews José de Lucena is an Adjunct Professor, Federal Rural University of Rio de Janeiro, Brazil. He has completed his Master in Geography from the State University of Rio de Janeiro and holds a Ph.D. in Atmospheric Sciences from the Alberto Luiz Coimbra Postgraduate Institute and Engineering Research (COPPE/UFRJ). His research interest is chiefly concerned with the urban climate and its research methods, climate change, and environment. He Participated and integrated research projects with several professionals and institutions in the area of Climatology and Urban Meteorology, Atmospheric Hydrological Modeling, Remote Sensing in Urban Areas and Urban Development in the Metropolitan Region of Rio de Janeiro. He coordinates the Integrated Laboratory of Applied Physical Geography (LIGA/UFRRJ) and integrates the Environmental Satellite Applications Laboratory of the Meteorology Department (LASA/UFRJ). He manages the website www.climatologia.com.br with information about land surface temperature (LST) of the Metropolitan Area of Rio de Janeiro from 1984 to the present.

Contributors

Elis Alves Instituto Federal de Educação, Ciência E Tecnologia Goiano, Ceres, Brazil

Max Anjos Laboratory of Climatology (LABOCLIMA), Federal University of Paraná (UFPR), Curitiba, Brazil

Eduardo Lacerda Barros Ceará State Secretariat of Environment (SEMA), Environment Chief Scientist Program, Fortaleza, Brazil

Anindya Basu Department of Geography, Diamond Harbour Women's University, Diamond Harbour, West Bengal, India

Asha Bauri Department of Geography, Kashipur Michael Madhusudan Mahavidyalaya, Kashipur, West Bengal, India

Jerzy Bański Institute of Geography and Spatial Organization, Polish Academy of Sciences, Warsaw, Poland

Melgris José Becerra Universidade Federal do Pará (UFPA), Instituto de Geociências, Belém, CEP, Brazil

Priyanka Biswas Department of Geography, Vidyasagar University, Midnapore, West Bengal, India

Nilanjana Das Chatterjee Department of Geography, Vidyasagar University, Midnapore, West Bengal, India

Bishal Chhetri Department of Geography, Southfield College, Darjeeling, West Bengal, India

Koel Roy Chowdhury Department of Geography, Presidency University, Kolkata, India

Ezequiel Correia Centre of Geographical Studies, Institute of Geography and Spatial Planning (IGOT), Universidade de Lisboa, Lisbon, Portugal

Meghan Crosby University of KwaZulu-Natal, Durban, South Africa

Otacílio Lopes de Souza da Paz Department of Geography, Federal University of Paraná, Curitiba, Paraná, Brazil

Heitor Soares de Farias Integrated Laboratory of Applied Physical Geography (LIGA), Federal Rural University of Rio de Janeiro (UFRRJ), Rio de Janeiro, Brazil

Andrews José de Lucena Integrated Laboratory of Applied Physical Geography (LIGA), Federal Rural University of Rio de Janeiro (UFRRJ), Rio de Janeiro, Brazil

Vitor Fonseca Vieira Vasconcelos de Miranda Laboratory of Environmental Satellites Applications (LASA), Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

Jader de Oliveira Santos Department of Geography, Ceará Federal University (UFC), Fortaleza, Brazil

Marianne de Oliveira Department of Geography, Federal University of Paraná, Curitiba, Paraná, Brazil

Davis Pereira de Paula Laboratory of Coastal and Oceanic Geology and Geomorphology (LGCO), Ceará State University (UECE), Fortaleza, Brazil

Eduardo Vedor de Paula Department of Geography, Federal University of Paraná, Curitiba, Paraná, Brazil

Jorge Adriàn Flores Rangel Universidad Anáhuac, Facultad de Estudios Globales, Ciudad de México, Mexico

Claudio Ubiratan Gonçalves Universidade Federal de Pernambuco (UFPE), Departamento de Geografia, Recife, Pernambuco, Brazil

Renan Gonçalves Pinheiro Guerra Ceará State Secretariat of Environment (SEMA), Environment Chief Scientist Program, Fortaleza, Brazil

Somenath Halder Department of Geography, Kaliachak College, Malda, West Bengal, India

Pablo Ibanez Laboratory of Economic and Political Geography (LAGEP), Federal Rural University of Rio de Janeiro (UFRRJ), Seropédica, Brazil

Fabiola Lana Iozzi Visiting Scholar at School of Public Health, University of São Paulo, São Paulo, Brazil

Iwona Kiniorska Jan Kochanowski University, Kielce, Poland

Deepak Kumar Swami Sardanand College, Delhi, India

Suresh Kumar Department of African Studies, University of Delhi, Delhi, India

Kabita Lepcha Department of Geography, University of Gour Banga, Malda, West Bengal, India

António Lopes Centre of Geographical Studies, Institute of Geography and Spatial Planning (IGOT), Universidade de Lisboa, Lisbon, Portugal

Brij Maharaj University of KwaZulu-Natal, Durban, South Africa

Francisco Mendonça Laboratory of Climatology (LABOCLIMA), Federal University of Paraná (UFPR), Curitiba, Brazil

Mukunda Mishra Dr. Meghnad Saha College, Itahar, Uttar Dinajpur, West Bengal, India

Maíra Oneda Dal Pai Department of Geography, Federal University of Paraná, Curitiba, Paraná, Brazil

Monalisa Patra Institute of Development Studies, Kolkata, India

Rajesh Sarda Department of Geography, University of Gour Banga, Malda, West Bengal, India

Bhupendra Bahadur Singh Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Pune, India

Dharmaveer Singh Symbiosis Institute of Geoinformatics, Symbiosis International (Deemed University), Pune, India

Manmeet Singh Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Pune, India

R. B. Singh Department of Geography, Delhi School of Economics, University of Delhi, New Delhi, India

Gabriel Ibrahin Tovar Universidad de Buenos Aires (UBA), Facultad de Farmacia y Bioquímica, Departamento de Química Analítica y Fisicoquímica, Buenos Aires, Argentina

Gustavo Westmann Head of the Trade and Investment Office, Embassy of Brazil to India, New Delhi, India

Abbreviations

ACSA	Airports Company of South Africa
ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APP	Permanent Preservation Areas
ARIO	Adaptive Regional Input–Output Model
BNDES	National Bank for Economic and Social Development
BSZ	Basic Settlement Zone
CAA	Constitutional Amendment Acts
CBD	Central Business District
CCCR-IITM	Centre for Climate Change Research at Indian Institute of Tropical Meteorology
CEP	Paranaguá Estuarine Complex
CGE	Computable General Equilibrium Models
COCTA	Organization Treaty Cooperation Amazon
COMPERJ	Petrochemical Complex of Rio de Janeiro
CORDEX	Coordinated Regional Climate Downscaling Experiment
CSZ	Controlled Settlement Zone
DAY	Deen Dayal Antyodaya Yojana
DHDR	District Human Development Report
ECLAC	Economic Commission for Latin America
ENSO	El-Nino and Southern Oscillation
ETI	Indigenous Territory Entities
EU	European Union
EWS	Economically Weaker Sections
FENAP	Federation of the Achuar Nationality of Peru
FUND	Climatic Framework for Uncertainty, Negotiation, and Distribution
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GTA	Gorkhaland Territorial Administration

GVA	Gross Value Added
HDI	Human Development Indexes
HLPCA	House Level Primary Census Abstract
IAM	Integrated Assessment Models
IBI	Index-based built-up Index
INDH	National Initiative for Human Development
IO	Input–Output models
IPCC	Intergovernmental Panel on Climate Change
ISM	Indian Summer Monsoon
ITCZ	Intertropical Convergence Zone
KSIA	King Shaka International Airport
LC	Livelihood Concentration
LQ	Location Quotient
LST	Land Surface Temperature
LULC	Landuse and Land Cover
LZM	Livelihood Zone Map
MARJ	Metropolitan Area of Rio de Janeiro
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MHI	Metropolitan Heat Island
MMRF	Monash Multi-Regional Forecasting model
NCR	National Capital Region
NDC	New Development Committee
NDVI	Normalized Difference Vegetation Index
NSSO	National Sample Survey Office (India)
NULM	National Urban Livelihood Mission
PCA	Principal Component Analysis
PET	Physiologically Equivalent Temperature
PM	Particulate Matter
PNGC	National Coastal Management Plan (Brazil)
PPP	Purchasing Power Parity
PRAD	Recovery Program of Degraded Areas (PRAD)
PSA	Payment for Environmental Services
PSZ	Priority Settlement Zone
QOL	Quality of Life
RAISG	Amazonian Network of Georeferenced Socio-Environmental Information
RSAI	Regional Science Association International
RSZ	Restricted Settlement Zone
SCS	Severe Cyclonic Storm
SJR	SCImago Journal Rank
SME	Small and Medium Enterprises
SMU	Seed Management Unit
SNIP	Source Normalized Impact Factor
SUDENE	Superintendency for the Development of the Northeast
SVF	Sky View Factor

UAA	Utilizable agricultural area
UCI	Urban Cool Island
UCMaps	Urban Climatic Maps
UHI	Urban Heat Island
ULB	Urban Local Body
WBDM&CD	West Bengal Disaster Management and Civil Defense Department
WCRP	World Climate Research Programme
WPAI	Women Political Awareness Index
WPEI	Women Political Empowerment Index
ZEIS	Special Zones of Social Interest

List of Figures

Regional Science, Regional Planning, and the Global South

Fig. 1 Major functions of scientific disciplines (*Source*: Compiled by the authors, following Messer-Davidow et al. 1993; Jenkins 1996; Becher and Trowler 2001; Hoskin 1992; Blackmore and Kandiko 2011; Fuller 1993; Rousseau and Rousseau 1998 and King 2004) 5
Fig. 2 Journals in the Scopus Source List 2019 having the keyword 'Regional Science' and their contributing subjects (Scopus sub-subjects) with the percentage of contribution of scholarly outputs subject-wise (*Source* Compiled by the authors from the Scopus Source List) 12
Fig. 3 Journals in the Scopus Source List 2019 having the keyword 'Planning' and their contributing subjects (Scopus sub-subjects) with percentage of contribution of scholarly outputs subject-wise (*Source* Compiled by the authors from the Scopus Source List) 14
Fig. 4 Visual representation of the invisible 'Brandt Line' to illustrate the economically developed and industrialized countries and those countries that are less economically developed (*Source*: Prepared by the authors based on the concept of Willy Brandt in the 1970s) 16

The Role of Local Resources as Factors of Regional Development

Fig. 1 Classification of local resources (*Source* author's own elaboration). 26
Fig. 2 Breakdown of local resources by type in the three voivodeships studied (%) (*Source* author's own elaboration). 28
Fig. 3 Distribution of groups of local resources (*Source* author's own elaboration). 29

Livelihood Zonation Mapping: An Unplugged Sect of Regional Science

Fig. 1 Conceptual breakthrough of 'livelihood zonation' (*Source* Developed by first author, after rigorous review) 40
Fig. 2 India: livelihood combination (Census 2011); **a** based on Weaver's method (1954), **b** based on Rafiullah's method (1956). *Source* Base map, Census of India (2011) 48
Fig. 3 India: livelihood combination (NSSO 2011), **a** based on Weaver's method (1954), **b** based on Rafiullah's method (1956). *Source* Base map, Census of India (2011) 51
Fig. 4 India: livelihood concentration (Census 2011): **a** location quotient of the cultivator, **b** agricultural labor, **c** household worker, and **d** other worker. *Source* Base map, Census of India (2011). 56
Fig. 5 India: livelihood diversification (Census 2011). *Source* Base map, Census of India (2011) 58
Fig. 6 India: GDP occupant ratio (Economic Survey 2011–2012; Census 2011). *Source* Base map, Census of India (2011). 60
Fig. 7 Position of Indian states and union territories according to *z*-score. *Source* Base map, Census of India (2011). 61
Fig. 8 India: livelihood zone map (based on computed *z*-score). *Source* Base map, Census of India (2011) 63

The Indigenous Territories and Local Sustainable Development in the Amazon Region

Fig. 1 Regionalization's limits and borders of the Amazon. *Source* drawn by the authors based on RAISG (2020) 72
Fig. 2 Phase of the evolution of the protection of the Amazon 1942–2018. *Source* drawn by the authors based on RAISG (2020). 75
Fig. 3 Evolution of protection in the Amazon. *Source* prepared by the authors based on RAISG (2020), NaturalEarth 76
Fig. 4 Evolution phases of indigenous territories recognition in the Amazon 1945–2016. *Source* prepared by the authors based on RAISG (2020), NaturalEarth 78
Fig. 5 Phases of evolution of the indigenous population in the Amazon 1945–2016. *Source* prepared by the authors based on RAISG (2020). 79
Fig. 6 Some indigenous peoples about territorial governance in the Amazon region. *Source* drawn by the authors based on RAISG (2020). 83
Fig. 7 Sustainable economy approaches. *Source* authors. 96

Fig. 8 Characteristics of the adaptation patterns of indigenous communities to the Amazonian environment. *Source* authors 100
Fig. 9 Holistic approach to the optimal use of the Amazon. *Source* authors 101

Territorial Planning and Regionalization in Brazil: Empirical Consolidation and the Role of the National Development Bank

Fig. 1 Brazilian GPD by region 118
Fig. 2 Total BNDES disbursements (1995–2018) 121
Fig. 3 BNDES disbursements by size of companies benefited (2002–2018) 121
Fig. 4 BNDES disbursements by region ($) 124
Fig. 5 BNDES disbursements by region (%) 124

Erosion and Coastal Structures in Brazilian Metropolises: The Case of Fortaleza and Its Inequalities

Fig. 1 Location map of the study area with an emphasis on the coastal neighborhoods of Fortaleza. *Source* Data base SEFIN—Fortaleza 129
Fig. 2 GERCO history in Brazil 130
Fig. 3 Mucuripe promontory, an area where the port of Mucuripe built in the late 1930s. Highlight for the presence of the Mucuripe lighthouse, built in the second half of the nineteenth century. *Source* Fortaleza Nobre 133
Fig. 4 Coastal structures on the coastline of the city of Fortaleza. **a** Groins in the Pirambu neighborhood; **b** Ripap installed in the Moura Brasil neighborhood; **c** Breakwater built in the Pirambu neighborhood; **d** Praia de Iracema Beach Nourishment; **e** Jetty in the Maceió stream, of the Mucuripe neighborhood. 138
Fig. 5 Type and concentration of coastal structures by neighborhood in the city of Fortaleza 140
Fig. 6 Situation of coastal structures on the coast of Fortaleza regarding the type and purpose of the structures. 143
Fig. 7 Area photograph of coastal structures installed on the coastline of the Barra do Ceará and the Moura Brasil neighborhoods (west of Fortaleza. Aerial image courtesy of Everton Marinho). 143
Fig. 8 Arrangement of coastal structures installed on the coast of Fortaleza, with their purposes, typology, and function 144
Fig. 9 Timeline showing the construction of the main coastal structures in the coast of Fortaleza between the years 1875 and 2019 145

Sustaining Port Activities Through Nature Conservation: The Case of Paraná Coast in Southern Brazil

Fig. 1 Environmental units of Paraná's coastline. *Source* The authors, 2020 . . . 153
Fig. 2 Location of the Paranaguá Estuarine Complex and its hydrographic units. *Source* The authors, 2020 . . . 156
Fig. 3 Port activity in the Paranaguá Estuarine Complex. *Source* The authors, 2020 . . . 157
Fig. 4 Usage and land cover of hydrographic units that drain into the CEP. *Source* Rutyna et al., in press . . . 159
Fig. 5 Estimated sediment production from hydrographic units (UHs) that drain into the Paranaguá Estuarine Complex (CEP). *Source* Rutyna et al., in press . . . 160
Fig. 6 Photographs taken in 1930 (**a**) and 2002 (**b**) evidencing of the filling of Antonina Bay with the emergence of sediment banks. Point 1: Ridge of the Faisqueira Mountain range. Point 2: Pier At Feira Mar municipal seat of Antonina. **c** Comparison of the bathymetric survey of part of the Antonina Bay between 1901 and 1979. *Source* Ademadan, 2010 and Odreski et al. (2003) . . . 162
Fig. 7 Erosive grooves at pasture areas in the basin of the Tagaçaba River. *Source* Carlos Wroblewski (2016) . . . 163
Fig. 8 Results of the extreme rainfall event of 11/03/2011. **a** Translational landslide in the mountains. **b** Floods and buryings at the alluvial plain of the Jacareí River. **c** Breaking of the bridge at the BR 277 highway, draining a part of the material to Antonina Bay. **d** Discharge of the material at Antonina Bay. *Source* a—Oscar Salazar Junior, 2011; b—Rogério Machado/SECJ, 2011; c—Orlando Kissner/Agência Estadual de Noticias, 2011; Estate News Agency, 2011 and d—Ecovia, 2011) . . . 164
Fig. 9 José Lutzenberger Agroforestry Settlement, in **a** 2002 and **b** 2020. The **c** oblique and **d** horizontal view of SAF. *Source* a and b—Google Earth Library; c and d—Otacílio Paz, 2018) . . . 166

Urban Environmental Changes in South America: A Study on Air Pollution and Urban Heat Island over Rio de Janeiro

Fig. 1 Metropolitan Area of Rio de Janeiro. *Source* CEPERJ/Government of the State of Rio de Janeiro . . . 175
Fig. 2 MARJ landscape. *Source* CEPERJ/Government of the State of Rio de Janeiro . . . 176
Fig. 3 Atmospheric flow pattern for the day 12/01/2010, at 09:00 a.m., local hour. *Source* Authors . . . 179

Fig. 4 Simulated trajectories for the day 12-01-2010, 09:00 a.m., local hour. *Source* Authors 180
Fig. 5 Areas that liberate atmospheric pollutants—soil use. *Source* Authors 183
Fig. 6 Areas that liberate atmospheric pollutants—industries. *Source* Authors 183
Fig. 7 Areas that liberate atmospheric pollutants—highways. *Source* Authors 184
Fig. 8 Areas that accumulate atmospheric pollutants—landscape. *Source* Authors 185
Fig. 9 Areas that accumulate atmospheric pollutants—air basins. *Source* Authors 185
Fig. 10 Areas that liberate and accumulate atmospheric pollutants. *Source* Authors 186
Fig. 11 LST map by MARJ (1984–2019). *Source* Authors 187
Fig. 12 LST map of MARJ (2011–2015). *Source* Authors 188
Fig. 13 LST map of MARJ (2016–2019). *Source* Authors 189
Fig. 14 IBI map of MARJ (1984–2019). *Source* Authors 190
Fig. 15 IBI map of MARJ (2011–2015). *Source* Authors 191
Fig. 16 IBI map of MARJ (2016–2019). *Source* Authors 191
Fig. 17 NDVI map of MARJ (1984–2019). *Source* Authors 192
Fig. 18 NDVI map of MARJ (2011–2015). *Source* Authors 193
Fig. 19 NDVI map of MARJ (2016–2019). *Source* Authors 194

Assessment of Climatic Guidelines and Urban Planning in North-Eastern Coast of Brazil

Fig. 1 Geographic location of Aracaju in Brazil. *Source* By the authors, 2020 201
Fig. 2 Methodology for UCMap elaboration in Aracaju. *Source* Adapted from Anjos (2017) 202
Fig. 3 **a** Green spaces and **b** SFV maps of Aracaju. *Source* Adapted from Anjos (2017) 203
Fig. 4 SFV and green spaces resulting in the map of urban morphology for Aracaju. *Source* By the authors, 2020 204
Fig. 5 **a** Aerodynamic surface roughness and **b** ventilation paths maps of Aracaju. *Source* Adapted from Anjos (2017) 205
Fig. 6 Aerodynamic surface roughness and ventilation paths resulting in the map of ventilation classes for Aracaju. *Source* By the authors, 2020 206
Fig. 7 PET map of Aracaju. *Source* Adapted from Anjos (2017) 207
Fig. 8 UCMap and climatopes of Aracaju. *Source* By the authors, 2020 208
Fig. 9 Public seating exposed to multiple daytime radiative fluxes in a district of Aracaju. *Source* Anjos (2017) 210

Fig. 10 Basic settlement zone and UCMap in Aracaju. *Source* By the authors, 2020 213
Fig. 11 Priority settlement zone and UCMap in Aracaju. *Source* By the authors, 2020 214
Fig. 12 Controlled settlement zone and UCMap in Aracaju. *Source* By the authors, 2020 215
Fig. 13 Restricted settlement zone and UCMap in Aracaju. *Source* By the authors, 2020 216

Aerotropolis and Urban and Regional Impacts: The Case of the King Shaka International Airport in Durban, South Africa

Fig. 1 Location of King Shaka International Airport in Durban. Source: Developed by authors 227

Drivers of Socioeconomic Development and Underdevelopment in Moroccan Sahara

Fig. 1 Typical Moroccan Sahara topography, snapped in 2018. *Source* Suresh Kumar 245
Fig. 2 Tan-Tan Festival, Moroccan Sahara, 2018. *Source* Suresh Kumar 246

An Overview of Climate Change Over South Asia: Observations, Projections, and Recent Advances

Fig. 1 Interannual temperature and precipitation anomalies over the land region of South Asia averaged between 5° N–40° N and 60° E–100° E (climatology used for the full period 1950–2019) 266

Environmental Vulnerability and Women Trafficking: Exploring the Bengal Sundarban Deltaic Region of India . . . .

Fig. 1 Sundarban deltaic region—the study area 281

Women Beyond the Politics of Presence in Urban Local Governance: Exemplifying Purulia in West Bengal, India

Fig. 1 Locating Purulia Municipality with special reference to wards having women representatives. *Source* Purulia Municipality, 2019 305
Fig. 2 Women Political Awareness Index Map of Purulia Municipality, 2015–20. *Source* Compiled by authors from Primary Survey, 2019 309

Fig. 3 Women Political Empowerment Index Map of Purulia Municipality, 2015–20. *Source* Compiled by authors from Primary Survey, 2019 . . . 311

Spatial Analysis of the Intra-urban Quality of Life: A Study in the Darjeeling Town in India

Fig. 1 Location map of Darjeeling town . . . 320
Fig. 2 Flowchart of the mapping methodology . . . 322
Fig. 3 **a** PC1 (amenities and good housing); **b** PC2 (transport); **c** PC3 (housing condition); **d** PC4 (gender); **e** PC5 (house ownership) and **f** quality of life in Darjeeling town . . . 330
Fig. 4 **a** *Z*-Score for Global Moran's *I* and **b** hotspots for QOL (Getis-OrdGi*) . . . 333

Three Decades of Urban Dynamics in India: Exemplifying Haora Sadar Subdivision

Fig. 1 Location map of Haora Sadar subdivision, Haora district, West Bengal. *Source* Authors . . . 343
Fig. 2 Flow chart showing the sequence of methods involved in the work. *Source* Authors . . . 344
Fig. 3 Gradual expansion of built-up area of Haora district in **a** 1990, **b** 2000, **c** 2010 and **d** 2016. *Source* Landsat Data classified by Authors . . . 346
Fig. 4 Line graph showing temporal changes in **a** patch density, **b** largest patch index and **c** Shannon's entropy. *Source* Authors . . . 348
Fig. 5 Graphs showing **a** types of houses on the basis of ownership, **b** purpose of staying and **c** kind of land conversions. *Source* Authors . . . 349
Fig. 6 Graphs showing **a** temporal change in available financial services, **b** temporal change in availability of electricity and **c** kind of land conversions. *Source* Authors . . . 352
Fig. 7 Graphs showing **a** availability of street lights on a temporal scale, **b** availability of roads on a temporal scale. *Source* Authors . . . 353
Fig. 8 Graphs showing **a** literacy rate scenario of Haora, **b** temporal change in available health facilities in Bally. *Source* Authors . . . 354

List of Tables

Regional Science, Regional Planning, and the Global South

Table 1 Journals in the scopus source list 2019 with the keyword 'Regional Science' in the journal title 10

The Role of Local Resources as Factors of Regional Development

Table 1 Assessment of local resources in terms of level of utility and uniqueness. Classes of resources: strategic (A), significant (B) or supplementary (C) 27

Table 2 Evaluation of local resources in terms of both utility and uniqueness 31

Livelihood Zonation Mapping: An Unplugged Sect of Regional Science

Table 1 Detailed methodological inputs 42

Table 2 India: deviation method—livelihood combination (*cultivators, agricultural labors, household workers, other workers*) 47

Table 3 India: maximum positive deviation method—livelihood combination (cultivators, agricultural labors, household workers, other workers) 49

Table 4 India: deviation method—livelihood combination by the source of employment (self-employed, waged or salaried, and casual labor) 50

Table 5 India: maximum positive deviation method—livelihood combination by the source of employment (self-employed, waged or salaried, and casual labor) 52

Table 6 India: State-wise concentration of livelihoods (location quotient method) 54

Table 7 India: state-wise diversification of livelihoods 57

Table 8 India: state-wise GDP occupant ratio 59
Table 9 India: scaled livelihood zones 62

The Indigenous Territories and Local Sustainable Development in the Amazon Region

Table 1 Data of total Amazonian and indigenous population in the Amazonian countries 73
Table 2 Population growth and percentage of the total and protected Amazon territory 73
Table 3 Population and areas recognized as indigenous territories in the Amazon by country 79

Erosion and Coastal Structures in Brazilian Metropolises: The Case of Fortaleza and Its Inequalities

Table 1 Coastal structures on the coast of Fortaleza 134
Table 2 Socio-spatial data of the coastal neighborhoods in Fortaleza 139
Table 3 Purpose, typology, function, and effect of coastal structures installed along the coast of Fortaleza 141

Sustaining Port Activities Through Nature Conservation: The Case of Paraná Coast in Southern Brazil

Table 1 Types of usage and land cover of hydrographic units that drain to the CEP 158
Table 2 Estimated sediment input for each bay. 161

Urban Environmental Changes in South America: A Study on Air Pollution and Urban Heat Island over Rio de Janeiro

Table 1 Parameters and percentages of influence on air quality 178

Assessment of Climatic Guidelines and Urban Planning in North-Eastern Coast of Brazil

Table 1 Details of specialized climatic guidelines that can be used in the planning process for Aracaju 212

Drivers of Socioeconomic Development and Underdevelopment in Moroccan Sahara

Table 1 Southern Sahara Region. 242

An Overview of Climate Change Over South Asia: Observations, Projections, and Recent Advances

Table 1 Observations and projections of climate change over South Asia . . . 269
Table 2 Scientific issues and applicable deep learning approaches in climate science and allied sectors. . . . 273

Environmental Vulnerability and Women Trafficking: Exploring the Bengal Sundarban Deltaic Region of India

Table 1 Decadal growth rate of population in North and South 24-Parganas districts. . . . 285
Table 2 Decadal variations of rural–urban population in North and South 24 Parganas districts . . . 286
Table 3 Number of immigrants to 24-Parganas districts from 1951 to 1991. . . . 287
Table 4 Number of beneficiaries under MGNREGA in West Bengal in financial year 2017–2018 . . . 289

Women Beyond the Politics of Presence in Urban Local Governance: Exemplifying Purulia in West Bengal, India

Table 1 Women participation in both houses across the world . . . 301
Table 2 Global scenario of women participation in National Parliaments. . . . 301
Table 3 Representation of women in Parliament of selected countries . . . 302
Table 4 Share of women representatives in upper house (senate) in selected countries . . . 303
Table 5 Women in Parliament in some selected states of India, 2019. . . . 304
Table 6 Selected indicators of Women Political Awareness and Empowerment Indices . . . 307
Table 7 Women Political Awareness Index (2015–2020), Purulia Municipality. . . . 309
Table 8 Women Political Empowerment Index (2015–20), Purulia Municipality. . . . 311
Table 9 Relationship between WPEI and social and economic factors . . . 312

Spatial Analysis of the Intra-urban Quality of Life: A Study in the Darjeeling Town in India

Table 1 Important indicators and their sources . . . 321
Table 2 Statistic of Kaiser–Meyer–Olkin measure of sampling (KMO) and the results of Bartlett's test. *Source* Computed by the authors . . . 325
Table 3 Total variance explained. *Source* Computed by the authors . . . 327

Table 4 Rotated component loadings matrix with communalities. *Source* Computed by the authors 328
Table 5 Factor scores with ranking of the wards on the basis of Composite Score Index. *Source* Computed by the authors 329
Table 6 Categorization of municipal wards on the basis of Composite Score Index. *Source* Computed by the authors. 331
Table 7 Descriptive statistics of Composite Score Index for Darjeeling town. *Source* Computed by the authors 332
Table 8 Global Moran's Index. *Source* Computed by the authors 332

Regional Science and Sustainable Regional Development

Regional Science, Regional Planning, and the Global South

Mukunda Mishra and R. B. Singh

1 Introduction

What the 'regional science' is. Is it an academic discipline in its classical sense? The definitions of 'academic discipline' itself available in the vast literature are diverse—some of them are lexical, and some others are persuasive or recursive categories in nature. As a working definition, an academic discipline is perceived as a concentration in one academic field of study or profession. The World Heritage Encyclopedia (2019) defines 'academic discipline' (i.e., academia) as:

> "[it] incorporates the types of knowledge, expertise, skills, people, projects, communities, problems, challenges, studies, inquiry, approaches, and research areas that are strongly associated with academic areas of study or areas of professional practice" (The World Heritage Encyclopedia 2019)

The long semantic prehistory of 'discipline' exists as a term indicating 'the order of knowledge for the purposes of instruction in universities.' Gibbons et al. (1994) speculate the concept of scientific discipline as 'the primary unit of internal differentiation of science is an invention of the nineteenth-century knowledge society.'

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the publisher or author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names, and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the publisher or author.

M. Mishra (✉)
Dr. Meghnad Saha College, Itahar, Uttar Dinajpur, West Bengal, India

R. B. Singh
Department of Geography, Delhi School of Economics, University of Delhi, New Delhi, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_1

However, regarding the ‘definition’ of regional science, we must agree with the fact that the definitions starting with an expression like ‘Regional Science is a field of social sciences…’ is misleading.

2 Emergence of an Academic Discipline

Science is a systematic study of the biotic and abiotic world and natural and socio-economic processes. It encompasses methods for knowledge creation in the form of testable or falsifiable theories, hypotheses, and predictions about the phenomenon of interest (Merton 1982; Merton and Sztompka 1996). A long trajectory from Ancient Greece, Rome, Byzantium, Renaissance, and the Industrial Revolution during the seventeenth century laid the development of modern science (Price 1961). The advancement of modern science results in inculcating an attitude of specialized scientific inquiries to form different branches of science, also referred to as fields, disciplines, or domains. Serenko and Bontis (2013) mention that each scholarly discipline has two fundamental objectives. The first is to advance the understanding of the phenomena, augment the body of knowledge, and record it in the form of scientific documentation. Most scholarly fields target to become a reference discipline, which provides a theoretical, conceptual, and methodological foundation for other scientific disciplines (Serenko and Bontis 2013). The second purpose is to improve the state of practice. It ensures the practical application of academic findings, which is ultimately devoted to increase the quality of life or enhance the ‘choice’ in living.

Robert E. Kohler (1982) in his popular work entitled ‘*From Medical Chemistry to Biochemistry: The Making of a Biomedical Discipline*’ elucidates the internal functions when biochemistry was emerging as a distinct field of science about a hundred years ago.

> “The initial development was possible as the discipline could attract specialists from pharmacology, physiological, organic, and pathological chemistry, experimental zoology, immunology, and hygiene who focused their attention on a theory of enzyme.” (Kohler 1982)

The initial formation of a new discipline is started with synthesizing knowledge from other established disciplines. The newly emerging disciplines are usually composed of experts from a variety of previously well-recognized disciplines. Let us view the history of science. It is marked with several great works. These path-breaking ideas mark the turning points in the development of a branch of knowledge. As Capel (1989) describes it as a typical process in which ‘the proposals for a new theoretical frame of reference or a new systematization of the known facts were preceded by an extensive historical introduction consisting in the evolution of the topic up to that moment.’ A newly emerged discipline gets matured with its functions. A discipline is involved in various functions (Fig. 1); not necessarily, all disciplines will render their involvement to all the functions with equal weight.

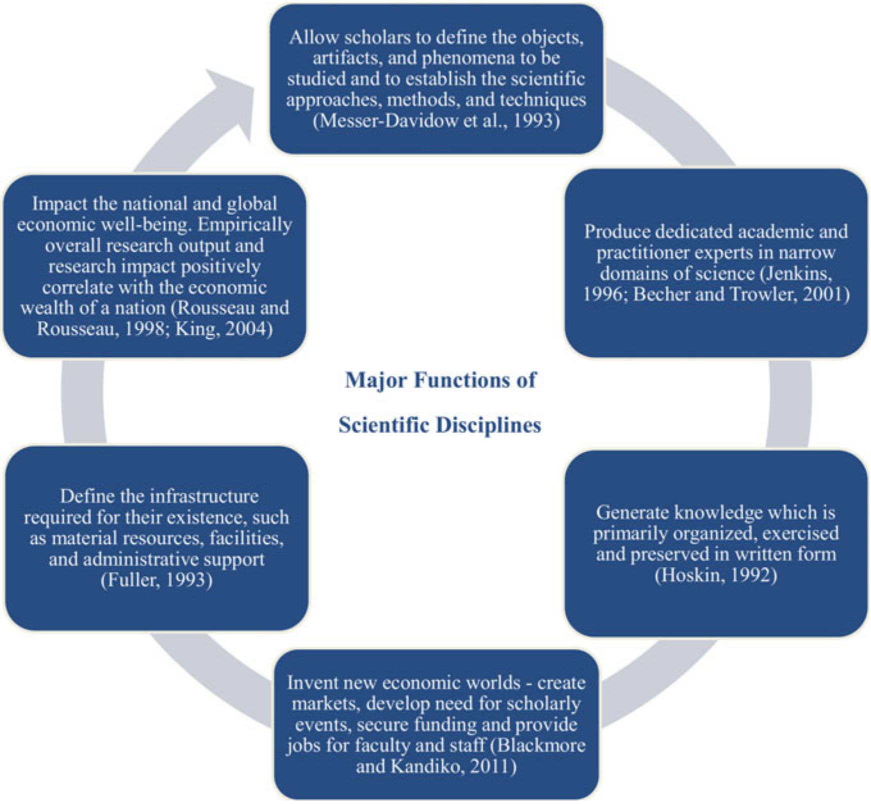


Fig. 1 Major functions of scientific disciplines (*Source*: Compiled by the authors, following Messer-Davidow et al. 1993; Jenkins 1996; Becher and Trowler 2001; Hoskin 1992; Blackmore and Kandiko 2011; Fuller 1993; Rousseau and Rousseau 1998 and King 2004)

Regional Science exclusively deals with the regions and their problems and strives for their feasible management. Unlike a discipline, Regional Science has been emerging as a cluster of disciplines, mutually interacting together to address a region with a sense of totality.

This ‘sense’ of ‘region’ has long been rooted deeply in the fundamental research practices to which the geographers are accustomed to. We prefer to quote Helen Couclelis (1992) from her chapter entitled ‘*Location, Place, Region, and Space.*’

> “The most fundamental concepts in the sciences are often expressed in ordinary language. In physics, it is mass and energy; in chemistry, the elements; demand and supply in economics; the organism in biology – and the list goes on. … Geography, too, has its basic concepts, and they also are expressed in common English words: location, place, region, space” (Couclelis 1992).

The geographical perspective of regions entails the conceptualization of two types of regions primarily—the formal and the functional region (Haggett 1965;

Claval 1998; Klapka and Tonev 2008). Formal regions are conceptualized to be nested horizontally (e.g., the climatic regions of the world), whereas the functional region is by hierarchical relationships on space with spatial flows or interactions of persons, goods, materials, energy, information, power, development, and many more (e.g., the orderly relations among the National Capital Region, State Capital Regions, District Head Quarters, and so on) (Ullman 1980; Klapka et al. 2013).

3 The Foundation of Regional Science Over the Transforming Socio-Economic Landscape

The term 'region' has a long tradition of interdisciplinary usage (Claval 1987). The disciplines of anthropology, sociology, public administration, history, economics, biology, psychology, and geography have almost common applications of the term (Contel 2015). Interestingly, all these disciplines propose their own definitions in compliance with that concept. However, geographers' conceptualization of 'region' is relevant for conceptualizing 'regional science.' The geographic perspective with the organization of the earth's surface brings forth the essence of regions and regionalization that result in the spatial division of the earth's surface into homogeneous classes. It provides a construct that helps in comprehending and presenting the complex variations in the world (Mishra and Chatterjee 2020).

The region, from a geographic standpoint, works as a tool of geographical research by serving as a statistical unit for detailed research. It is the unit used for spatial representation using visual, verbal, mathematical, digital, and cognitive approaches (National Research Council 1997). Furthermore, a 'region' is an object of geographical investigations by getting treated as the unit where a specific goal is to be achieved. For example, a 'demogeographic region' is used for planning and managing demographic processes (Kornev 1983). Nonetheless, 'region' is a fundamental unit of spatial management and planning by specifying a territory or a part of it for which a specific spatial, development, or regulatory plan deems necessary.

Let us glimpse back to the 1960s when the foundation of Regional Science when the herculean efforts of Walter Isard (1919–2010) were setting the foundation stone of Regional Science. What is Regional Science? The question could not be answered without discussing what made this Regional Science inevitable.

Careful readings of the series of Isard's speculation in the form of '*Location and Space Economy*' (Isard 1956), '*Methods of Regional Analysis: An Introduction to Regional Science*' (Isard 1960), '*Introduction to Regional Science*' (Isard 1975), and '*Methods of Interregional and Regional Analysis*' (Isard 1998) unfold the entire panorama of the Regional Science to an inquisitive scholar. All these scholarly works do inculcate in them the main objective of the Regional Science:

> "[The] main objective shall be to foster the exchange of ideas and promote studies focusing on the region and utilizing tools, methods and theoretical frameworks designed for regional analysis, as well as concepts, procedures and analytical techniques of the various social and other sciences" (Isard 1998: p. 1).

Professor Isard's 'ambition' of formulating a general theory of location and space economy emerged from his criticism over the traditional general equilibrium analysis based on perfect competition. As Fujita (1999) states, Isard appraised a general theory that should be identical to the general theory of monopolistic competition. Moreover, he argued for an evolutionary approach, anticipating that it would help embody dynamic relations in the general theory (Fujita 1999). Isard's speculation for a unified general theory addressing the entire range of spatial economic equations is noted in his own text as:

> "…the general theory of location and space-economy is conceived as embracing the total spatial array of economic activities, with attention paid to the geographic distribution of inputs and outputs and the geographical variations in prices and costs. Modern general equilibrium theory is a special case of this theory, in which transport costs are taken as zero and all inputs and outputs are viewed as perfectly mobile; international trade theory, as narrowly conceived by Ohlin, is also a special case of this theory." (Isard 1969: 53)

The general theory of location and space economy, standing on the 1960–1970s economic landscape, successfully established itself as problem-solving methods for complex planning equations. Moreover, how complex a problem could it solve? Let us hear from an early carrier civil engineer at the University of Kyoto when he was getting an offer of a 'big job' from his boss, Professor Kozo Amano, a former engineer at the Japan National Railway:

> "[He said,] As you know, a superexpress railway, Shinkansen, has just been completed between Tokyo and Osaka. The Ministry of Transportation wants to extend it all over Japan. However, the Ministry of Construction is strongly against it because they want to develop instead a turnpike system all over Japan. So, you should develop an econometric model of Japanese regional economy, and compare the economic impact of the nationwide development of Shinkansen network with that of a turnpike network." (Fujita 1999: 372)

Isard's (1960) '*Methods of Regional Analysis: An Introduction to Regional Science*' came out as the problem solver of the above complex real-life research question to build an interregional input–output model in which 'interregional trade-pattern coefficients were endogenously determined by using a gravity-type model' (Fujita 1999: 372)

In spite of having a robust theoretical foundation to address the real-life regional problems, there was some incompleteness both in the book and in the ideas of the regional sciences, which restrain it from taking the pivotal role in regional development planning. The guiding literature of the Regional Science, i.e., Isard's volume, was highly economic and prognostic in orientation (Garrison 1962). The methods of regional science could be able to project a region at some future date, provided that a changed set of parameter values and most of the parameters identified were those using economic variables. Moreover, most of the methods and techniques have evolved from economic work. Practically, there are a large number of regional problems where non-economic parameters and measures are more relevant.

The rapidly changing socio-economic scenario and the consequent modification of analytical standpoints have made a very critical transformation of the meaning of ‘development plan’ during the last five decades. The post-1950s economic literature conceptualized the optimum resource mobility across the broad economic sectors. The fundamental changes in national or regional planning objectives and policies in the developed countries and the post-imperial developing nations made this change relevant (e.g., Schultz 1953; Clark 1957; Chenery Hollis 1960; Johnston and Mellor 1961; Uzawa 1963; Baumol William 1967; Fuchs 1968; Lucas and Edward 1974; Johnston and Peter 1975; Lilien 1982; Abraham and Larry 1986; Syrquin 1988; Timmer 1988; Rogerson 1991). It remains the cornerstone of the modern concept of ‘development.’ Gore (2000) speculates this practice as the ‘vision of the liberation of people and peoples based on structural transformation.’ However, the economic liberalization in the 1970s and its immediate consequences made it inevitable for the concept of ‘development’ to get revised. Inclusion of social parameters within the practice of addressing the complex real-world phenomena was the need of the time. Consequently, the goal of structural transformation was replaced with the goal of spatial integration (Sumner and Tribe 2008).

Dudley Seers (1969), the then director of the Institute of Development Studies at the University of Sussex, in his seminal work entitled ‘The Meaning of Development,’ described the ‘new meaning’ of development beyond the ‘GDP per capita’ rather into the ‘basic needs.’ A countercurrent in the measurement of development emerged gradually, which resulted in replacing the ‘economic’ measures from the centrality with the multi-dimensional and multi-sectoral measurement involving economic, social, political, and cultural changes aimed at improving people’s life (Sumner 2007; Deneulin and Shahani 2009; Alkire 2010). This re-definition of development during the 1970s set forth a ‘quasi-economic’ notion of development plans that started providing space for the other spatial and social science disciplines to contribute to the development planning literature.

4 Regional Science and Regional Planning

Regional planners become key personnel to the thoughtful development of cohesive regions that both serve the needs of the communities within them and keep in mind the environmental impact of large groups of people living together. They try to understand with their academically learned skills how a region is growing and what needs to be done to ensure that growth happens in a logical and reasonable way. They seek to determine the best way for a community or group of communities to grow for the benefit of all involved.

The ‘growth-based’ understanding of development planning was premised on the idea that other things being equal, the growth of the economy would produce and free resources that could benefit the whole of society, either by market-driven ‘trickle down’ effects or by state-driven social policy. This traditional planning approach of development considered economic growth as a proxy for development.

The regional planners exhibit the 'development plans' having far broader societal aspects than that of it interpreted through 'economic mode.' However, during this shift of tacitly economic to liberal societal treatment for the development of a region, the Regional Science fails to lead.

An established set of journals, recognition of scholarly output, and an impact on other disciplines are often regarded as the indicators of a discipline's academic maturity (Baskerville and Myers 2002). The best approach to exploring the intellectual core and impact of a discipline is to analyze citation patterns using a set of major journal articles in the field under investigation (Katerattanakul et al. 2006; Taneja et al. 2009). The Scopus Source List-2019[1] is used for this purpose.

Table 1 shows the list of nine journals fetched from the Scopus Source List having the keyword 'Regional Science' in their titles. The scholarly articles in these journals are served primarily by the contributors from nine different subjects (Scopus Sub-subjects) with 'Geography, Planning, and Development' taking the lead contribution, followed by 'Economics and Econometrics' (16.54%) (Fig. 2).

In contrast, when the data is filtered from the Scopus Source List-2019 with the keyword 'Planning' in the journal title, it fetched 60 journals with a diverse range of subjects contributing the scholarly contents (Fig. 3). The subject (Scopus sub-subject) 'Geography, Planning, and Development' is the leading contributor (23%), followed by 'Management, Monitoring, Policy, and Law' (11.4%). The content of the 'Planning' journals is contributed by various disciplines other than economics and econometrics.

The letter, written by Isaac Newton in 1675 to his fellow scientist Robert Hooke, mentions the most famous statement—'standing on the shoulders of giants.' Robert Merton (1968) examined this metaphor's origin in his work entitled '*On the Shoulders of Giants.*'

> "What Descartes did was a good step. You have added much several ways, and especially in taking the colours of thin plates into philosophical consideration. If I have seen a little further it is by standing on the shoulders of Giants." (Merton 1968)

The twelfth-century theologian and author John of Salisbury's phrase in a treatise on logic called *Metalogicon* described that the knowledge and understanding gained by those who have gone before us provides the foundation for our own progress. Similarly, a new discipline (i.e., a receiving discipline) is usually built on other disciplines' (which are termed as reference disciplines) prior works. Usually, the receiving disciplines take the opportunity to improve the theories and methods invented in other domains and further disseminate this enhanced knowledge. Moreover, by borrowing knowledge from other areas, the receiving disciplines gain the potentiality to attract scholars from other fields and create opportunities for interdisciplinary collaboration.

However, for the last five decades, 'Regional Science,' being an emerging discipline, fails to capture the journal space compared to the emerging idea of

[1] See the Scopus Journal List at www.scopus.com.

Table 1 Journals in the scopus source list 2019 with the keyword 'Regional Science' in the journal title

Title	Scopus Sub-subject area	Citation count	Scholarly output	Percent cited	Cite score	SNIP	SJR	Percentile	Rank	Rank out of
Regional science and urban economics	Economics and econometrics	1026	305	73.4	3.4	1.707	1.235	79	128	637
	Urban studies	1026	305	73.4	3.4	1.707	1.235	84	31	200
Journal of regional science	Environmental science (miscellaneous)	555	160	69.4	3.5	1.597	0.999	73	22	82
	Development	555	160	69.4	3.5	1.597	0.999	84	37	239
Papers in regional science	Geography, planning and development	921	286	68.2	3.2	1.585	0.91	80	131	679
	Environmental science (miscellaneous)	921	286	68.2	3.2	1.585	0.91	70	25	82
International regional science review	General environmental science	335	80	90	4.2	1.469	0.867	80	42	210
	General social sciences	335	80	90	4.2	1.469	0.867	92	18	249
Regional studies, regional science	Geography, planning and development	300	144	59.7	2.1	1.294	0.546	65	237	679
	Economics and econometrics	300	144	59.7	2.1	1.294	0.546	62	240	637
	Sociology and political science	300	144	59.7	2.1	1.294	0.546	75	303	1243
Annals of regional science	General social sciences	511	201	62.2	2.5	1.27	0.75	84	39	249
	General environmental science	511	201	62.2	2.5	1.27	0.75	62	79	210

(continued)

Table 1 (continued)

Title	Scopus Sub-subject area	Citation count	Scholarly output	Percent cited	Cite score	SNIP	SJR	Percentile	Rank	Rank out of
Regional science policy and practice	Management, monitoring, policy and law	94	100	48	0.9	0.836	0.352	28	237	333
	Geography, planning and development	94	100	48	0.9	0.836	0.352	41	398	679
	Development	94	100	48	0.9	0.836	0.352	40	143	239
Regional science inquiry	Development	78	133	37.6	0.6	0.381	0.207	28	172	239
	Geography, planning and development	78	133	37.6	0.6	0.381	0.207	27	489	679
	Economics and econometrics	78	133	37.6	0.6	0.381	0.207	20	506	637
	Sociology and political science	78	133	37.6	0.6	0.381	0.207	39	751	1243
Studies in regional science	General social sciences	17	95	9.5	0.2	0.012	0.102	16	209	249
	General environmental science	17	95	9.5	0.2	0.012	0.102	11	187	210

Source Scopus Source List 2019

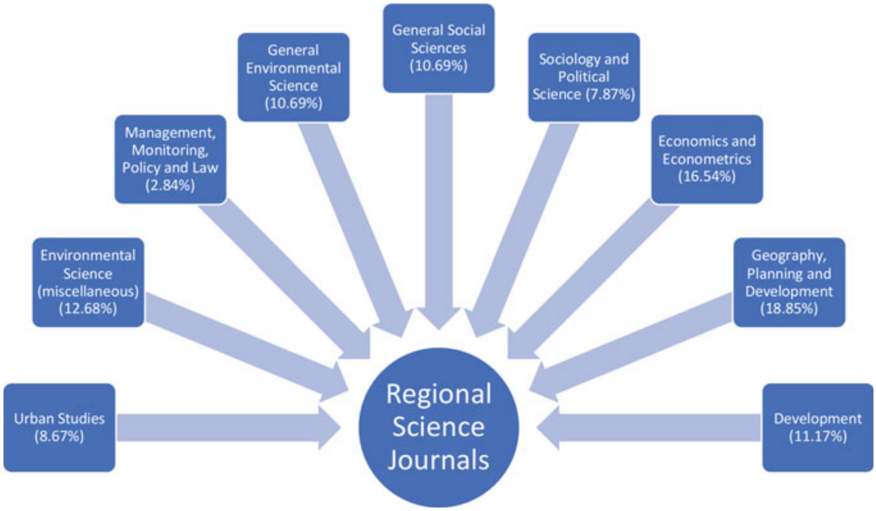


Fig. 2 Journals in the Scopus Source List 2019 having the keyword 'Regional Science' and their contributing subjects (Scopus sub-subjects) with the percentage of contribution of scholarly outputs subject-wise (*Source* Compiled by the authors from the Scopus Source List)

'Planning.' The 'Planning' journals have been successful in attracting most of the regional planners to serve as a platform for disseminating their scholarly outputs where the 'Science of the Region' remains very selective.

5 Reinstallation of Regional Science at the Centre of Regional Development Planning

The first decade of the new millennium was eventful. It seems a favorable juncture in reinstalling the Regional Science at the center of development planning. The 2008s Global Economic Crisis was a severe alert to the policy researchers and policymakers. Paul Krugman (2008), who was awarded the Nobel Memorial Prize in Economic Sciences for the contributions to New Trade Theory and New Economic Geography, speculated that the regional crises were often more important than the national crisis. The scholarly world witnessed that some regions were becoming poorer than their national economies (Bailly and Gibson 2017). Lagging regions need to see their economic base renewed if they are to stay competitive, and this requires that all actors—natural, economic, social, political, and education—work together proactively. The practitioners of Regional Science are well accustomed to the same.

For instance, climate change issues have stormed the laboratories of almost all fields of knowledge—may it be natural science, biological science, mathematical science, or social science. There are basically three genres of economic models dealing with the issues of the impact of climate change on the economy and development:

- Input–output models (IO) like the adaptive regional input–output model (ARIO), which was firstly used for the comprehensive assessment of indirect damage by Hurricane katrina in Louisiana of US (Hallegatte 2008) and then also used in the evaluation of flood risk under climate change in Copenhagen (Hallegatte et al. 2011), in Mumbai (Ranger et al. 2011) and in London (Crawford-Brown et al. 2013);
- Computable general equilibrium models (CGE) like the Monash multi-regional forecasting (MMRF) model, which is a multi-regional and multi-sectoral dynamic model applied to study the effects of climate change on the Australian economy (Garnaut 2008) and the customized version as spatial regional CGE model (Jahn 2014) to model the regional spatial, economic, and welfare impacts of climate change from extreme weather events as well as the urban CGE model (Hirte et al. 2014) to model the regular city flooding due to change in land quality via climate change;
- Integrated assessment models (IAM) considers the mutual influences and feedback between the earth system and the socio-economic parameters to address the policy issues. For instance, the model named Climatic Framework for Uncertainty, Negotiation, and Distribution (FUND), which is a widely used IAM, developed initially by Tol (1997), is a policy optimization model with the objective function that is a welfare function depending on population and GDP and damages due to climate change for each region.

However, the complex interaction between climate change and socio-economic development can hardly be explored without taking a deep insight into the matter of how the regional version of ‘deflected’ climatic parameters is excerpting impacts on regional society or economy to shape the human development of that region. Practically, it is not possible to be any global policy framework that will be equally effective for each and every region to mitigate climate change and its impact on local society or economy.

The last year of the second decade of the millennium has been witnessing the pandemic outbreak of the novel COVID-19, spreading violently in almost all parts of the globe. Loss of human lives is the primary threat of a pandemic. Beyond a severe health hazard, it has long-term social, economic, and behavioral implications that humankind will be facing during the decade to come. Like the global phenomena of the climate change, the COVID-19 pandemic also carry its impact differently on the different regions depending upon its economic strength, health and medical systems’ tenability, government policies and probably the most powerful will be the health behavior of the residing population of the region. All these things have been emerging as the newer research dimensions under the purview of Regional Science.

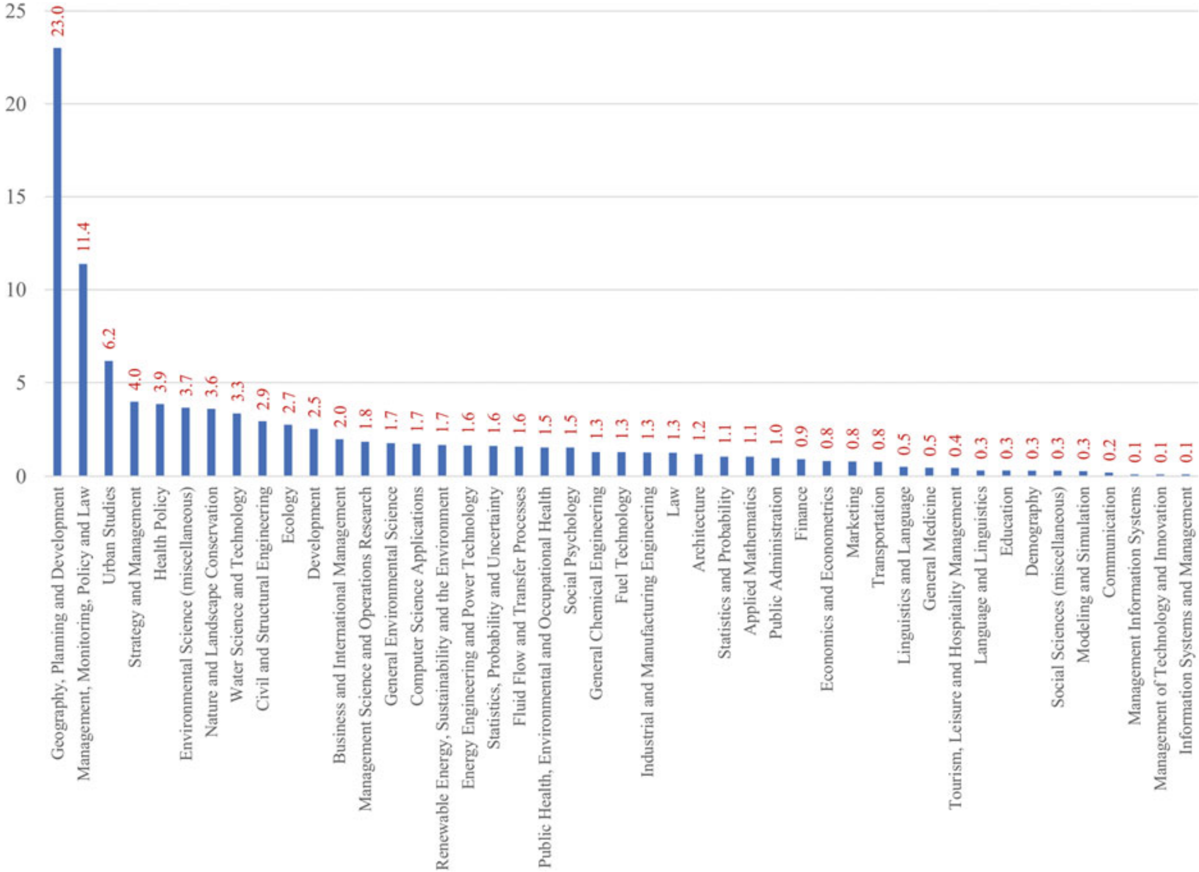


Fig. 3 Journals in the Scopus Source List 2019 having the keyword 'Planning' and their contributing subjects (Scopus sub-subjects) with percentage of contribution of scholarly outputs subject-wise (*Source* Compiled by the authors from the Scopus Source List)

Alongside the needs, the principle methodological changes incorporated in Regional Science have a significant concern (Mishra and Chatterjee 2020). Multi-criteria-based predictive models are gradually making places in socio-economic sciences. The statistical models, user perception-based models, and the modern machine learning algorithms—all these can be effectively used in Regional Science to predict the different socio-economic phenomena. These modern techniques should be used in the spatial investigation of regional issues to empower the researchers to predict socio-economic phenomena precisely. The geographic information systems (GIS) and the even broader area of geoinformatics have been around for decades. However, they have taken on new significance as technology has been upgraded to manage and display increasingly large data sets. The applications of big data to regional science seem infinite (Bailly and Gibson 2017).

6 Global South: Regional Scientists' Vision

The phrase 'Global South' is the modern replacement of the terms like 'Third World' or 'Periphery,' which denote regions outside Europe and North America, i.e., refers broadly to the regions of Asia, Latin America, Africa, and Oceania. We are all concerned with the 1970s 'Brandt Line,' which was 'a visualization created to illustrate international inequalities and the socio-economic gulf that separates regions of the world (Fig. 4). Snaking across continents to divide the world into the richer North and the poorer Global South, the Brandt Line has for four decades been one of the most recognizable and influential ways of visualizing world politics' (Less 2020). However, with the march of time, it is realized that this view has been too simplistic to represent the actual socio-economic inequalities.

A very significant development is gained globally, which has enabled many millions of people to come out of absolute poverty. However, there is substantial evidence that inequality between the world's richest and poorest countries is widening. In 1820, Western Europe's per capita income was three times bigger than Africa's, but by 2000, it was thirteen times as big (Royal Geographical Society 2021). In addition, in 2013, Oxfam reported that the richest 85 people in the world owned the same amount of wealth as the poorest half of the world's population (OXFAM 2013).

One of the most appropriate measures for comparing levels of economic development is gross domestic product (GDP) per capita at purchasing power parity (PPP). It measures the goods and services produced per person within an economy, adjusting the differences in the cost of living across the countries. Professor Nicholas Less (2020) of the University of Liverpool has brought very detailed observations regarding the economic inequality situation between the North and South. Some key observations are:

Fig. 4 Visual representation of the invisible 'Brandt Line' to illustrate the economically developed and industrialized countries and those countries that are less economically developed (*Source*: Prepared by the authors based on the concept of Willy Brandt in the 1970s)

- Data indicate that per capita real incomes have increased on average for states of both the North and the South (with China included). However, the absolute difference between North and South grew from 12,714 to 30,903 PPP US dollars between 1980 and 2016.
- The G77[2] states grew by an average of 66% over 36 years, whereas the OECD[3] states grew by 114%, so when considering states as equal units, the South fell behind instead of catching up.

By 2016, the state at the 75th percentile in the South had only achieved the level of income of the state at the 25th percentile for the North in 1972. So, even the state richer than three-quarters of the rest of the South in 2016 had not yet reached the income level the majority of Northern states enjoyed in 1980.

There are many causes for these inequalities. The *capitalist expansion school* opines that underdevelopment is not a product of internal factors of Third World

[2]The Group of 77 (G77) at the United Nations is a coalition of 134 developing countries, designed to promote its members' collective economic interests and create an enhanced joint negotiating capacity in the United Nations. There were 77 founding members of the organization headquartered in Geneva, but it has since expanded to 134 member countries according to the organization. Current list of member states is available at http://www.g77.org/doc/members.html.

[3]The Organization for Economic Co-operation and Development (OECD) is an international economic organization of 34 countries, founded in 30 September 1961 to stimulate economic progress and world trade. List of member states is available here: https://www.oecd.org/about/document/list-oecd-member-countries.htm.

societies, but rather the direct consequence of processes of capitalist expansion, and of the integration of these societies within the capitalist world system. Walter Rodney (1972), in his famous book '*How Europe Underdeveloped Africa*' speculates that the creation of the Third World was not simply about colonial conquest and incorporating these territories into European colonial empires. Instead, it had also to do with their active 'underdevelopment' by the colonial metropole through the extraction of raw natural resources and labor for the exclusive benefit of the metropole, and with devastating consequences for local economies, polities, and societies (Sajed 2020).

In contrast, the *internalist school* points out a range of internal factors as the cause of backwardness. The availability of natural resources, different levels of health and education, country's internal economy and its industrial sectors, international trading policies and access to markets, how a country is governed, conflict within and between countries, and country's vulnerability to natural hazards and climate change—all these determine the 'growth quotient' of a country or a region.

In a broader sense, the term 'Global South' does not signify a spatial limit like that used to be referred to before as Third World. Instead, it incorporates the spaces in the 'North' also that are characterized by exploitation, oppression, and neocolonial relations. Also, vice versa, some spaces that used to be part of the Third World now inhabit an ambiguous political and economic space because of rapid processes of modernization and integration into the global economy (for instance, Hong Kong, Singapore, Taiwan, South Korea, i.e., the so-called Asian tigers). Again, the countries in the Gulf Cooperation Council (e.g., Saudi Arabia, UAE, Qatar, Kuwait, Oman, and Bahrain) are geographically positioned in the 'South,' though economically occupy spaces in the 'North' countries in Southeast Europe and the Balkans, where some of them have been politically integrated into the European Union; however, they strongly comply with the Global South in terms of their economic structures and socio-cultural characteristics.

Obviously, the use of the phrase 'Global South' (in comparison with the 'third world') marks a shift from a central focus on development or cultural difference toward an emphasis on geopolitical relations of power (Dados and Connell 2012). The post-colonial global south has been witnessing a rapid transformation in its society, economy, culture, and policies. The emergence of the Global South countries is clear from their rising participation in global governance in recent decades. The developing countries have become increasingly active participants in global policy-making (Kaul 2013). However, the intense inquisitiveness about these countries by the practitioners of the Regional Science grounds on an entirely different viewpoint. The most common things about the Global South nations are that they are mostly (not all) low-income and often politically or culturally marginalized. Besides, there is clear evidence of the uneven spatial distribution of resources, economic activities, literacy, and health condition. The most striking fact is the coexistence of development and underdevelopment that makes the planning process complicated. However, the spatial clusters of the development and underdevelopment are more 'regional' than 'administrative' in nature below the national level. Regional Science has popularly been regarded as a science of synthesis at the crossroads of various scientific disciplines. On one hand, it is located among the earth or natural sciences, whereas on the other hand, it is contributed by various social science disciplines. This dynamic orientation of the discipline has made it sensitive to the conjunctural issues where the synthesis of knowledge from different disciplines is inevitably essential for addressing the interaction of phenomena on any segment of the earth's surface. This expertise of the regional scientists makes them fit for coming at the forefront of the spatial analysis and sustainable management of complex regional problems, particularly for the 'rapidly transforming' Global South.

7 Conclusion

An academic discipline is identified by its journals, and technically, regional science began in 1955 with the publication of the first volume of the 'Papers and Proceedings' by the Regional Science Association. The journal is now renamed as the 'Papers in Regional Science.' In 1958, the 'Journal of Regional Science' was published for the first time. The number began to increase since the 1970s. The International Regional Science Association (RSAI)—British and Irish section with the Regional Studies Association has been publishing the journal of 'Spatial Economic Analysis' since 2006.

Interestingly, the Regional Studies Association has been emerging as an organization involving economists, planners, geographers, political scientists, management academics, policymakers, and practitioners. It is clear that the necessity of the pluralistic research practices under the banner of 'Regional Science' is felt, and the action is taken. The learned society, concerned with analyzing regions and regional issues, has set out to form an international network comprising academicians, students, practitioners, and policymakers. Disciplines are subject to change, and their boundaries are shifted and modified when knowledge from one discipline overlaps with another. The regional scientists need to play a crucial role in installing the discipline of 'Regional Science' at the center of the scholarly investigation of regions and framing plans for sustainable regional development.

References

Abraham K, Larry K (1986) Cyclical unemployment: sectoral shifts or cyclical unemployment? J Polit Econ 94:507–522

Alkire S (2010) Human development: definitions, critiques, and related concepts. Background paper for Human Development Report 2010. Retrieved from http://hdr.undp.org/en/reports/global/hdr2010/papers

Bailly AS, Gibson LJ (2017) Emerging trends in regional science. Asia-Pac J Reg Sci 1:53–61. https://doi.org/10.1007/s41685-017-0028-2

Baskerville RL, Myers M (2002) Information systems as a reference discipline. MIS Q 26(1):1–14

Baumol William J (1967) Macroeconomics of unbalanced growth: the Anatomy of the Urban Crisis. Am Econ Rev 57:415–426

Becher T, Trowler P (2001) Academic tribes and territories: intellectual enquiry and the cultures of discipline. Open University Press, Philadelphia, PA

Blackmore P, Kandiko CB (2011) Motivation in academic life: a prestige economy. Res Post-Compuls Educ 16(4):399–411

Capel H (1989) The history of science and the history of the scientific disciplines: goals and branching of a research program in the history of Geography, Geo Critica (Universidad de Barcelona) XIV(84). ISSN 0210-0754. http://www.ub.edu/geocrit/geo84.htm

Chenery Hollis B (1960) Patterns of industrial growth. Am Econ Rev 50:624–653

Clark C (1957) The conditions of economic progress, 3rd edn. Macmillan, London

Claval P (1987) The region as a geographical, economic and cultural concept. Int Soc Sci J 39(2): 159–172

Claval P (1998) Introduction to regional geography. Blackwell, Oxford

Contel FB (2015) Concepts of region and regionalization: aspects of its evolution and possible uses to health regionalization. Saúde e Sociedade 24(2):447–460. https://doi.org/10.1590/S0104-12902015000200005

Couclelis H (1992) Location, place, region, and space. In: Ronald FA, Melvin GM, Judy MO (eds) Geography's inner worlds: pervasive themes in contemporary American geography. Rutgers University Press, New Brunswick, New Jersey

Crawford-Brown D, Syddall M, Guan D, Hall J, Li J, Jenkins K, Beaven R (2013) Vulnerability of London's economy to climate change: sensitivity to production loss. J Environ Prot 4(6): 548–563

Dados N, Connell R (2012) The global south. Contexts 11(1):12–13. https://doi.org/10.1177/1536504212436479

Deneulin S, Shahani L (eds) (2009) An introduction to the human development and capability approach: freedom and agency. Human Development and Capability Association, London

Fuchs V (1968) The service economy. Columbia University Press, New York

Fujita M (1999) Location and space-economy at half a century: revisiting professor Isard's dream on the general theory. Ann Reg Sci 1999(33):371–381

Fuller S (1993) Disciplinary boundaries and the rhetoric of the social sciences. In: Messer-Davidow E, Shumway DR, Sylvan DJ (eds) Knowledges: historical and critical studies in disciplinarity. The University Press of Virginia, Charlottesville, VA, pp 125–149

Garnaut R (2008) Climate change impacts on Australia. The Garnaut review (chapter 6). Cambridge University Press, Cambridge

Garrison WL (1962) Methods of regional analysis: an introduction to regional science by Walter Isard. In: Bramhall DF, Carrothers GAP, Cumberland JH, Moses LN, Price DO, Schooler EW (eds) Economic geography, vol 38, issue 1, pp 88–90

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P, Trow M (1994) The new production of knowledge: the dynamics of science and research in contemporary societies. SAGE, London

Gore C (2000) The rise and fall of the Washington consensus as a paradigm for developing countries. World Dev 28(5):789–804

Haggett P (1965) Locational analysis in human geography. Edward Arnold, London

Hallegatte S (2008) An adaptive regional input-output model and its application to the assessment of the economic cost of Katrina. Risk Anal 28(3):779–799

Hallegatte S, Ranger N, Mestre O, Dumas P, Corfee-Morlot J, Herweijer C, Wood RM (2011) Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen. Clim Change 104(1):113–137

Hirte G, Nitzsche E, Tscharaktschiew S (2014) Optimal climate change adaptation in cities (Working paper). Retrieved from http://www.webmeets.com/files/papers/wcere/2014/810/Optimal%20Adaptation%20in%20Cities_A%20CGE%20analysis%20of%20economic%20and%20spatial%20effects.pdf

Hoskin K (1992) Control, organization, and accounting: a genealogy of modern knowledge-power. Syst Pract 5(4):425–439
Isard W (1956) Location and space economy. MIT Press, Cambridge MA
Isard W (1960) Methods of regional analysis: an introduction to regional science. MIT Press, Cambridge MA
Isard W (1969) General theory: social, political, economic, and regional. MIT Press, Cambridge, MA
Isard W (1975) Introduction to regional science. Prentice-Hall, Englewood Cliffs NJ
Isard W (1998) Methods of interregional and regional analysis. Ashgate, Aldershot
Jahn M (2014) A computable general equilibrium model for regional climate change impact analysis. HWWI Research Papers 154. Hamburg Institute of International Economics (HWWI)
Jenkins A (1996) Discipline-based educational development. Int J Acad Dev 1(1):50–62
Johnston B, Mellor J (1961) The role of agriculture in economic development. Am Econ Rev 51(4):566–593
Johnston BF, Peter K (1975) Agriculture and structural transformation: economic strategies in late-developing countries. Oxford University Press
Katerattanakul P, Han B, Rea A (2006) Is information systems a reference discipline? Commun ACM 49(5):114–118
Kaul I (2013) The rise of the global south: implications for the provisioning of global public goods, human development report office (Occasional Paper 2013/08). UNDP, New York
King DA (2004) The scientific impact of nations: what different countries get for their research spending. Nature 430(6997):311–316
Klapka P, Halás M, Tonev P (2013) Functional regions: concept and types. Mezinárodní kolokvium o regionálních vědách 19(XVI):94–101
Klapka P, Tonev P (2008) Regiony a regionalizace. In: Toušek V, Kunc J, Vystoupil J (eds) Ekonomická a sociální ge-ografie. Vydavatelství a nakladatelství Aleš Čeněk, Plzeň, pp 371–397
Kohler RE (1982) From medical chemistry to biochemistry: the making of a biomedical discipline. Cambridge University Press, Cambridge, MA
Kornev IN (1983) The demogeographic region as an object for planning and management. Sov Geogr 24(5):361–368
Krugman P (2008) The return of depression economics and the crisis. Times Columns, New York
Less N (2020) The Brandt Line after forty years: The more North-South relations change, the more they stay the same? Rev Int Stud 47(1):85–106. https://doi.org/10.1017/S026021052000039X
Lilien D (1982) Sectoral shifts and cyclical unemployment. J Polit Econ 90:777–793
Lucas R, Edward P (1974) Equilibrium search and unemployment. J Econ Theory 7:188–209
Merton RK (1968) The Mathew effect in science. Science 159(3810):56–63
Merton RK (1982) Social research and the practicing professions. Abt Books, Cambridge, MA
Merton RK, Sztompka P (1996) On social structure and science. University of Chicago Press, Chicago, IL
Messer-Davidow E, Shumway DR, Sylvan DJ (eds) (1993) Knowledges: historical and critical studies in disciplinarity. The University Press of Virginia, Charlottesville, VA
Mishra M, Chatterjee S (2020) Contouring human development: methods and applications using an Indian district as case study. Springer, Singapore. https://doi.org/10.1007/978-981-15-4083-7
National Research Council (1997) Rediscovering geography: new relevance for science and society. The National Academies Press, Washington, DC. https://doi.org/10.17226/4913
OXFAM (2013) Annual report 2013. URL: https://www.oxfamamerica.org/explore/research-publications/annual-report-2013/. Accessed on 26 Jan 2021
Price DJDS (1961) Science since Babylon. Yale University Press, New Haven, CT
Ranger N, Hallegatte Stéphane, Bhattacharya Sumana, Bachu Murthy, Satya Priya K, Dhore Farhat Rafique (2011) An assessment of the potential impact of climate change on flood risk in Mumbai. Clim Change 104(1):139–167
Rodney W (1972) How Europe underdeveloped Africa. Bogle-L'Ouverture Publications, London
Rogerson R (1991) Sectoral shifts and cyclical fluctuations. Revista de Analisis Economico 6:37–46

Rousseau S, Rousseau R (1998) The scientific wealth of European nations: taking effectiveness into account. Scientometrics 42(1):75–87

Royal Geographical Society (2021) A 60 seconds guide to the Global North/South divide. URL: https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=9c1ce781-9117-4741-af0a-a6a8b75f32b4&lang=en-GB. Accessed 26 Jan 2021

Sajed A (2020) From the third world to the global south. E-International Relations. https://www.e-ir.info/2020/07/27/from-the-third-world-to-the-global-south/

Schultz TW (1953) The economic organization of agriculture. McGraw-Hill, New York

Seers D (1969) The meaning of development. Int Dev Rev 11(4):2–6

Serenko A, Bontis N (2013) The intellectual core and impact of the knowledge management academic discipline. J Knowl Manag 17(1). https://doi.org/10.1108/13673271311300840

Sumner A (2007) Meaning versus measurement: why do economic indicators of poverty still predominate? Dev Pract 17(1):4–13

Sumner A, Tribe MA (2008) International development studies: theories and methods in research and practice. Sage, London, pp 1–12

Syrquin M (1988) Patterns of structural change. In: Hollis C, Srinivasan TN (eds) Handbook of development economics (volume 1). North Holland, Amsterdam and New York, pp 203–273

Taneja A, Singh A, Raja MK (2009) Computing journals and their emerging roles in knowledge exchange. Commun ACM 52(11):125–131

Timmer PC (1988) The agricultural transformation. Handbook of development economics, vol 1. North Holland, Amsterdam and New York, pp 275–331

Tol RS (1997) On the optimal control of carbon dioxide emissions: An application of FUND. Environ Model Assess 2(3):151–163

Ullman EL (1980) Geography as spatial interaction. University of Washington Press, Seattle and London

Uzawa H (1963) On a two-sector model of economic growth II. Rev Econ Stud 30:105–118

World Heritage Encyclopedia (2019) URL: http://worldheritage.org/article/WHEBN0014924067/Discipline%20(academia). Accessed on 16 Dec 2019

Mukunda Mishra is Assistant Professor and the designated Vice Principal of Dr. Meghnad Saha College in West Bengal, India. He completed his postgraduate studies in Geography and Environmental Management at Vidyasagar University with securing the top rank in both the B.Sc. and M.Sc. panels of merit. He was awarded a Ph.D. in Geography from the same university. He was selected for the prestigious National Merit Scholarship by the Ministry of Human Resource Development, Government of India. His research chiefly focuses on analyzing unequal human development and on creating multi-criteria predictive models.

R. B. Singh is Former Professor of Geography at the Delhi School of Economics, University of Delhi; the Secretary-General and Treasurer of the International Geographical Union (IGU); the Chair of Council for Scientific and Industrial Research (CSIR)–Central Food Technological Research Institute of the Government of India, and Member of the International Council for Science (ICSU) and the Scientific Committee of Urban Health and Well-Being. He was awarded the prestigious Japan Society for the Promotion of Scientific Research Fellowship and has presented papers and chaired sessions in more than 40 countries. He has published 15 books, 40 edited research volumes, and more than 215 research papers.

The Role of Local Resources as Factors of Regional Development

Jerzy Bański and Iwona Kiniorska

1 Introduction

Regional development is in large measure conditioned by the quality and quantity of internal resources present in a given region, as well as the degree to which those resources are the focus of social or economic utilization. It is for this reason that today's development policy in EU member states attaches more and more weight to internal potential in the form of defined resources. A new paradigm for territorial development policy is thus taking shape, with this taking greater account than hitherto of local specifics, and this is taken to mean, not only economic and social factors, but also valuable cultural and natural features. The assumption then is that activation of internal potential has a favourable effect on the conditions inhabitants live under, also allowing more effective use to be made of funds designated for development. It is to these kinds of assumption that the theoretical concepts of territorial capital (Camagni 2008), endogenous capacity (Scott and Storper 2003) and local conditioning and local networking (Fujita et al. 1999) are addressed.

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the publisher or author concerning the legal status of any country, area or territory or of its authorities or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the publisher or author.

J. Bański (✉)
Institute of Geography and Spatial Organization, Polish Academy of Sciences,
Warsaw, Poland
e-mail: jbanski@twarda.pan.pl

I. Kiniorska
Jan Kochanowski University, Kielce, Poland

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_2

According to Romer (1990), a factor of fundamental importance in the development of a region is the activation of its internal potential, as determined by the resources it possesses at the outset. A high level of own potential has a positive influence on the way favourable living conditions for inhabitants take shape, and awareness of this should translate into major objectives for regional development. In the view of Porter (1990), this goal can be achieved through the effective use of endogenous resources. Equally, the utilization of external factors is considered to depend greatly upon the activity of the local system itself. In the "system" or "configuration" of this kind, an important role is played by the participation of representatives of the local community, and this involves both the formulation and introduction of mechanisms by which development can be achieved and innovation ensured (Jouen 2008; Garofoli 1992). In these circumstances, we refer to local development as a complex process whereby local authorities use their own resources—and involve external partners—to stimulate the economic development of the particular unit of territory (Blakely 1989).

Internal resources form an element in the implementation of the concept of neo-endogenous development. In this case, it is assumed that there will be a search for—and use made of—all possible internal potential with a view to the greatest possible absorption of external factors taking place, so that an area's own resources may, in turn, be multiplied and magnified (Ray 1997). Regions or smaller units of territorial administration should activate their own potential so that socioeconomic development can be shaped and proper use made of endogenous support instruments. The stimulation of development from outside is important, at times even essential, but without a strong local base, even major resources injected in support of development may end up being wasted.

Bearing in mind the resources that shape the internal potential in a given area, it is possible to distinguish between two key categories: (1) universal resources that can be generated in any other area or many other areas; and (2) local or specific resources that underpin the unique character of a given territorial unit. The latter category, which this study focuses on, offers a foundation upon which an area's competitiveness can be built, in line with the way in which valuable features representative of that area are difficult to either replicate or substitute for. Furthermore, the most specific resources may not be separated from their place of occurrence, being deeply rooted in the local space and community.

Local resources play a particular role in weakly developed regions and peripheral areas. In these areas, appropriate activation can assure these resources of a status as major agents of development (Pike et al. 2006). This in turn denotes a need for a more individualized approach to be taken to regions, so that fully effective use can be made of their internal resources. In other words, alternative strategies of development are required, depending on whether the conceptualization is a regional or local one (Pike et al. 2007). This is also confirmed in numerous studies in which the authors seek out internal development potential in areas which currently are only weakly developed (Bahl et al. 1984; Bryden and Hart 2004; Wong 1998).

The results of work carried out in three regions of eastern Poland (the provincial regions—Voivodeships—of Podlaskie, Lubelskie and Podkarpackie) that can be regarded as peripheral, and are in fact among the most weakly developed regions in Poland. In addition, those regions are characterized as the area of unfavourable population transformations, including excessive migration outflow and deformation of demographic structure (Banski and Flaga 2013). The main aim of the work has been to achieve fuller insight into local resources in the above areas, as well as an assessment of the potential for development which they offer.

2 The Concept of Local Resources and Research Methods

There is no universal or even widely accepted definition of local resources. Rather, much has depended on authors' needs and research interests, with diverse categories being created to characterize given areas. Nevertheless, most researchers believe that local resources can be an important factor underpinning development, with proper utilization likely to strengthen social and economic development in its territorial aspects, as local markets, entrepreneurship, infrastructure and inhabitants all experience a stimulatory effect (Dale 2002; Konsolas 1990; Sweeney 1995; Schucksmith 2010). As this argument makes clear, considerable attention is paid to the role of a local community as a factor determining the proper use of all the potential inherent in a given area (Dale 2002; Conroy 1998; Knack and Keefer 1997).

For the purposes of this chapter, local resources will be understood as unique or near-unique and, at the same time, socially and economically useful features, factors and phenomena in a defined area and actually or potentially shaping its internal potential for development. In other words, these are elements of the internal potential of a given area, creating opportunities for new development impulses to be generated.

It is possible to propose a three-level division of resources into categories, groups and types (see Fig. 1). To put things at the most general level, local resources can be material in nature (i.e. be raw materials, products, valuable natural features, etc.) or non-material (in the form of relationship skills and capacities, linkages, culture, etc.). In the first category, we are dealing with natural resources generated irrespective of human beings, as well as anthropogenic ones that arise as a consequence of the human activity. The second category of resources is also divided into two groups, i.e. social resources associated with specific features of inhabitants and cultural resources arising out of local customs and traditions, specific ethnic, religious and cultural features as the historical past. Also, the need to be taken account of is the general way in which the use of local resources is shaped by very complicated sets of features or phenomena, to the extent that they may be assigned to more than one type.

The logic of the research procedure required three main stages. The first of these entailed the identification of resources using different source materials. The Internet, of course, proved an especially important source of information, with the use of keywords plus names of regions and names of localities capable of giving rise to

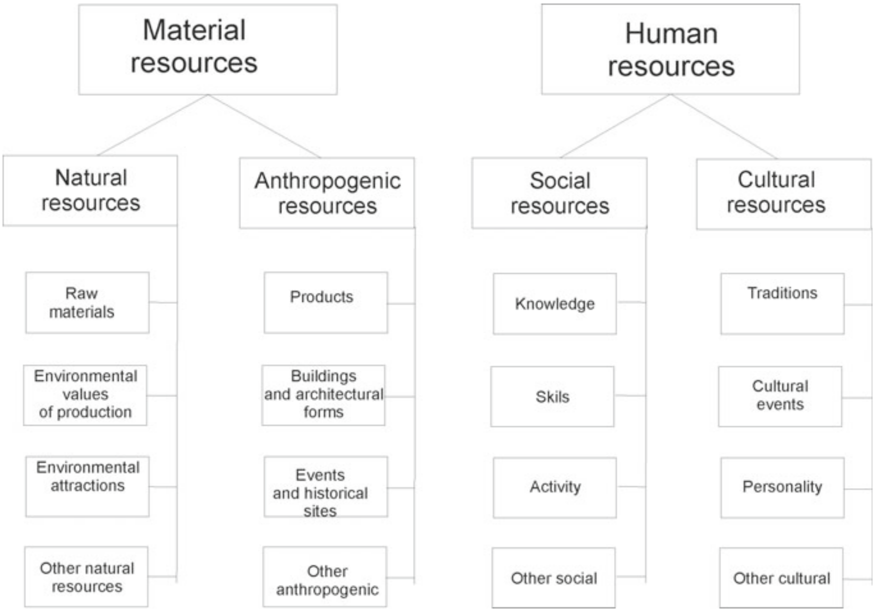


Fig. 1 Classification of local resources (*Source* author's own elaboration)

extensive resources of data. In contrast, it was a literature that most often served to enhanced knowledge of a resource. In the case of resources that the further research process was able to recognize as very important for a region's development, these also became the subject of extra field-based research.

A second stage of the work saw all the resources recognized subjected to assessment from the point of view of their uniqueness and utility in terms of five independent experts who are specialists in regional development. At this point, the notions of uniqueness and utility need explaining, given the need for cohesive interpretation of them by all the participating experts. Thus, uniqueness was taken to denote a phenomenon, i.e. resource, either not occurring at all in other places, or at most present only very rarely elsewhere. Most especially, it was things capable of being considered one of a kind ("one-offs") that were being looked for. Utility in turn relates to the possibility of a resource being put to use in the shaping of local development. The utility of each studied resource assessed by experts received either a low, average or high evaluation. A low assessment implies a limited potential for development, while a high one denotes a potential for market success. In the case of uniqueness, the principle was the same—it could be at the local, regional or national level. The most valuable resources are obviously those that are unique at the national level, i.e. have no counterpart (comparable object) in other regions of the country. As a result, it proved possible to distinguish between three classes of resources (Table 1) Strategic (A), Significant (B) or Supplementary (C).

Table 1 Assessment of local resources in terms of level of utility and uniqueness. Classes of resources: strategic (A), significant (B) or supplementary (C)

Utility	Uniqueness		
	Local level	Regional level	National level
Low	C	C	B
Average	C	B	A
High	B	A	A

Source author's own elaboration

The third stage of the work was analytical in nature, entailing a reconnaissance of the spatial distribution and structure of resources, as well as analysis of the experts' assessments. Statistical and cartographic methods were applied in this case, though the process began with all of the resources identified being assigned to categories, groups and types.

3 Results

The result of the first stage was gathered information on 220 local resources, including 63 in Podkarpackie Voivodeship, 68 in Lubelskie and 89 in Podlaskie. Among the local resources identified, there is a decided prevalence of examples of the material resources category, with a leading role played by architectural forms and buildings (93 resources or some 42% of all valuable features identified), as well as valuable natural features shaping attractiveness from the point of view of tourism (51 resources—23%). Best represented within the category of non-material resources are customs and traditions (64 resources—29%). The remaining types of resources are less well-represented. As configured regionally, the breakdown by different types of resources is similar, with certain spatial differences observable.

In line with the above remark, the resources identified are capable of being assigned to more than one type, group or even category. They are thus of a mixed nature. A total of 107 resources are representative of one type, while 83 represent two, 25—three, 4—four and 1 as many as 5. The most uniform in nature is the group of natural resources (Fig. 2). Among the 71 examples of such resources, only 18 could simultaneously be assigned to other types. These are mainly valuable natural features that help make an area attractive to tourists while at the same time serving as places associated with history or characterized by the presence of architectural heritage. In the case of 155 valuable features of the anthropogenic group, there were 66 displaying the aforementioned kind of feature. Analogously, among 45 social resources, there are 33 that are of a mixed character, while among 97 cultural resources, a similar situation applies to 69.

From the point of view of geographical location, most of the resources are of a "point" nature, which is to say their precise location in a defined place can be referred to. There are far fewer resources which exist on a linear from (e.g. the *GreenVelo* cycle trail, the Podlaskie White Stork Trail, etc.), or covering larger areas (as with Lake Wigry National Park, the "Biebrza Valley" Area of Protected

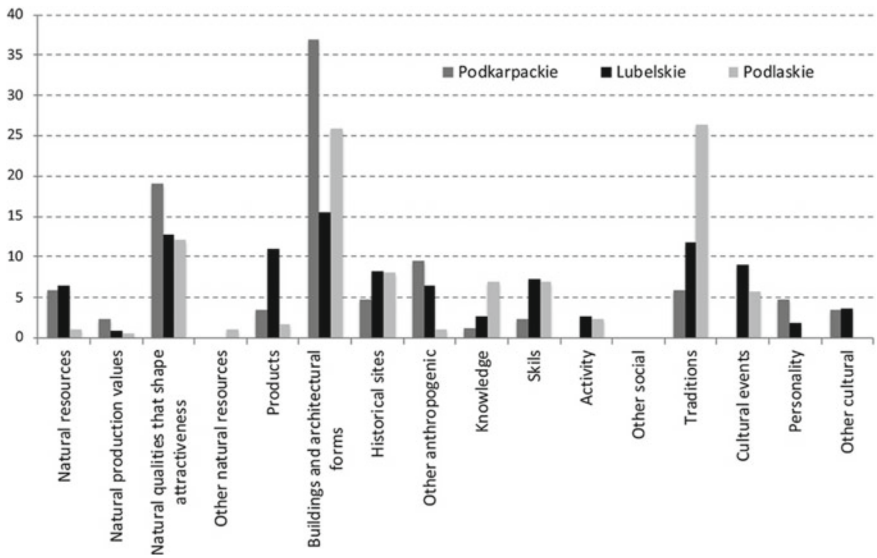
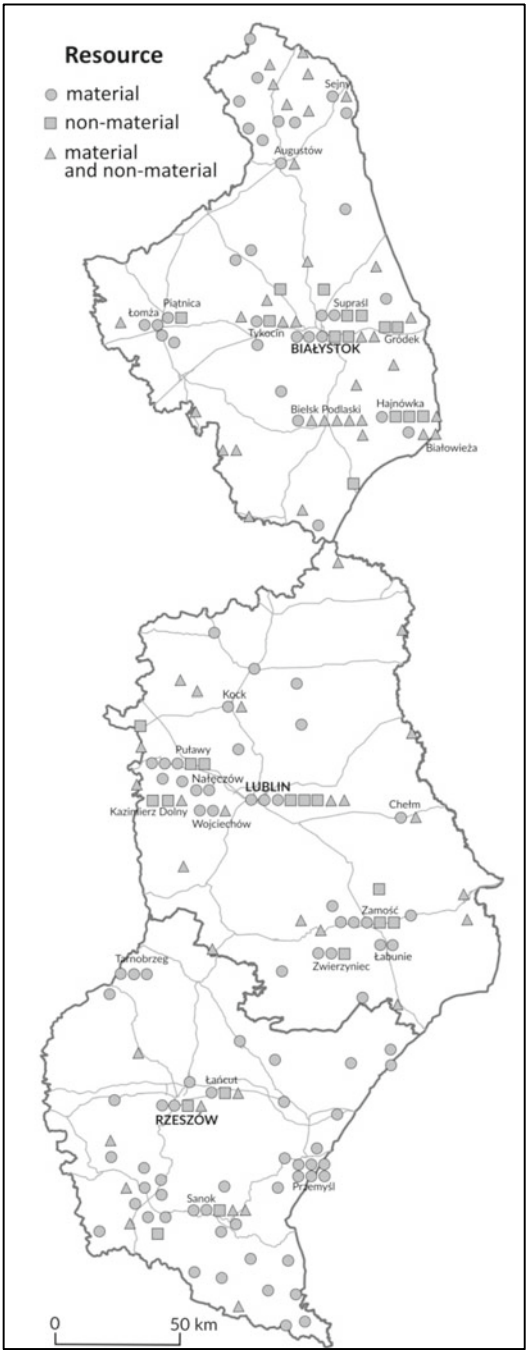


Fig. 2 Breakdown of local resources by type in the three voivodeships studied (%) (*Source* author's own elaboration)

Landscape, etc.). In terms of spatial configuration, the local resources can be said to be moderately dispersed, albeit with distinct concentrations in a couple of areas (Fig. 3). These are areas already much visited by tourists on account of both their natural and their historic-cultural attributes. There are also concentrations of resources around the regions' capitals, i.e. Białystok, Lublin and Rzeszów, in areas in their immediate vicinity, and in and around other larger localities. The large number of valuable features identified in these cases reflects the sizes of the urban areas, the functional role these centres play in their regions and their rich historical pasts.

In terms of their level of utility, the resources were not be evaluated very highly by the experts. Most typically, evaluations are average or low, and this is seen to be true in all three regions studied. Among the assets assessed, most favourably are in fact well-known across Poland already and hence constitute resources already subject to "exploitation". These are:

- Lake Solińskie (a dam reservoir along the River San surrounded by an attractive hilly landscape, with considerable utilization in tourism);
- Kazimierz Dolny (a historic town located in a naturally attractive area that also plays host to various festivals as well as more spontaneous get-togethers of artists);
- the academic potential of Lublin (as the capital of its province region, with its many higher education institutions creating significant academic potential and achieving the highest indicator values for numbers of students per inhabitant);



The resources covering larger areas or not associated with a clearly-defined locality

Voivodeship: Podkarpackie
Local resources: Molotov Line, Food products, Petroleum, Craft Trials

Voivodeship: Lubelskie
Local resources: Cake "Lublin onion", "Green Velo", Agricultural potential, Shale gas deposit, Swamp turtle, Limestones

Voivodeship: Podlaskie
Local resources: Protected Landscape Area "Biebrza Valley", Protected Landscape Area "Narwia Valley", Protected Landscape Area "Rospuda Valley", Protected Landscape Area "Suwalski Lake District", Protected Landscape Area "Sejny Lake District", Podlasie Stork Trial, The Wood and Sacrum Trial, Tatar Trial, "Green Velo"

Fig. 3 Distribution of groups of local resources (*Source* author's own elaboration)

- the stud farm in Janów Podlaski (famous for the breeding of pureblood Arab horses, with annual auctions at which some fetch prices exceeding a million euros);
- the mineral waters in the Nałęczów area (with the healing properties of the waters themselves and the unique microclimate ensuring the presence of popular spas and health resorts);
- Zamość Old Town (a pearl of Renaissance architectural heritage (Polish and Italian) already well-visited as a magnet destination for both organized tours and individual tourism).

Białowieża National Park (one of the last natural forests on the European Lowland, a refuge for the European bison and many other unique animal and plant species).

The assessment of the level of uniqueness of resources appears much more favourable. While resources receiving average evaluations again prevail, uniqueness at the national level (the highest rating) was found to be characteristic of 10–20 resources in each region. These are almost twice the figures obtained with the utility assessment. Furthermore, only a small number of resources were assessed as of low value. Among all, the resources valued most highly by all the experts were:

- the stud farm in Janów Podlaski (*see above*);
- the Old Town in Zamość (*see above*);
- Białowieża National Park (*see above*);
- Biebrza National Park (a valuable natural area of marsh and fen with numerous unique wetland bird species, including ruffs *Philomachus pugnax*);
- Magurski National Park (a refuge for forest fauna typical for the lower montane forest zone and the Carpathian foreland);
- the “Grabarka” hill (the most important site of religious cult importance for followers of the Russian Orthodox faith);
- *Szkoła Orląt* in Dęblin (training pilots and aviation engineers);
- The Parish Church of the Assumption in Haczów (Europe’s tallest wooden church in the Gothic style).

Crosstable analysis in relation to levels of utility and uniqueness points to the existence of 40 strategic resources (class A—shown as the dark grey field in Table 2). Among these are 16 that obtained the highest average assessments for the features studied. The collection of significant resources (class B) in turn runs to 107 items, while the supplementary resources (class C) are 73 in number. We can see that resources evaluated highly from the point of view of their utility also received high scores for their uniqueness. Only 3 out of 19 such resources (Nałęczów’s mineral waters, the academic potential of Lublin and the chalk quarries in the Chełm area) were assessed as unique at the regional level, while all the remainder were considered to achieve uniqueness on the scale of the country as a whole. In contrast, in the cases of 39 resources assessed most favourably from the unique point of view, as many as 21 are regarded as of average utility only, while 2

Table 2 Evaluation of local resources in terms of both utility and uniqueness

Utility	Uniqueness		
	Local level	Regional level	National level
Low	26	41	2
Average	6	105	21
High	0	3	16

Source author's own elaboration

(the museum of unusual bicycles and the Young Violinists' Competition held in Lublin are even regarded as low utility.

The highest utility level characterizes the naturally valuable features that help make a place or object attractive to tourists. Among these, there are eight resources assessed most favourably by the experts. Resources of other types were only assigned lower assessment values. Among these, there are only a relatively small group of resources of high value from the point of view of development. In numerical terms, the clearly prevalent resources are those with average assessment values. The same is in fact, true in the case of the uniqueness assessment carried out for the resources. Among these, it is mostly uniqueness on the regional level that is achieved. Nevertheless, it is worth stressing how there are a greater number of resources receiving highest-level assessments from experts. These are included among five types of resource, i.e. valuable natural features helping shape attractiveness from the point of view of tourism, architectural forms and buildings, historical places, customs and traditions and cultural events.

4 Discussion

Analysis of the local resources present in eastern Poland reveals how resources in the material category prevail over their non-material counterparts. In other words, this is an area whose local and regional development may be more shaped by natural potential and what people achieved in the past than by valuable contemporary features of a social or cultural nature. This is probably the result of this area's characteristics and notably its visibly low current level of socioeconomic development (Bański and Janicki 2013; Jóźwik and Sagan 2014). In regions of eastern Poland, it is possible to point to a whole range of negative social, demographic and economic phenomena that have ensured the emergence of extensive problem areas (Bański and Flaga 2013). This also explains why the social potential in the form of knowledge and skills, activeness of inhabitants and of local leaders and cultural events is relatively limited and less important than the valuable material resources.

In eastern Poland, a particularly unfavourable kind of conditioning preventing full use of internal resources for development relates to the low levels of both entrepreneurship and social activeness on the part of inhabitants. A 2012 study carried out by the author in rural areas revealed that the three voivodeships under analysis here are characterized by Poland's lowest values for numbers of businesses per 1000 inhabitants of productive age. Equally unfavourable features characterize this area's figures for activeness in society, with this again reflecting the relatively low level of education among inhabitants, as well as a considerable migratory outflow, in particular, involving society's youngest and most active adults.

The above conclusions gain support in extended interviews run with cultural animators and representatives of the administration at regional levels within the voivodeships studied. In general, they pointed to the same resources which were identified in the course of this study. This meant a prevalence of material values, with only relatively few resources of a social or cultural nature being mentioned. Respondents drew attention to the high value of regional resources, which have broader connotations assigned to them than the study had made clear. Among these, there were aspects like the multi-cultural nature of regions, its clean natural environment and the wealth of flora and fauna, the hospitality of inhabitants, the polycentric settlement structure, opportunities for trade with the East and so on. While these features are indeed of great importance in the context of socioeconomic development, they do not represent concrete resources but are rather reflections of the general character of the area studied.

A second key conclusion arises out of the assessments of the utility and uniqueness of the resources identified. In the opinions of the experts, the regions studied have far more resources of value thanks to their uniqueness than they do from the point of view of their potential to shape social and economic development. Almost all the resources regarded as being of high utility are at the same time, either unique or rare. Hence, the conclusion that high development potential relates first and foremost to unique resources. Equally, the mere fact that a resource is not found elsewhere offers no guarantee that its level of utility in the context of local development will be high.

It is thus worth considering what features, other than uniqueness, local resources should have in order that conditions for a given area's development can prove favourable. Obviously, much depends on the category resources belong to. Thus, in the case of raw materials, they must be present in quantities allowing them to achieve economic significance. In contrast, where valuable features determining attractiveness to tourists are concerned, uniqueness has to combine with aesthetic features of the surroundings, transport access, the degree to which the areas in question are supplied with tourist and other infrastructure and even the economic potential of those availing themselves of the services on offer. Indeed, a still more diverse set of features will be required in the case of social and cultural resources. While it is true that resources of this category offer only limited development potential in eastern Poland, it is very much upon them (and upon attendant knowledge, activeness, skill and personality) that the mobilization of the potential of material resources there can be seen to depend.

The greater part of the resources assigned high values for uniqueness (as opposed to those of major practical benefit) is such as to indicate that the regions under study in eastern Poland are characterized by the presence of unused internal potential. It is probable that some of the resources identified are basically still in a "dormant" state. However, their individual potential is anyway generally low. Furthermore, they are located far from larger concentrations of population and are typically of limited accessibility in terms of transport. It is thus hard to expect them to do much to build development potential, given their isolation. In this context, the best solution would seem to be an effort to interlink resources only, achieving lower values for utility, with this also forming a basis for new local products that draw on the value of several resources to be developed. This requires a full understanding of the links actually or potentially present between local resources, as well as the devising of entirely new local products. Concepts for such new products that draw on potential resources should be clear as to their objective and type of recipient and intended results. Naturally, the activity of this kind should also be coordinated by regional authorities.

In 2014, a specifically commissioned pilot project was implemented by the Marshal's Office of Lubelskie Voivodeship for the development of strategies for several products that would make use of the region's local resources. One such product was named the "active weekend—come to the theme village", with the aim here being to make use of five such resources, i.e. the Tartar Village of Studzianka, the Masłomęckie Association of the Village of the Goths, the village of Malinowa Wieś, the profession of the blacksmith and forge in the village of Wojciechów and folk medicine. This product may be based on associations that bring together people actively pursuing the goal of revitalizing disappearing skills (such as sieve-making and blacksmithing), as well as on the various theme villages that have made their appearance. This product seeks to inspire investors to broaden the range of the said theme villages located in this area. Indeed, the development of these is actively proposed, while local communities are encouraged to propagate the traditions and skills hanging on from the old days.

Another example is resources which might be linked is the so-called silver economy. The Lublin region has four resources (the production of herbs, the mineral waters of Nałęczów, thermal waters and the academic potential of Lublin itself), and on the basis of these, it has been possible to advocate for a new product that would be linked with healthcare and cosmetic services for elderly people. This product makes use of the local potential associated with the herb-growing that takes place in several local villages, with the spa and health resort that is in Nałęczów (with its specific microclimate and waters and many treatments, renewal and spa centres already in place), as well as the research potential inherent in the academic staff of the Medical University of Lublin. In turn, the types of resources best represented in eastern Poland (i.e. valuable natural features making the area attractive, combined with architecture, traditions, and customs) of course show linkage with tourist functions. This all makes it possible for many new tourist products to be devised and developed. Analysis of resources by type of structure also shows that half of these are of mixed character—a feature that in fact needs to be viewed as very favourable, given that these kinds of resources may prove attractive to various different groups of recipients. And, this makes it easier to create new local or regional products on their basis.

It needs to be emphasized that regions of eastern Poland are located peripherally in many senses, with limited transport access and a relatively minor potential to provide services. For these reasons also, new products using local resources need to focus in on areas where obstacles and problems are least marked. These areas are above all the larger urban centres and areas in their vicinity or else areas located along the main transport routes. In Poland, there are many examples of economic success being built upon different types of local resources. These include the aforementioned theme villages which draw on valuable natural features, local traditions, history, specific agricultural products and so on. However, this first requires commitment on the part of local people, the breaking of stereotypes, a willingness to leave the house and a process of self-discovery vis-à-vis capacities and skills. In fact, shortfalls in all of these areas represent a significant break in development in eastern regions of Poland.

5 Closing Remarks

The activation of a region's internal valuable features represents one aspect conditioning socioeconomic development, which exerts a favourable influence on the lives of inhabitants and facilitates the effective use of funds invested inwardly from outside the region. Internal valuable features also offer a basis upon which to build a given area's competitive advantage. The analysed internal resources can be considered rather only in the context of local development. However, it can be assumed that the set of several resources may become the basis for shaping new products creating competitive advantages of the region in specific sectors of activity.

In the case of Poland, which receives more than any other EU member state in structural funding, the use of regional potential is of particular significance. Conceptualizations of regional development in relation to resources usually distinguish two categories of resource, i.e. universal and local (specific). The latter can be divided into material and non-material, while within them it is possible to identify groups of resources and concrete kinds thereof.

In eastern Poland, diverse groups of local resources were identified, with these including—irrespective of the region—the great numbers of buildings and other architectural items, as well as valuable features capable of contributing to tourist attractiveness and customs and traditions. The research showed that identified resources are of average uniqueness, while they are only of utilitarian value (from the point of view of local development) to an average or limited degree. In the assessment of the experts, the greatest number of highly utilitarian resources is associated with the same valuable features as shape attractiveness from the tourism point of view.

Almost, all the resources for which the index of utilitarian value is high are at the same time characterized by high values for uniqueness. However, there is a relatively large group of highly unique resources (e.g. customs and traditions, cultural events and items of architectural heritage) that only attain more limited utilitarian values. In this case, an activation process ought to be linked with the shaping of new regional products, constructed simultaneously on the basis of several complementary local resources. It is in this way that effective use can still be made of resources rated as of more limited utility.

It can be accepted that the number of resources identified is determined by the level of detail of research carried out and the scale of the frame of reference. This study took in three regions—a circumstance that most likely excluded a series of poorly known resources impacting upon small settlement units or even individual households. Interesting results might also arise from studies of local resources in small territorial units (a single *gmina* or a set of several). These should find their place in newly developed strategies and plans for the development of the units in question. For, through the use of local resources, it is possible to implement the development of small territorial units in the most favourable directions.

Acknowledgements Publication is prepared under the research projects of the National Science Centre, nb. UMO-2015/19/B/HS4/01298, *Evaluation of the local resources and their spatial differentiation in the regions of Eastern Poland.*

References

Bahl R, Miner J, Schroder L (1984) Mobilizing local resources in developing countries. Public Adm Dev 4:215–230

Bański J, Flaga M (2013) The areas of unfavourable demographic processes in Eastern Poland—selected aspects. Barometr Regionalny 11(2):17–24

Bański J, Janicki W (2013) The influence of the EU's eastern frontier on the socioeconomic situation of border areas, as exemplified by Lublin province (Poland). Eur Urban Reg Stud 20 (3):299–313

Blakely EJ (1989) Planning local economic development. Theory and practice. Sage, London-New York

Bryden J, Hart K (eds) (2004). A new approach in rural development in Europe. Edwin Mellon Press

Camagni R (2008) Regional competitiveness: towards a concept of territorial capital. Modelling regional scenarios for the enlarged Europe. Springer, Berlin-Heidelberg, pp 33–47

Conroy P (1998) Partnership in action, the role of community development in Ireland. The Community Workers Coop

Dale P (2002) Community involvement in local strategic partnership. Urban Forum, CDF

Fujita M, Krugman P, Venables A (1999) The spatial economy: cities, regions, and international trade. MIT Press, Cambridge, MA

Garofoli G (1992) Endogenous development and Southern Europe: an introduction. In: Garofoli G (ed) Endogenous development and Southern Europe. Avebury, Aldershot

Jouen M (2008) Endogenous local development versus foreign direct investment strategies: are there alternative re-gional strategies in EU 27? In: Tönshoff S, Weida A (eds) Where top-down, where bottom-up? Frankfurt am Main, Peter Lang

Jóźwik B, Sagan M (eds) (2014) Eastern Poland. Development challenges. Instytut Europy Środkowo-Wschodniej, Lublin

Knack S, Keefer P (1997) Does social capital have an economic payoff? A cross-country investigation. Quart J Econ 112:4

Konsolas N (ed) (1990) Local development: regional science studies in Southern Europe. Regional Development Institute, Athens
Pike A, Rodrigues-Pose A, Tomaney J (2006) Local and regional development. Routledge, New York, London
Pike A, Rodrigues-Pose A, Tomaney J (2007) What kind of local and regional development and for whom? Reg Stud 41(9):1253–1269 (Routledge)
Porter ME (1990) The competitive advantage of nations. The Macmillan Press LTD, London
Ray C (1997) Towards a theory of the dialectic of rural development. Sociologia Ruralis 27 (3):345–362
Romer PM (1990) Endogenous technological change. Quart J Econ 98:71–102
Schucksmith M (2010) Disintegrated rural development: neo-endogenous rural development, planning and place-shaping in diffused power contexts. Sociologia Ruralis 50(1):1–20
Scott AJ, Storper M (2003) Regions, globalization, development. Reg Stud 37:579–593
Sweeney G (ed) (1995) Regional and local development. Dublin Institute of Technology
Wong C (1998) Determining factors for local economic development: the perception of practitioners in the North West and Eastern Regions of the UK. Reg Stud 32(8):707–720

Jerzy Bański is Full Professor of Human Geography in the Institute of Geography and Spatial Organization, Polish Academy of Sciences (IGSO PAS). His main research interests include rural and agricultural geography, land use, regional policy, spatial organization and local development. From 2018, he is Director of the IGSO PAS; in the period 2006–2012, he was President of the Polish Geographical Society, and from 2017, he is the chair of the Commission of Local and Regional Development, International Geographical Union. Jerzy Bański is author of 390 publications, including 24 books and more than 190 papers with review processes. He was coordinator of 40 research projects and the member of 35 other national and international projects (e.g. FP6, FP7, Horizon, ESPON).

Iwona Kiniorska is Assistant professor in the Institute of Geography and Environmental Sciences of the Jan Kochanowski University in Kielce. She received PhD of Earth sciences in Geography. Her research interests focus on urbanized and rural areas (conditions, living standards, quality of living, social inequalities) and entrepreneurship, tourism in rural areas and local development.

Livelihood Zonation Mapping: An Unplugged Sect of Regional Science

Somenath Halder and Rajesh Sarda

1 Introduction

Out of the current roundup hazardous condition, the 'newnormal' (Carr 2020) provides extraordinary scope to redefine almost everything, either starting from human relation, country's resource potential, future of humanity, or some academic conventional notions and thoughts. In this milieu, this is a small attempt to enlighten the probable gray corner of regional science. Meanwhile, the sub-branch of regional geography or regional science has inherent contrasting nature with systematic geography (Wood 2001). In a simplified manner, regional science would confer as a multidisciplinary ground where the main focus is imposed upon human activities with spatial dimension, within the background of institutional function and structure, and the focal purpose of understanding social forms and behavior based on the mentioned dimensions (Alonso 1964; Isard 1956). Nonetheless, this *chapter* has a lesser scope for elaborative interpretation of regional science or the already developed corners and wings of science. In academia, this branch of science is called different names, e.g., 'area studies', 'regional studies', 'spatial science', and so forth. Aside from the controversies, debates, and gray corners of *regional science*, this established sub-branch (spatial science) has 'very bright prospects'.

S. Halder (✉)
Department of Geography, Kaliachak College, Malda, West Bengal, India

R. Sarda
Department of Geography, University of Gour Banga, Malda, West Bengal, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_3

The worthwhile reason is this branch of science capably addresses ‘a broader and deeper framework for the analysis and modeling of regional phenomena, and the solution of large-scale regional and interregional problems than other fields’. Side by side, there is another merit (of regional science) like interdisciplinary perspective and foundations and elasticity in disciplinary conventions (Boyce 2004). This little effort would be a gray-scanned part of regional geography where human capital, remaining undocumented even having vital potentiality toward economic growth and development of any geographical entity, and versatility of peoples’ vocations involving numerous multidisciplinary dimensions. The prime focus of this study is encompassing intellectual reach to assess the central tendency and deviation of livelihood combination of peoples in the context of locational dimension and its mapping. Meanwhile, before proceeding further, it is necessary to discuss the definition of *livelihood* and its inherent dilemma of synonymously using with the *occupation*. ‘Livelihood’ itself is a complex topic in the sense of its contextual extension and area-specific adaptations (de Stagé et al. 2002). Generously the definition of *livelihood* is known as ‘means of making a living’, while authentically, it can be defined as ‘livelihood comprises, assets (including both material and social) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks (drought, flood, war, etc.), maintain or enhance its capabilities end assets, while not undermining the natural resource base’ (Chambers and Conway 1992). Among others, a notable definition of Young et al. (2001) is ‘livelihoods are how people access and mobilize resources that enable them to pursue goals necessary for their survival and longer-term well-being, thereby reducing the vulnerability created and exacerbated by conflict.’

However, the said definitions seemed to be very broad. While according to Ellis (2000, p. 10), ‘a livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by (an) individual or household.’ Simply, in order to meet the requirement of the present study, here, the concept of ‘livelihood’ refers to any means of vocation which fulfill the peoples’ daily needs for living and survival, and the term also may capable of covering all kinds of earning sources. Thus, the line and length of this adopted terminology have the quality of flexibility rather than any academic rigidity. Within the corner of focussed action, in this volume, the term *livelihood* precisely confers the (any) means of vocation by which active workers (male, female, or transgender) fulfill their daily needs and nearly satisfy their family’s urge for survival. In other words, any kind of traditional, non-traditional, formal, informal, organized sector, unorganized sector, or any clubbed category of vocation(s) made by the authentic body (*like* Census, NSSO, Economic Bureau, etc.) are ever included and covered inside this term. Other adjacent terms, *like* ‘zonation’ and ‘mapping’, need to be clarified here. According to Merriam-Webster (n.d.) dictionary, the term ‘zonation’ simply means ‘structure or arrangement of zones which may show the distribution of any kind of natural or man-made phenomenon into the formulated region(s)’. Supplementary, the word ‘mapping’ briefly indicates ‘the act or process of map-making' (Merriam-Webster n.d.). Other than these, this chapter's enhanced scope and content is a reinterpretation of regionalizing and mapping processes of peoples' means of earning with standard categorized datasets and methods.

The remainder of the chapter has contended as follows. Section 2 discusses the conceptual outline and the generic idea behind such development. Section 3 explains the sources of the big secondary dataset, the significance of regionalization incorporated, and the design of statistical workouts to manifest nature and spatial distributional pattern of livelihood in Indian states and union territories. Section 4 shortly concerns with the limitations of the present chapter. Whereas, the beginning part of Sect. 5 put light on the reason behind the selection of a developing nation like India under the domain of 'Global South'. The proceeding part of the same (Sect. 5) interprets the results based upon four standard dimensions for livelihood zonation. Section 6 is concerned with country-level livelihood zonation and its suitable policy implications for further development of the nation. Finally, Sect. 7 concludes the entire discourse with future research suggestions.

2 Conceptual Framework

A few decades before, during the acquaintance with the chapters of agricultural geography—an extension of regional science, some scattered concepts were peeping into mind. However, after a while, those ideas went on a subconscious level of memory. Recently, after visualizing the *title* of this present edited volume, those undocumented ideas reawaken once again. The scope of this volume seems to be 'nutritious' enough to re-conceptualize and formulate the regionalization of Indian livelihoods. Meanwhile, couples of authors have attempted *this* issue in the micro-level analysis (in countries *like* Uganda, Nigeria, Sudan, and South Sudan), but their precise focus is upon 'famine early warning system network' (Grillo and Holt 2009; Browne and Glaeser 2010; Holt and Coulter 2011; Holt et al. 2018; Langford et al. 2018). Herewith lays the novelty of this present work, which is endeavored to show administrative region-wise regionalization of broadly classified or clubbed occupation(s) and their scientific zoning, based on large database and standardize methods. From Fig. 1, the conceptual frame of this chapter is easily understandable. Side by side, for comparatively detailed discussion, it can be said that the present chapter undertakes the established methods (e.g., crop combination, location quotient, crop diversification, and GDP geographical area ratio) after judiciary and appropriate modification of those equations with simplified fashion. In the case of zonation, out of any critical approach, this study follows the predetermined geophysical and administrative boundaries (neo-federal states and union territories of India) and specific time frame of the latest census year, 2011. At the same time, the next section throws light on the pursued methodology and database with more clarity.

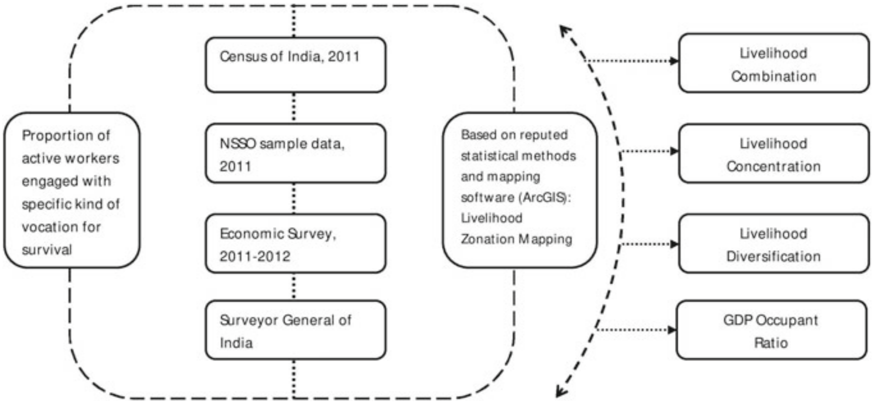


Fig. 1 Conceptual breakthrough of 'livelihood zonation' (*Source* Developed by first author, after rigorous review)

3 Materials and Methods

Whether it is a small or large geographic area, the livelihood pattern or group of clubbed vocations evidently vary from one geographic area to another. This is why the building of 'Livelihood Zone Map' (LZM) is a logical step enough not only for livelihood-based analysis but also for food security, community resilience, and for baseline policy to enhance the country's economy booster (Grillo and Holt 2009; Browne and Glaeser 2010). As per the study concern, limiting onto spatial analysis and base census year of 2011, the sources of a large dataset (secondary) are Census of India (2011), National Sample Survey Organization (68 round table: 2011–2012), and Union Budget & Economic Survey, Government of India (2011–2012). The state and union territory-wise secondary data of Indian population, economically active population and broad livelihood category (*cultivator*, *agricultural labor*, *household worker*, and *other worker*) wise workers' proportions are collected from Census (2011), while sample data of another broad livelihood category (based on employment status: *self-employed*, *waged, or salaried*, and *casual labor*) are collected from NSSO (2011). On the other hand, data on state and union territory-wise share of GDP are gathered from Union Budget and Economic Survey (2011–2012). Whereas other sources of best-supporting literature are several books' chapters, journals, and reports.

As per the nature and objective of the present piece concerns with second-hand data-oriented spatial extension and distribution of livelihood phenomenon, from the extreme north of Jammu & Kashmir to the extreme southern part of Tamil Nadu and extreme eastern part of Arunachal Pradesh to extreme of the western part of Gujarat, the methodological part seemed (unprompted) self-valued. Synonymously the present work is also encrypted toward the availability and nature of secondary data. But other things apart, the basics of the computational methodology can be seen in Table 1. First of all the pioneering methods *like* 'crop combination' (Weaver 1954; Rafiullah 1956), 'crop concentration' (Location Quotient majorly used by Agricultural Department of India), 'crop diversification' (Bhatia 1965), and simple GDP geographical ratio are being adopted after appropriate modification and coded as *livelihood combination*, *livelihood concentration*, *livelihood diversification*, and *GDP occupant ratio*. In the case of *livelihood combination*, two parallel methods (Weaver's method and Rafiullah's method) and two different kinds of datasets (Census and NSSO) have been used for cross-comparison and validation. On the contrary, for the aftermath zonation of livelihood phenomenon in a large country like India, 'z'-score (McLeod 2019) method has been applied, which is as follows:

$$Z = \frac{x - \mu}{\sigma}$$

where Z = 'Z' score of individual station or area, = individual value of jth component (in any unit) of ith area, μ = mean value of jth component (in any unit) of ith area, and σ = standard deviation of jth component (in any unit) of ith area. The reason behind selecting the 'z'-score method is it assesses the position of a raw score in terms of its distance from the mean when measured in standard deviation units. The derived score is positive if the value lies above the mean and vice versa. Scholarly it is popularized as a standard score due to its wider scope for comparing scores on different kinds of variables by standardizing the distribution (Rumsey 2016; McLeod 2019). In due course, through software-based zonation and mapping, to reach a standardized and auto-fit method and suit the zonation, the 'natural breaks method' has been incorporated. Supportively, this method is considered for optimizing the arrangement of the set of values into 'natural' classes (i.e., optimal class range found *naturally* in a dataset). Simultaneously, the merits of the adopted method are as follows: (1) it describes the real classes within the data, and (2) it is capable of generating choropleth map(s) that have accurate representations of trends of data (Jenks 1967).

Along with these, to perform the fundamental statistical computation, majorly the available software, Microsoft Office Excel and subordinately SPSS (Version 20.0) have been used. In addition, most important for mapping the spatial array of livelihood phenomenon ArcGIS (latest version) tool is made functional. Lastly, based on the statistic, computed outcome, and mapping layouts, the present draft has been made, while the next section is underlining the limitations.

4 Limitations

In order to reach the ultimate goal of zonation of a lesser-highlighted theme and in such a big country like India, several limitations spontaneously stuck with it. *First*, to overcome the missing data problem, this study has to follow the broad category

Table 1 Detailed methodological inputs

Items	Detailing	Equations	Description	References
Crop combination	Pioneering method	$\mathrm{SD} = \frac{\sqrt{\sum d^2}}{n}$	Where SD = standard deviation d = deviation (hypothetical − actual) n = number of crops	Weaver (1954)
		$D = \frac{\sum d^2}{n}$	Where D = variance d = deviation (hypothetical − actual) n = number of crops	
Livelihood combination	Adopted method	$\mathrm{SD} = \frac{\sqrt{\sum d^2}}{n}$	Where SD = standard deviation d = deviation (hypothetical percentage of workers − actual percentage of workers) n = number of categorized livelihood (having >1% proportion)	
		$D = \frac{\sum d^2}{n}$	Where D = variance d = deviation (hypothetical percentage of workers − actual percentage of workers) n = number of categorized livelihood (having >1% proportion)	
Crop combination	Pioneering method	$d = \sqrt{\frac{\sum D_p^2 - D_n^2}{N^2}}$	Where d = deviation D_p = positive difference from the median values D_n = negative difference from the median values N = number of functions (crops)	Rafiullah (1956)
		$d = \frac{\sum D_p^2 - D_n^2}{N^2}$	Where d = deviation	

(continued)

Table 1 (continued)

Items	Detailing	Equations	Description	References
			D_p = positive difference from the median values D_n = negative difference from the median values N = number of functions (crops)	
Livelihood combination	Adopted method	$d = \sqrt{\frac{\sum D_p^2 - D_n^2}{N^2}}$	Where d = deviation D_p = positive difference from the median values D_n = negative difference from the median values N = number of functions (categorized livelihood having >1% proportion)	
		$d = \frac{\sum D_p^2 - D_n^2}{N^2}$	Where d = deviation D_p = positive difference from the median values D_n = negative difference from the median values N = number of functions (categorized livelihood having >1% proportion)	
Location quotient	Pioneering method	$\mathrm{LQ} = \frac{x'}{x} \div \frac{X'}{X}$	Where LQ = location quotient x' = component of the individual x = all components of the individual X' = component of the entire region/country X = all component of the entire region/ country	Dominantly used by regional scientists but the original source is unknown
Livelihood concentration	Adopted method	$\mathrm{LC} = \frac{w'}{w} \div \frac{W'}{W}$	Where LC = location quotient of livelihood concentration	

(continued)

Table 1 (continued)

Items	Detailing	Equations	Description	References
			w' = workers of x category in the component areal unit or state w = workers of all categories in the component areal unit or state X' = workers of x category in the entire region/country X = workers of all categories in the entire region/country	
Crop diversification	Pioneering method	$\mathrm{CD} = \frac{\mathrm{PSA}}{N}$	Where CD = crop diversification PSA = percentage of sown area under x crop N = number of x crops	Bhatia (1965)
Livelihood diversification	Adopted method	$\mathrm{LD} = \frac{\left(\frac{\mathrm{PAW}}{\mathrm{EAP}}\right)\times 100}{N}$	Where LD = livelihood diversification PAW = proportion of active occupants (>15 years of age) under component areal unit (state) EAP= proportion of economically active population (15–80 years of age) under component areal unit (state) N = number of livelihood category having more than 10%	
GDP occupant ratio	Adopted method	$\mathrm{GDPOR} = \frac{\mathrm{GDP}\ (\%)}{\mathrm{Ocu}\ (\%)}$	Where GDPOR = GDP occupant ratio GDP (%) = gross domestic product in percentage Ocu (%) = area-wise occupant in percentage	

Source Modified equations are developed by first author, when the references of pioneering equations are given respectively of livelihood or, say, the proportion of workers engaged with specific vocations, which make itself limited detailing vocations or clubbed vocation. For example, the category of ‘other worker,’ proposed by Census (2011), systematically included the workers engaged with other than primary and secondary types of economic activities (i.e., tertiary and quaternary type of economic activities). So, it is nearly impossible to differentiate the proportion of workers belonging to both types of economic activities in states and union territories. *Second*, in case of two larger states, *like* Andhra Pradesh and Jammu & Kashmir, the available datasets are traced from census year 2011, thus the updated information and the redefined boundaries of mentioned states (e.g. Andhra Pradesh has been redivided into two states like Telangana and Andhra Pradesh; Jammu& Kashmir has been reformed as union territories like Jammu & Kashmir and Ladakh) are not incorporated in this study. *Third*, due to limited time, current mass-scalar health emergency, and objective, this study endeavors up to the meso- to macro-level or from country to state level. Apart from these, it can be said that hopefully, this chapter may (partially) encourage the thinkers and upcoming researchers in regional science.

5 Exemplifying the Global South: India

After prefacing the literal terms, concepts, and methods, now the job has come to a turn-up of addressing the ground-level consultation of the issue. Paralleled to this, an unfixed query may peep that why should India as a geographical entity from *Global South* has been intruded. Introductorily, the term ‘Global South’ unlike compass-oriented direction of southern hemisphere rather referred to as a more open and value-free alternative to ‘Third World’ (Mitlin and Satterthwaite 2013; Pagel et al. 2014; di Nicola 2020). Although after recognition as an emerging term but mostly as a critical concept, it is precisely delineating as geopolitical space that would be economically disadvantaged nation-states and post-Cold War dichotomies North–South (Mahler 2017). Contemporarily, this concept has employed, within a variety of fields, as a key to signify denounced injustices, dependencies, and ‘subalternity’ among the comprehensive sovereign world (Schneider 2017). Thus, zooming into the present contextual decisive *small world* (Global South) and India to encounter its baseline human capital and regional scenario is of inherent importance. In the present geopolitical condition, India has partially attested to herself as ‘rising power’ by the Global South rhetoric (Hall 2010; Chakrabarti 2016). Such rhetoric, on one side, is inclusive of irredentism and contestation on the other side. The said features are eternally connected with western ideals and norms developing through a complex process of interactions and cooperation and subjectively shaping up the global order (Chakrabarti 2016). Out of these complexities, from the point of view of the regional scientist, India is such a nation having a young demographic profile, a large number of human capital, diversified size of neo-federal states, natural resources, and inquisitive potentiality of sociopolitical and cultural environment for further development possessively acquired its position to be included in this volume. The upcoming sections discuss the pre-mentioned livelihood dimensions across India's states and union territories, thematically one after another.

5.1 Livelihood Combination

The study of livelihood combination, a newly adopted concept, and the concerned zones constitutes a significant aspect of human geography and regional geography. It offers a reasonable basis for a broad zoning club of vocations. In the real-world scenario, several kinds of livelihoods develop in combinations. It is rarely observed that a particular livelihood occupies a position of total isolation with other classified livelihoods in a given spatial dimension at a given point of time or census year. Herewith lays the importance of mapping the spatial distribution of standard livelihood combination. The distribution maps of the standard categorized individual or clubbed livelihood(s) are quite interesting and needful for planners. Side by side, it is even more valuable to understand the integrated agglomeration of various livelihoods evolved from a spatial perspective. In this sub-section, for the building of livelihood combination, two methods have been followed, i.e., *deviation method* (Weaver 1954) and *maximum positive deviation method* (Rafiullah 1956), and the data sources are Census (2011) and sample data of NSSO (2011). According to the Census of India (2011), there are four basic categories of livelihoods (e.g., cultivator, agricultural labor, household worker, and other workers). According to NSSO (2011) based on employment status, there are three categories of livelihoods (e.g., self-employed, waged or salaried, and casual labor). This means the upcoming sections may reveal the cross-methodical and cross-data model livelihood analysis, focusing on regional orientation.

A close examination of Table 2 reveals that two states (Goa and Kerala) and six union territories (Chandigarh, Delhi (NCR), Daman & Diu, Lakshadweep, Puducherry, and Andaman & Nicobar Islands) have a mono livelihood. In this part, all the data analysis is based on Weaver's method (1954), taking into account those categorized livelihood having more than one percent of workers in each Indian states and union territories. Figure 2a also shows that in the earlier mentioned two states (Goa and Kerala) and six union territories (Chandigarh, Delhi, Daman & Diu, Lakshadweep, Puducherry, and Andaman & Nicobar Islands) where mono livelihood is in dominant position, the categorized worker like *other worker* ranked as the first livelihood. The northerly-located 11 hilly states (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Rajasthan, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, and Assam) and extreme southern states (Andhra Pradesh, and Tamil Nadu) have two livelihood combinations. In the five states, *like* Jammu & Kashmir, Uttarakhand, Sikkim, Manipur, and Assam, it is observed that the category of *other workers* is the first-ranked livelihood, and *cultivator* is the second-ranked livelihood. While in the states of Himachal Pradesh, Rajasthan, Arunachal Pradesh, Nagaland, Mizoram, and Meghalaya, *cultivator* is the

Table 2 India: deviation method—livelihood combination (*cultivators, agricultural labors, household workers, other workers*)

Type of livelihood combination	Number of states/UTs	Name of states and union territories
Mono livelihood	8	Chandigarh, Delhi (NCR), Daman & Diu, Goa, Lakshadweep, Kerala, Puducherry, Andaman & Nicobar Islands
Two livelihood combinations	13	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Rajasthan, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, Andhra Pradesh, and Tamil Nadu
Three livelihood combinations	14	Punjab, Haryana, Uttar Pradesh, Bihar, Tripura, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Dadra & Nagar Haveli, Maharashtra, Karnataka
Four livelihood combinations	–	–

Source Census (2011) (computed by authors)

first-ranked livelihood and *other worker* is the second-ranked livelihood (Fig. 2a). However, in the extreme southern part, the situation is little bit different. Andhra Pradesh agricultural labor is the first-ranked livelihood, and other workers are the second, and in Tamil Nadu, *other worker* is the first-ranked livelihood, and *agricultural labor* is the second. For more explanation, it can be said that among the states like Jammu & Kashmir, Uttarakhand, Sikkim, Manipur, and Assam the opportunity of primary economic activity (i.e. agriculture and allied activities) is comparatively low and resulting in a higher proportion of 'other worker' due to mountainous or hilly topography and cold climate. On the other hand, among the northeastern states of India and western states (Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, Himachal Pradesh, Rajasthan), unlike previously mentioned states, the geo-climatic condition is comparatively suitable for agricultural activities, so why here *cultivator* is the first-ranked livelihood, and *other worker* is the second. Table 2 also shows that there are 14 states/UTs (Punjab, Haryana, Uttar Pradesh, Bihar, Tripura, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Dadra & Nagar Haveli, Maharashtra, and Karnataka) having three livelihood combinations. Figure 2a again reveals the fact that, in the case of three livelihood combinations, none of the mentioned states follow any specific pattern in ranked livelihood, and this would be due to different sociopolitical and infrastructural conditions prevail over different states.

The analyzed data outcome followed by Rafiullah's method (1956) provides a different livelihood combination scenario of Indian states and union territories. A perusal of Table 3 depicts the scenario that a major portion of Indian states and union territories (i.e., 23 states and six union territories) have a mono livelihood pattern. In details, in the states and union territories like Jammu & Kashmir, Uttarakhand, Punjab, Chandigarh, Haryana, Delhi (NCR), Sikkim, Manipur,

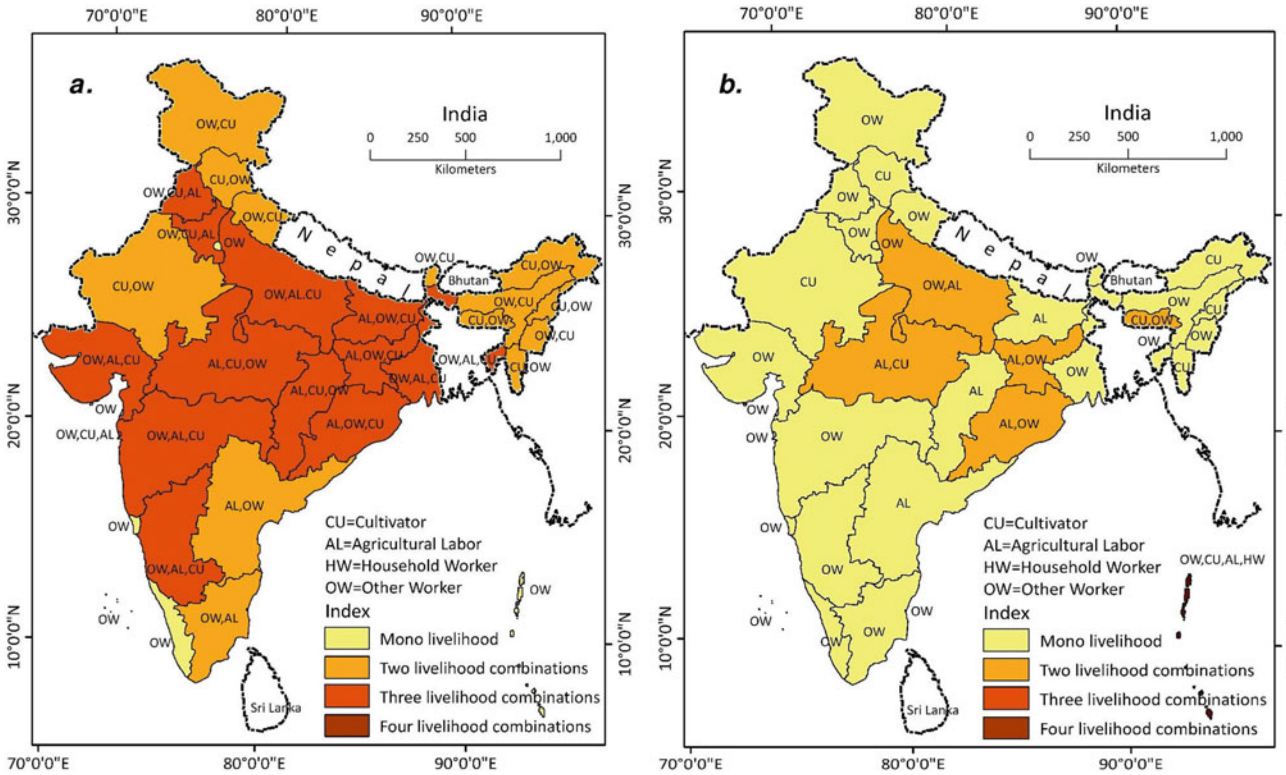


Fig. 2 India: livelihood combination (Census 2011); **a** based on Weaver's method (1954), **b** based on Rafiullah's method (1956). *Source* Base map, Census of India (2011)

Tripura, Assam, West Bengal, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Karnataka, Goa, Lakshadweep, Kerala, Tamil Nadu, and Puducherry are the macro-regions where the category of 'other worker' is observed as a first rank livelihood. Simultaneously, in the states of Himachal Pradesh, Rajasthan, Arunachal Pradesh, Nagaland, and Mizoram, *cultivator* is the first-ranked livelihood, and among rest of the following states (under mono livelihood) Bihar, Chhattisgarh, and Andhra Pradesh, *agricultural labor* is the first-ranked livelihood (Fig. 2b). According to the maximum positive deviation method (Rafiullah 1956), only five states have two livelihood combinations (Uttar Pradesh, Meghalaya, Jharkhand, Odisha, and Madhya Pradesh). Under this category only in Jharkhand and Odisha, *agricultural labor* is the first-ranked livelihood, *other worker* is combined as second, and among rest of the states as follows, Uttar Pradesh (*other worker, agricultural labor*), Meghalaya (*cultivator*, *other worker*), and Madhya Pradesh (*agricultural labor*, *cultivator*). However, with the help of this method, three livelihood combination dominating state(s) have not been found, whereas Andaman & Nicobar Islands is proved where four livelihood combination is dominating (Fig. 2b).

Going with the same method, i.e., *deviation method* of Weaver (1954), when the dataset is different, and the data source is sample data of NSSO (2011), it assuredly presents a picture of *livelihood combination* a pole apart. Unlike Census data, National Sample Survey Organization (2011) has classified (based on employment status) the state and union territory-wise distribution of workers into three specific categories, i.e., *self-employed*, *waged or salaried*, and *casual labor*. Therefore, after examining Table 4, it is observed that only in Delhi (NCR) mono livelihood is in dominant position having *waged or salaried* category as in top rank without any

Table 3 India: maximum positive deviation method—livelihood combination (cultivators, agricultural labors, household workers, other workers)

Type of livelihood combination	Number of states/UTs	Name of states and union territories
Mono livelihood	29	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Rajasthan, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Assam, Tripura, Chandigarh, Delhi (NCR), Daman & Diu, Goa, Lakshadweep, Kerala, Puducherry, Bihar, West Bengal, Chhattisgarh, Gujarat, Dadra & Nagar Haveli, Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu
Two livelihood combinations	5	Uttar Pradesh, Meghalaya, Jharkhand, Odisha, and Madhya Pradesh
Three livelihood combinations	–	–
Four livelihood combinations	1	Andaman & Nicobar Islands

Source Census (2011) (computed by authors)

Table 4 India: deviation method—livelihood combination by the source of employment (self-employed, waged or salaried, and casual labor)

Type of livelihood combination	Number of states/UTs	Name of states and union territories
Mono livelihood	1	Delhi (NCR)
Two livelihood combinations	16	Jammu & Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Bihar, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, Assam, Daman & Diu, Dadra & Nagar Haveli, and Goa
Three livelihood combinations	19	Rajasthan, Uttar Pradesh, Tripura, Manipur, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Maharashtra, Karnataka, Lakshadweep, Kerala, Puducherry, Andhra Pradesh, Tamil Nadu, and Andaman & Nicobar Islands

Source NSSO (2011) (computed by authors)

combination. Side by side, three union territories (Chandigarh, Daman & Diu, and Dadra & Nagar Haveli) and 13 states (Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Haryana, Bihar, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, Assam, and Goa) fall under the group where two livelihood combinations are in a dominant position (Fig. 3a). For more detailed description, it can be said that, in the state of Himachal Pradesh, Punjab, Uttarakhand, Haryana, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Meghalaya, Assam, the livelihood category like *self-employed* gains the first rank, and *waged or salaried* is the second combination. Whereas in Chandigarh, Daman & Diu, Dadra & Nagar Haveli, and Goa, *waged or salaried* is the first-ranked category, and *self-employed* is the second combination of livelihood. Afterward, it is also observed that only in the two Indian provinces like Jammu & Kashmir and Uttar Pradesh *self-employed* occupying the first rank of livelihood, and *casual labor* is the second dominating combination (Fig. 3a). Moreover, under the next type (three livelihood combinations), more states and union territories have different sequential livelihood combinations. Among 19 states and union territories, the order of livelihood combination like *self-employed* as the first rank, *casual labor* as the second combination, and *waged or salaried* as the third combination is dominant in Uttar Pradesh, Manipur, West Bengal, Odisha, Chhattisgarh, Madhya Pradesh, Andhra Pradesh, and Kerala. Whereas in the rest of the provinces (Rajasthan, Tripura, Jharkhand, Gujarat, Maharashtra, Karnataka, Lakshadweep, Puducherry, Tamil Nadu, and Andaman & Nicobar Islands), variety of sequential combination of livelihood has been observed (Fig. 3a).

After close observation of Table 5, it would not have been wrong to say that Rafiullah's method (1956) of the *maximum positive deviation method* of NSSO's sampled livelihood data provides a much-generalized result. Except for Tripura, among the rest of the 34 states and union territories (Jammu & Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Uttar

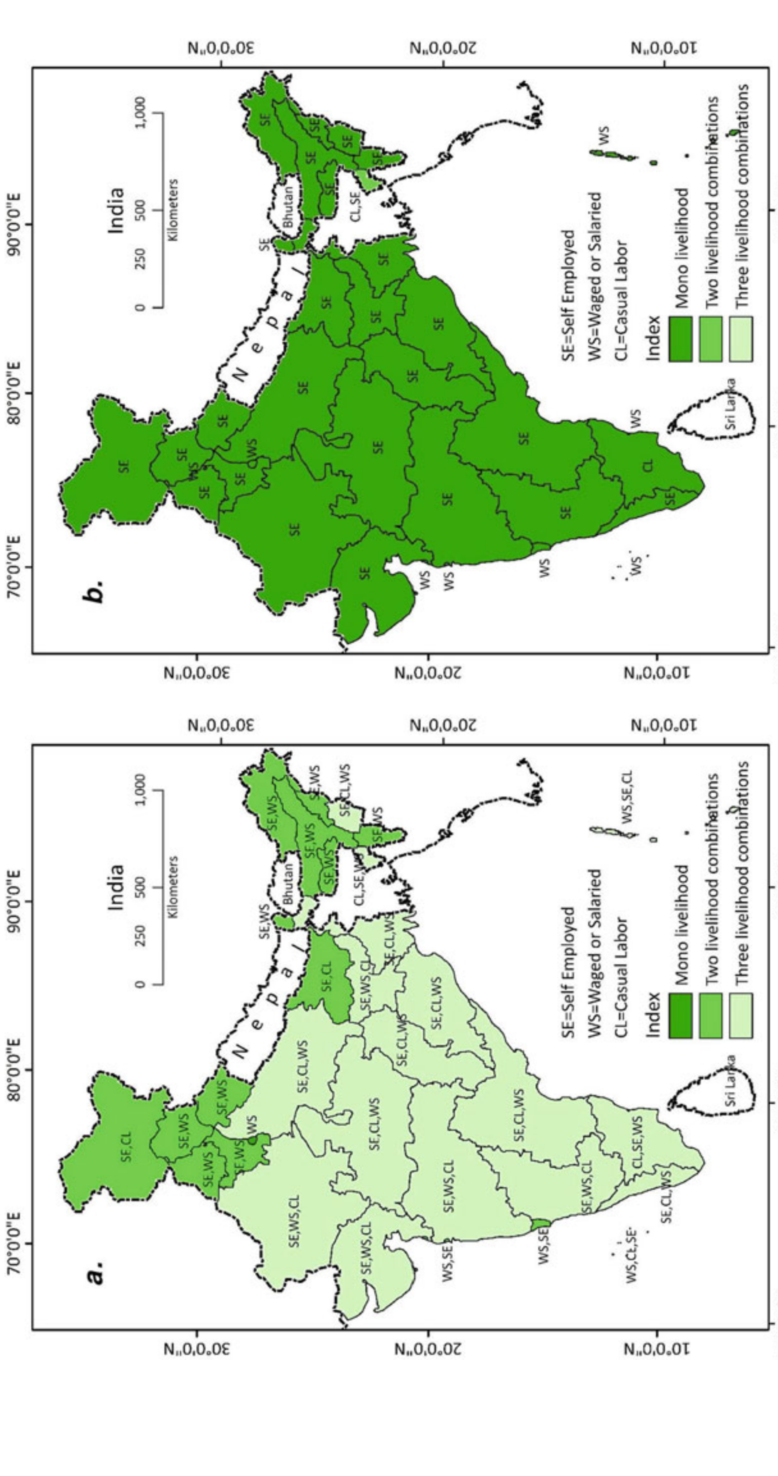


Fig. 3 India: livelihood combination (NSSO 2011), **a** based on Weaver's method (1954), **b** based on Rafullah's method (1956). *Source* Base map, Census of India (2011)

Table 5 India: maximum positive deviation method—livelihood combination by the source of employment (self-employed, waged or salaried, and casual labor)

Type of livelihood combination	Number of states/UTs	Name of states and union territories
Mono livelihood	34	Jammu & Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Uttar Pradesh, Bihar, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Andhra Pradesh, Karnataka, Goa,Lakshadweep, Kerala, Puducherry, Tamil Nadu, and Andaman & Nicobar Islands
Two livelihood combinations	1	Tripura
Three livelihood combination	–	–

Source NSSO (2011) (computed by authors)

Pradesh, Bihar, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Andhra Pradesh, Karnataka, Goa, Lakshadweep, Kerala, Puducherry, Tamil Nadu, and Andaman & Nicobar Islands), mono livelihood are in a dominant position (Table 5). Separately in seven union territories and one small state (Chandigarh, Delhi (NCR), Daman & Diu, Dadra & Nagar Haveli, Lakshadweep, Puducherry, Andaman & Nicobar Islands, and Goa), *waged or salaried* category is the top-ranked livelihood, and in remaining states (Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Haryana, Rajasthan, Uttar Pradesh, Bihar, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu), *self-employed* is the crown-ranked livelihood, except Tamil Nadu where *casual labor* category is the first-ranked livelihood (Fig. 3; Table 3b). Similarly, in Fig. 3, the cross-comparative analysis of the same livelihood combination based on different methods is mismatched with each other, and it would be due to the internal mechanism of computations rather than the nature of the dataset.

5.2 *Livelihood Concentration*

Livelihood concentration, a newly adopted concept, signifies the variations in the magnitude of any categorized livelihood (or clubbing of vocations) in an area or region at a given point of time or census year (Husain 1996). The concentration of any kind of categorized livelihood in an area or region broadly depends on the natural environment, sociopolitical setup, governable planning and policy, domestic and foreign trade, the potentiality of human capital, and so on. The above-mentioned factor(s) singularly or in combinational fashion reacts to the development of a particular type of categorized or clubbed vocation in a specific area or region and at a given point of time. On the other hand, the geographers for the determination of the character of any phenomenon had already applied the location quotient method (Table 1). Along with the method, the regional character of livelihood distribution, or say concentration, is examined and determined, first by comparing the proportion of a particular category of active workers with the proportion of all categories active working population, and secondly, by comparing the proportion of the particular category of active workers of the entire region with the proportion of all categories active working population of the entire region. This approach makes it possible to draw a demarcation line between less specialized and more specialized zone(s) or region(s) (Husain 1996; Singh and Dhillon 2004).

Table 6 clearly shows and helps understanding not only the region-wise concentration of different types of categorized livelihoods, proposed by census, but also the internal geographical setup of respective regions as background. As for example, the category of *cultivator* is mostly concentrated in the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Haryana, Rajasthan, Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, Jharkhand, Chhattisgarh, Madhya Pradesh, and Maharashtra (Fig. 4a). While the category of *agricultural labor* is majorly concentrated in the populated states, having surplus workers, *like* Uttar Pradesh, Bihar, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Andhra Pradesh and Tamil Nadu (Fig. 4b). Again, the category of *other worker* (including *tertiary* and *quaternary* category of workers) especially concentrated in major developed states and union territories of India *like* Jammu & Kashmir, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Sikkim, Manipur, Mizoram, Tripura, Assam, West Bengal, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Karnataka, Goa, Lakshadweep, Kerala, Tamil Nadu, Puducherry, and Andaman & Nicobar Islands (Fig. 4d). Side by side, the remained and lesser important but potentially developing category, *household worker*, is concentrated in few selected states *like* Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, Manipur, Assam, West Bengal, Odisha, and Tamil Nadu (Fig. 4c). Figure 4 may also vividly display the spatial scenario of livelihood concentration phenomena of a nation of the South Asian domain.

5.3 Livelihood Diversification

The concept of livelihood diversification, a modified concept originating from 'crop diversification,' has an opposite connotation of livelihood concentration. A singular occupant tries to fulfill his/her (and his/her household) daily needs and basic

Table 6 India: State-wise concentration of livelihoods (location quotient method)

Livelihood (census classification)	Magnitude of livelihood concentration	Number of states or union territories	Name of states and union territories
Cultivator	>1	17	Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Haryana, Rajasthan, Uttar Pradesh, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya, Assam, Jharkhand, Chhattisgarh, Madhya Pradesh, and Maharashtra
	<1	18	Punjab, Chandigarh, Delhi (NCR), Bihar, Tripura, West Bengal, Odisha, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Andhra Pradesh, Karnataka, Goa, Lakshadweep, Kerala, Tamil Nadu, Puducherry, and Andaman & Nicobar Islands
Agricultural labor	>1	9	Uttar Pradesh, Bihar, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Andhra Pradesh, and Tamil Nadu
	<1	26	Jammu & Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Karnataka, Goa, Lakshadweep, Kerala, Puducherry, and Andaman & Nicobar Islands
Household worker	>1	9	Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, Manipur, Assam, West Bengal, Odisha, and Tamil Nadu
	<1	26	Himachal Pradesh, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Sikkim, Arunachal Pradesh, Nagaland, Mizoram, Tripura, Meghalaya, Jharkhand, Chhattisgarh, Madhya Pradesh, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Andhra Pradesh, Karnataka, Goa, Lakshadweep, Kerala, Puducherry, and Andaman & Nicobar Islands
Other worker	>1	24	Jammu & Kashmir, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi (NCR), Rajasthan, Sikkim, Manipur, Mizoram, Tripura, Assam, West Bengal, Gujarat, Daman & Diu, Dadra & Nagar Haveli, Maharashtra, Karnataka, Goa,

(continued)

Table 6 (continued)

Livelihood (census classification)	Magnitude of livelihood concentration	Number of states or union territories	Name of states and union territories
			Lakshadweep, Kerala, Tamil Nadu, Puducherry, and Andaman & Nicobar Islands
	<1	11	Himachal Pradesh, Uttar Pradesh, Bihar, Arunachal Pradesh, Nagaland, Meghalaya, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, and Andhra Pradesh

Source Census (2011) (computed by authors)

requirements by means of potentiality he/she already deserves or owned and depend upon socio-economical and sociopolitical environments in a given area. In the case of mono livelihood or specialization, the competence for livelihood sharing occupancy is weak. The impacts of regional infrastructural facility, sociopolitical and economic, techno-infrastructural development, and last but not least, the natural environment would determine the magnitude of livelihood diversification (Husain 1996). For all-around comprehension of the geography of livelihood, agglomeration, and setup of a region, the description of livelihood diversification is essential. Usually, the intensity of degree of diversification can be measured by relating the proportion of the economically active population (age group: 15–79) with the active working population (age group: above 15) in combination in a regional unit. Normally, it is assumed that when the number of categorized or clubbed livelihood in an enumeration unit is large (about 10) and each categorized livelihood occupying only 10 percent among the total, it would mean that the categorized livelihood is uniformly distributed among all the ten categories. Side by side, the data outcome indicates the high degree or extreme case of livelihood diversification. On the contrary, if the particular category of livelihood occupies 100 percent of the total sharing of occupants, there is no diversification (Singh and Dhillon 2004). A pilot evaluation of Table 7 reveals that in South Asian nations like India, a major proportion of states and union territories have highly diversified livelihood (as per categorization by Census 2011), whereas a lesser number of states and union territories have specialization. After a close examination of Table 7, it is observed that the states and union territories *like* Punjab, Haryana, Uttar Pradesh, Jammu & Kashmir, West Bengal, Uttarakhand, Tripura, Bihar, Assam, Gujarat, Odisha, Tamil Nadu, Maharashtra, Karnataka, Jharkhand, Andhra Pradesh, Madhya Pradesh, Dadra & Nagar Haveli, and Meghalaya have higher diversified livelihood index (more than 22). On the other hand, the state and union territories *like* Lakshadweep, Delhi (NCR), Goa, Chandigarh, and Daman & Diu belong to the derived classified group of specialization (Fig. 5). The most dominating factor behind this would be the small territorial configuration. At the same time, the rest of

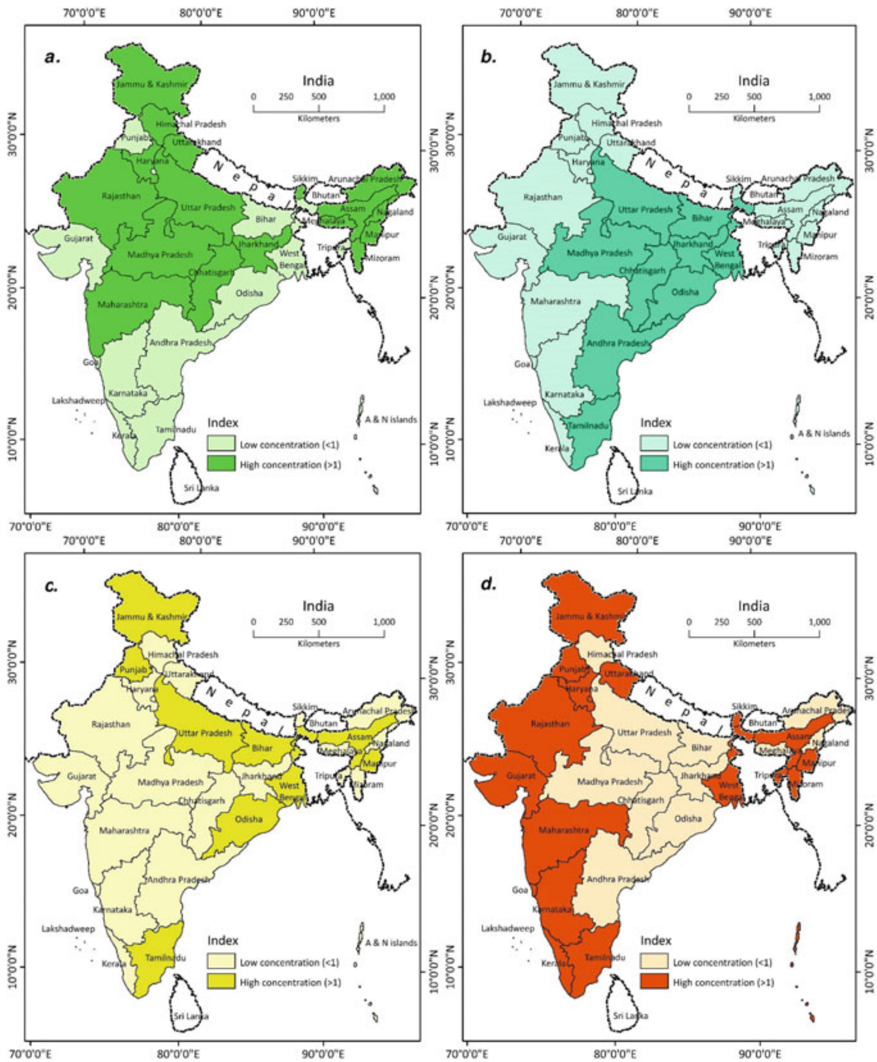


Fig. 4 India: livelihood concentration (Census 2011): **a** location quotient of the cultivator, **b** agricultural labor, **c** household worker, and **d** other worker. *Source* Base map, Census of India (2011)

the Indian states and union territories have moderate livelihood diversification, e.g., Chhattisgarh, Kerala, Puducherry, Andaman & Nicobar Islands, Rajasthan, Manipur, Mizoram, Arunachal Pradesh, Sikkim, Himachal Pradesh, and Nagaland. Figure 5 helps understand the spatial phenomenon of livelihood diversification and the future of livelihood development and welfare agendas to be highlighted.

Table 7 India: state-wise diversification of livelihoods

Magnitude of livelihood diversification	Index value	Number of states and union territories	Name of states and union territories
Low	39.5–64.9	5	Lakshadweep, Delhi (NCR), Goa, Chandigarh, and Daman & Diu
Moderate	23.5–38.5	11	Chhattisgarh, Kerala, Puducherry, Andaman & Nicobar Islands, Rajasthan, Manipur, Mizoram, Arunachal Pradesh, Sikkim, Himachal Pradesh, and Nagaland
High	16.3–22.5	19	Punjab, Haryana, Uttar Pradesh, Jammu & Kashmir, West Bengal, Uttarakhand, Tripura, Bihar, Assam, Gujarat, Odisha, Tamil Nadu, Maharashtra, Karnataka, Jharkhand, Andhra Pradesh, Madhya Pradesh, Dadra & Nagar Haveli, and Meghalaya

Source Census (2011) (computed by authors)

5.4 GDP Occupant Ratio

GDP occupant ratio is a very simple technique to examine the relative proportion of area or region based on sharing of gross domestic product (GDP) and the proportion of active working population or occupants in respect to the entire region or country. The outcome of *GDP occupant ratio* is supposed to be pinpointing the roundup potentiality of the area- or region-specific proportion of occupants in respect of prime economic parameter (GDP). Higher the nation's share of GDP in a specific region and lower the proportion of active occupants give the high magnitude of *GDP occupant ratio* and vice versa. Table 8 encompasses the scenario of area- or region-wise *GDP occupant ratio. The result shows that 16 states and union territories have a moderate ratio (1–3), 13 states have a lower ratio (less than 1). O*nly one state and two union territories have a higher GDP occupant ratio (more than 3). To say this in more details, (Fig. 6) Jammu & Kashmir, Himachal Pradesh, Punjab, Rajasthan, Sikkim, Mizoram, Arunachal Pradesh, West Bengal, Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Haryana, Puducherry, and Andaman & Nicobar Islands have moderate GDP occupant ratio (1–3). While Uttarakhand, Uttar Pradesh, Bihar, Nagaland, Manipur, Tripura, Meghalaya, Assam, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, and Andhra Pradesh have lower GDP occupant ratio (less than 1). However, Goa, Chandigarh, Delhi (NCR) have remarkably higher GDP occupant ratio (more than 3). In the meantime, the problem of unavailability of data on GDP from Lakshadweep, Dadra & Nagar Haveli, and Daman & Diu is also persisting.

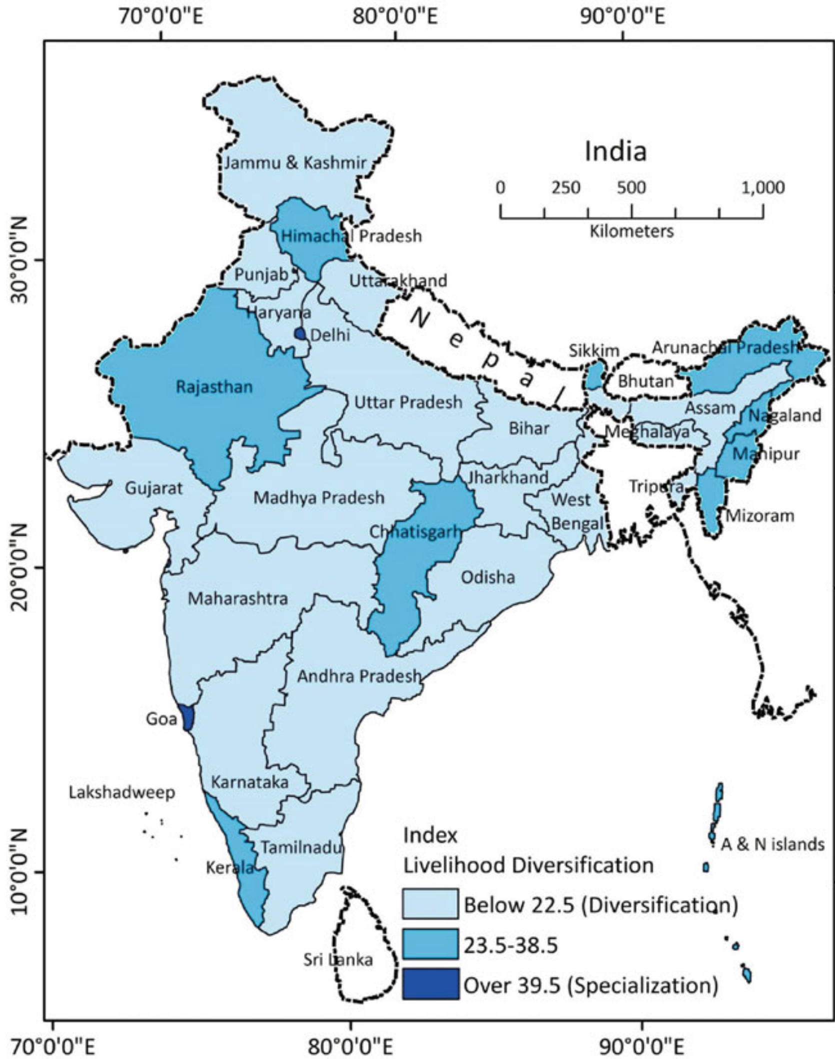


Fig. 5 India: livelihood diversification (Census 2011). *Source* Base map, Census of India (2011)

6 LZM and Policy Prospect

While after thematic- and dimension-wise discussions, the roundup interpretation of *livelihood zone map* (LZM) has endeavored here. In the interim, it is well-known fact that the 'regional scientists have long faced challenges in developing the interdisciplinary field where their focus is on the spatial context of social, economic and environmental phenomena, and dealing with spatial data presents considerable

Table 8 India: state-wise GDP occupant ratio

Magnitude of GDP occupant ratio	Ratio	Number of states and union territories	Name of states and union territories
Low	Less than 1	13	Uttarakhand, Uttar Pradesh, Bihar, Nagaland, Manipur, Tripura, Meghalaya, Assam, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, and Andhra Pradesh,
Moderate	1–3	16	Jammu & Kashmir, Himachal Pradesh, Punjab, Rajasthan, Sikkim, Mizoram, Arunachal Pradesh, West Bengal, Gujarat, Maharashtra, Karnataka, Kerala, Tamil Nadu, Haryana, Puducherry, and Andaman & Nicobar Islands
High	More than 3	3	Goa, Chandigarh, and Delhi (NCR)
Data not available	–	3	Lakshadweep, Dadra & Nagar Haveli, and Daman & Diu

Source Census (2011) (computed by authors)

methodological challenges' (Stimson 2016, p. 11). In order to reach the focussed objective (i.e., delineation of livelihood zone of India), the overall regionalization of India based on the livelihood phenomenon is of prior importance. Additionally, *livelihood zone map* (LZM) can be defined as a map of areas or reframed zones within which people or inhabitants of that area or zones share a similar pattern of livelihood (Browne and Glaeser 2010) broadly. For further re-conceptualization of the sum-up, the phenomenon of distribution of livelihood zones, across neo-federal states and union territories of India, and agglomeration of computed data is standardized with the help of *z*-score method, and cluster zonation has been made through software-oriented Jenks's (1967) 'natural breaks method'. In the meantime, Fig. 7 illustrates the position of each Indian state and union territory in respect of their average *z*-score. The said figure shows that Goa (0.68) ranked at top position and Lakshadweep (−0.50) ranked at the bottom position. While the administrative areal unit like Delhi (NCR), West Bengal, and Manipur ranked at a higher position having scores ranges from 0.33 to 0.28 and states/union territory like Uttarakhand, Jharkhand, and Daman & Diu ranked at a lower position having scores ranges from −0.31 to −0.24. On the other hand, the rest of the Indian states and union territories ranked under intermediate positions (Table 9). Separately, Fig. 8 portrays the summarized livelihood conditions of India. Starting with the descending order, 'very good' quality of livelihood conditions (0.28–0.68) prevails over Goa, Delhi (NCR), West Bengal, and Manipur. The possible reason(s) behind the successful regions would be a small size, except West Bengal, of the regions with comparatively better implementations of administrative policy and planning, greater infrastructural conditions, and the overall quality of human capital. While the next value range (−0.02 to 0.28) or 'good' quality of livelihood conditions are observed in Punjab, Puducherry, Chandigarh, Tamil Nadu, Kerala, Andaman & Nicobar

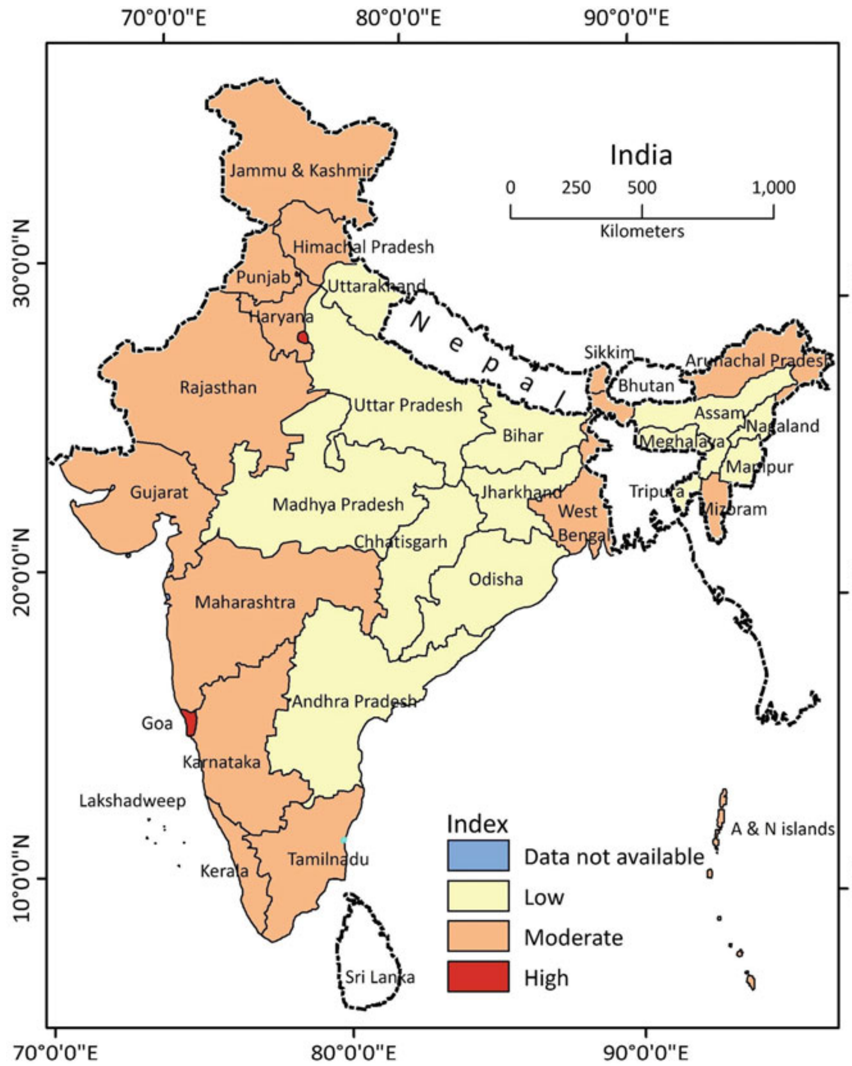


Fig. 6 India: GDP occupant ratio (Economic Survey 2011–2012; Census 2011). *Source* Base map, Census of India (2011)

Islands, Haryana, Bihar, Himachal Pradesh, Nagaland, Sikkim, and Jammu & Kashmir. Again in the case of the second category of 'good' quality, livelihood conditions are dominated over a comparatively larger number of Indian regions, and the probable causes are infrastructural bases for primary economic activity and very recent development of workable human resources and work participation aptitudes. Whereas the states and union territories like Mizoram, Arunachal Pradesh, Madhya Pradesh, Chhattisgarh, Meghalaya, Daman & Diu, Jharkhand, Uttarakhand, and

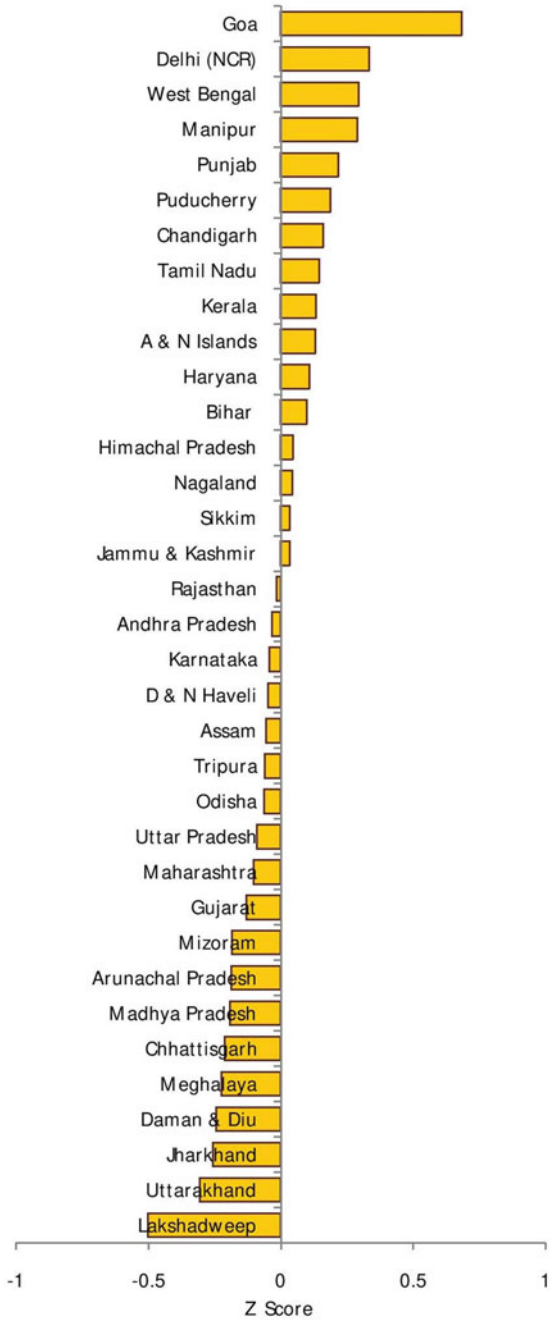


Fig. 7 Position of Indian states and union territories according to *z*-score. *Source* Base map, Census of India (2011)

Table 9 India: scaled livelihood zones

Quality of livelihood condition	Index value range	Number of states and union territories	Name of states and union territories
Poor	(−)0.50 to (−) 0.18	9	Mizoram, Arunachal Pradesh, Madhya Pradesh, Chhattisgarh, Meghalaya, Daman & Diu, Jharkhand, Uttarakhand, and Lakshadweep
Moderate	(−)0.18 to (−) 0.02	10	Rajasthan, Andhra Pradesh, Karnataka, Dadra & Nagar Haveli, Assam, Tripura, Odisha, Uttar Pradesh, Maharashtra, and Gujarat
Good	(−)0.02 to (+) 0.28	12	Punjab, Puducherry, Chandigarh, Tamil Nadu, Kerala, Andaman & Nicobar Islands, Haryana, Bihar, Himachal Pradesh, Nagaland, Sikkim, and Jammu & Kashmir
Very good	(+)0.28 to (+) 0.68	4	Goa, Delhi (NCR), West Bengal, and Manipur

Source Based on computed result

Lakshadweep fall under the category of 'poor' quality of livelihood conditions, and value ranges from −0.50 to −0.18 (Fig. 8). Thus, the above-said nine states and union territories are the regions that need more exclusive care and situational up-gradation of livelihood condition as well as infrastructural improvement. On the contrary, under the category of 'moderate' quality, livelihood conditions (−0.18 to −0.02) prevail over the states and union territories like Rajasthan, Andhra Pradesh, Karnataka, Dadra & Nagar Haveli, Assam, Tripura, Odisha, Uttar Pradesh, Maharashtra, and Gujarat. However, this third category ('moderate' quality of livelihood conditions) also requires the attention of the planners and policymakers for their economic development and up-gradation of livelihood conditions.

It is the ardent obligation of an academician to take the lessons of gaps and linking the derived result, from the ground, with realities and also to put effort into appropriate policy proposals. In view of the above, in this part, an initiative has been taken to formalize suitable policy proposals. The regions where three livelihood combinations persist those regions are in a better position in a practical sense because domination of more categorized or clubbed livelihoods is not only good for country's economy but also fruitful for recovery of any kind of functional interruption and for enhancing coping capacity from any kind of environmental hazards. Consequently, the reframed policy for livelihood promotion should not only be focussed on major and lucrative vocations but also on marginal occupations. According to the sampled database of NSSO (2011) and computed result, it has been found that among the major states and union territories, the proportions of the self-employed category of occupants are in the dominant position, and it is beneficiary of any country. Because this categorized group would minimize the 'job creation' pressure from the administrative side. Equally, an administration (regional

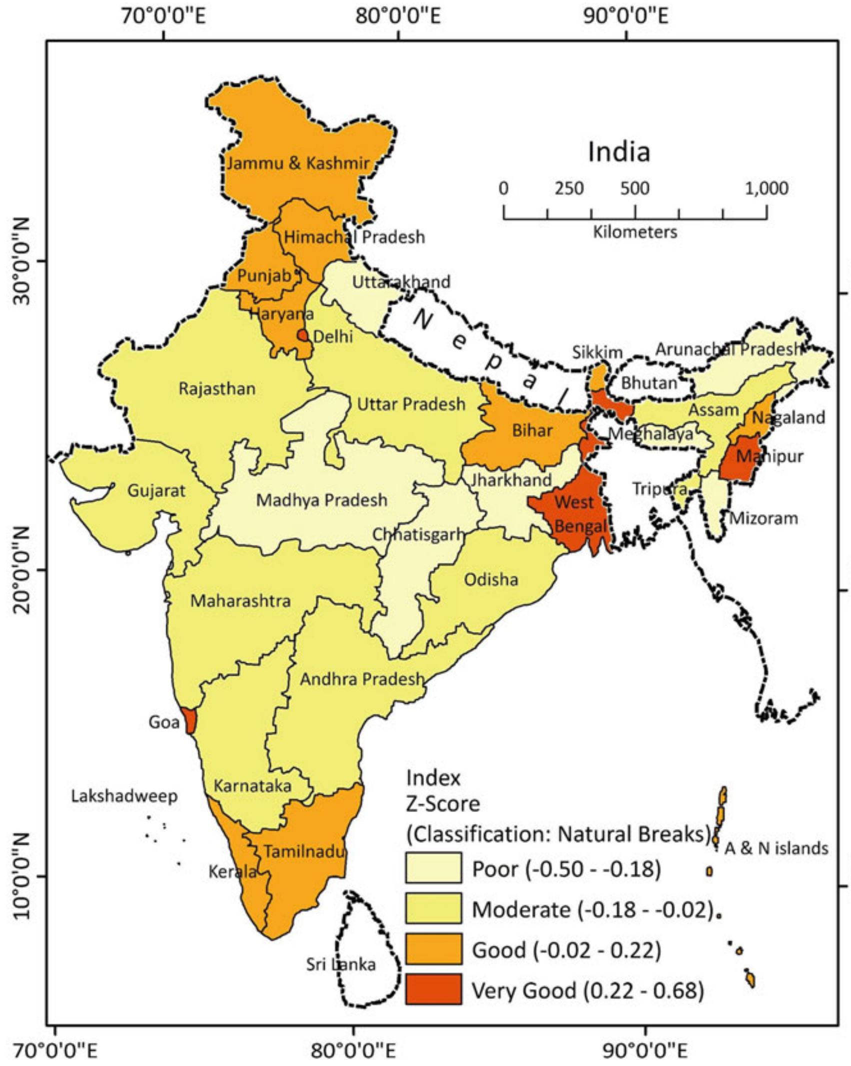


Fig. 8 India: livelihood zone map (based on computed *z*-score). *Source* Base map, Census of India (2011)

and central) must work for another important category like 'casual labor', for their job security, wage equity, welfare, and so on. Based on the findings of livelihood concentration (identified Census category of livelihoods), outcome suitable and welfare policies should throw focus on the zones where each specifically categorized livelihood sustains in lower magnitude. Diversification of livelihood of any region has a very complementary impact upon regional as well as the country's economy. More the livelihood diversity more is the strength of the local economy.

Thus, for the sustenance of diversity among legalized vocations, well-thought policy implications like taxation discount, attractive startup policy, encouragement through small financing, etc., should be enforced. From the overall study, it has been realized that the category of livelihood *like* ‘household worker’ (Census 2011) is accounted for in very small proportions across the 35 states and union territories of India. Additionally, this category has many potentialities as an important contributor toward county’s fiscal growth, because under this category, women workers with ease may involve and earn their own bread and butter and strengthen their households. Secondly, the said category does not require any hard or near impossible professional degree/diploma for the poor to participate as ‘household workers’. Thus, more attention is needed in this small corner for future development. Subsequently, if the aforesaid proposal(s) have been enacted gradually in a large country like India, it will not only modify the fiscal deficit of the country but also helps increment in GDP, minimize the livelihood crisis, address the multidimensional poverty, and ultimately fill the regional gaps of a higher degree of GDP occupant ratio.

7 Conclusion

Correspondingly, in this conclusive part, the unsaid components are attempted to address. Although this study is exclusively connected with a big database and macro-level analysis, and depending upon statistically engineered methodology, there are lots of areas for a minute and reframed policy and planning. Owing through in detail, from launch to the end section, it is easily observable that each and every dimension (calibrated through one or more than one method) have a different kind of spatial outcome of livelihood phenomenon, and for mitigation of problem in the area or region-specific and dimension-specific, policy should be redesigned accordingly. Simultaneously, in a geographically and socioculturally diversified corner of ‘Global South’ (i.e., India), each and every single region (i.e., state or union territory) has its own potentiality of nature’s capital and human capital. Thus, for any kind of targeted achievement and eradication of area-wise problems, planners and administrators should consider those potential points for desired salvation.

Instead of all, this chapter may be capable of opening a new vista of scholarly examination of the workforce in any geographical entity. As a reason, not only the economy and economic administration but also the economic activities of the people and their vocational security can build (any) self-dependent healthy society, culture, and ultimately the nation. Concisely, it can be said that this study is opening a new avenue of research and analysis instead of having some inherent limitations. Furthermore, the possible forthcoming research suggestions are as follows: clustered or group of country-level or global-level analysis of livelihood scenario, district-level as well as state-level analysis of livelihood phenomena, the primary data-oriented study of livelihood scenario and its zonation, and many more.

References

Alonso W (1964) Location and land use: towards a general theory of land rent. Harvard University Press, Cambridge, p 204

Bhatia SS (1965) Patterns of crop concentration and diversification in India. Econ Geogr 40:40–56

Boyce D (2004) A short history of the field of regional science. Reg Sci 83:31–57. https://doi.org/10.1007/s10110-003-0176-9

Browne S, Glaeser L (2010) Livelihood mapping and zoning exercise: Uganda, A special report by FEWS NET, pp 1–58. Retrieved on August 30, 2020 from: https://fews.net/sites/default/files/documents/reports/UG_zonedescriptions_en.pdf

Carr A (2020) COVID-19, indigenous peoples and tourism: a view from New Zealand. Tourism Geographies 22(3):491–502. https://doi.org/10.1080/14616688.2020.1768433

Census (2011) Census of India website: office of the registrar general & census commissioner, India (ORGI). Retrieved on May 11 2020 from: https://censusindia.gov.in/digitallibrary/Tables.aspx

Chakrabarti S (2016) Global South rhetoric in India's policy projection. Third World Q. https://doi.org/10.1080/01436597.2016.1248931

Chambers R, Conway G (1992) Sustainable rural livelihoods: practical concepts for the 21st century. IDS discussion paper 296, Brighton: IDS. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/775

de Stagé R, Holloway A, Mullins D, Nchabeleng L, Ward P (2002) Learning about livelihoods: insights from southern Africa. Oxfam GB

di Nicola V (2020) The Global South: an emergent epistemology for social psychiatry. World Soc Psychiatry 2(1):20–26. https://doi.org/10.4103/WSP.WSP_1_20

Economic Survey (2011–2012) Union budget and economic survey, Government of India. Retrieved on 10 July 2020 from https://www.indiabudget.gov.in/budget2012-2013/index.asp

Ellis F (2000) Rural livelihoods and diversity in developing countries. Oxford University Press, New York

Grillo J, Holt J (2009) Application of the livelihood zone maps and profiles for food security analysis and early warning. Guidance for FEWS NET, pp 1–23. Retrieved on 30 Aug 2020 from: https://fews.net/sites/default/files/uploads/Guidance_Application%20of%20Livelihood%20Zone%20Maps%20and%20Profiles_final_en.pdf

Hall I (2010) The other exception? India as a rising power. Aust J Int Aff 64(5):601–611. https://doi.org/10.1080/10357718.2010.513371

Holt J, Coulter L (2011) Livelihood zoning "plus" activity in Sudan, a special report by FEWS NET, pp 1–80. Retrieved on 30 Aug 2020 from: https://documents.wfp.org/stellent/groups/public/documents/ena/wfp239943.pdf

Holt J, Svesve B, Browne B, Fletcher E (2018) Revised livelihoods zone map and descriptions for Nigeria, a report by FEWS NET, pp 1–144. Retrieved on 30 Aug 2020 from: https://reliefweb.int/report/nigeria/revised-livelihoods-zone-map-and-descriptions-nigeria-september-2018

Husain M (1996) Systematic agricultural geography (reprinted version: 2002). Rawat Publications, Jaipur and New Delhi

Isard W (1956) Location and space economy. MIT Press, Cambridge MA

Jenks GF (1967) The data model concept in statistical mapping. Int Yearb Cartography 7:186–190

Langford G, Ngirazi D, Drabe A, Guma J (2018) Livelihoods zone map and descriptions for the republic of South Sudan (updated), a report by FEWS NET, pp 1–74. Retrieved on 28 July 2020 from: https://fews.net/sites/default/files/documents/reports/Livelihoods%20Zone%20Map%20and%20Descriptions%20for%20South%20Sudan.pdf

Mahler AG (2017) Global south. In: O'Brien E (ed) Oxford bibliographies in literary and critical theory. Retrieved on September 19, 2020 from https://globalsouthstudies.as.virginia.edu/what-is-global-south

McLeod SA (2019) Z-score: definition, calculation and interpretation. Retrieved on 11 Jun 2020 from https://www.simplypsychology.org/z-score.html

Merriam-Webster (n.d.) Mapping. In: Merriam-Webster.com dictionary. Retrieved 20 Oct 2020, from: https://www.merriam-webster.com/dictionary/mapping
Merriam-Webster (n.d.) Zonation. In: Merriam-Webster.com dictionary. Retrieved 20 Oct 2020, from: https://www.merriam-webster.com/dictionary/zonation
Mitlin D, Satterthwaite D (2013) Urban poverty in the Global South: scale and nature. Routledge, London and New York, p 13
NSSO (2011) State-wise percentage distribution of workers according to broad employment status: 2011–12, National sample survey office, 68th Round, July 2011–June 2012
Pagel H, Ranke K, Hempel F, Köhler J (2014) The use of the concept 'Global South' in social science and humanities. Symposium paper "GlobalerSüden/Global South: KritischePerspektiven", InstitutfürAsien- &Afrikawissenschaften, Humboldt-Universität zu Berlin, 11 July 2014. Retrieved on 1 Sept 2020 from https://www.academia.edu/7917466/The..ies
Rafiullah SM (1956) A new approach to functional classification of towns. Geographer 8:40–53
Rumsey DJ (2016) Statistics for dummies, 2nd edn. Wiley, New Jersey, USA
Schneider N (2017) Between promise and skepticism: the global south and our role as engaged intellectuals. Global South 11(2):18–38. https://doi.org/10.2979/globalsouth.11.2.02
Singh J, Dhillon SS (2004) Agricultural geography, 3rd edn. Tata McGraw-Hill Publishing Company Limited, New Delhi
Stimson RJ (2016) Some challenges for regional science research. J Reg Res 36:11–34. https://www.semanticscholar.org/paper/Some-challenges-for-regional-science-research-Stimson/bc61a4e28415af5e19bdbf65feaf9385ac82b74d
Weaver JC (1954) Crop combination regions in Middle West. Geogr Rev 44:176–181
Wood G (2001) Regional Geography. In International enclyclopedia of the social & behavioral sciences. Retrieved 10 June 2020 from https://www.sciencedirect.com/science/article/pii/B0080430767025821
Young H, Jaspers S, Brown R, Frize J, Khogali H (2001) Food security assessment in emergencies: a livelihoods approach. ODI HPN Network Papers 36. ODI, London. https://www.files.ethz.ch/isn/96840/networkpaper036.pdf

Somenath Halder is Assistant Professor in the Department of Geography at Kaliachak College, West Bengal, India. He has been working especially on marginal communities since 2008, in the home state as well as other major states across India. His research chiefly focuses on community, livelihood, and spatial analysis. He obtained his Ph.D. from the Visva-Bharati, Santiniketan, India. He has several publications in journals and books of international repute.

Rajesh Sarda is a doctoral research scholar in the Department of Geography at University of Gour Banga, West Bengal, India. He has been working on environment and spatial analysis. He has several publications in journals of international repute.

Sustainable Regional Development in South America

The Indigenous Territories and Local Sustainable Development in the Amazon Region

Melgris José Becerra, Jorge Adriàn Flores Rangel, Claudio Ubiratan Gonçalves, and Gabriel Ibrahin Tovar

1 Introduction

Amazonia is the largest tropical rainforest on the planet. It hosts a quarter of the world's terrestrial species, accounting for 15% of global terrestrial photosynthesis, and produces about 20% of its oxygen supply. The Amazon basin covers over 8 million km^2 and plays a vital role in regulating South America's rainfall cycle through phenomena known as flying rivers (Marengo 2006). The Nutrient drainage by the Amazon River to the Atlantic Ocean helps foster oceanic life that sequesters carbon (Subramaniam 2008). Besides, the primary productivity of the Amazon

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

M. J. Becerra
Universidade Federal do Pará (UFPA), Instituto de Geociências, Belém, CEP 60440-554, Brazil

J. A. Flores Rangel
Universidad Anáhuac, Facultad de Estudios Globales, Ciudad de México, Mexico

C. U. Gonçalves
Universidade Federal de Pernambuco (UFPE), Departamento de Geografia, Recife, Pernambuco, Brazil

G. I. Tovar (✉)
Universidad de Buenos Aires (UBA), Facultad de Farmacia y Bioquímica, Departamento de Química Analítica y Fisicoquímica, Buenos Aires, Argentina
e-mail: gtovar@conicet.gov.ar

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_4

biosphere is essential to the global carbon budget, being its maintenance paramount to mitigate the effects of climate change (Yang et al. 2018).

Analyzing the Amazonian territory invites us to think about its structure and formation socio-spatial, in this space where different forms of territorialization converge and feed. The appropriation of the Amazonian territory changes the structure of relationships between Amazonian societies. The social practices and its relationships with the people in this territory from which the appropriation is carried out express these territorial changes.

The particular characteristic of each culture in the Amazon has left a lot of people for those ancestral and traditional inhabitants, from sacred places and respective places with different ends. This can explain the modalities of spatial occupation, advantages in each region, considering their physical structure, extensions, and limits as well as the change of their natural surroundings (Guevara Romero et al. 2015). Therefore, they have sustainable support for resources, determined for the intensity in which the vegetation cover is modified. Consequently, they are advisers of the exchange processes that support the soils and their effects, considering these elements allowing forms of adaptation, appropriateness, and identity, evidencing the transformation of the uses of the territory.

Let us consider that these elements explain the modalities of territorial occupation. They are consequent improvements, as each population modifies and adapts the territorial physical structures, natural surroundings, its boundaries, and the densification of areas that suit its cultural heritage. The people and the indigenous communities have marked roots in their territory; their view is more palpable and visible because they have based on their cosmovision and their relationship with the land. This particular characteristic determines their behavior, and the approval of their natural resources, surroundings (Guevara Romero et al. 2015). The indigenous people keep up a connection with the territory they inhabit. Also, they have a perception that goes from their cosmovision to compatibility with external elements to their culture; and execute decision making, based on the forms of organization of the surrounding society.

In the last year, the natural environment's protection and conservation have been a priority worldwide (Liang et al. 2016). Natural resources are the most incredible wealth that cares for humankind. The idea of a mediated environment has become part of our collective consciousness, generating a great debate around this problem and giving rise to various theories. Political positions are needed for the preservation and regeneration of the natural environment. It will guarantee a better quality of life for future generations and aim for sustainable development.

Sustainable Development is the one that assures the needs of the present without compromising the possibilities of future generations to satisfy one's own needs, according to the World Commission on Environment and Development (Brundtland 1987). From this perspective, sustainability is shown as an alternative to environmental degradation, trying to find creative answers to rectify the faults and avoid new problems in the regional context. The sustainable use of Amazon's resources is not a new topic (Brack Egg 1996). However, this work provides new elements to show a constructive perspective from an integrative vision between the indigenous peoples' own knowledge and the understanding of non-indigenous people.

2 Amazonian Territoriality

The Amazon is multi-diverse and multicultural in terms of the societies that inhabit this territory, which is inhabited mainly by indigenous people and communities. To speak of territory from the knowledge of those who inhabit it is to refer to any extension of the terrestrial surface inhabited by human groups, by a society, constituted as a field of social relations developed on the basis of natural resources in constant evolution, where they have schematized the elements that make up space according to a scale, be it local, municipal, regional, or national.

The Amazon is a territory of extremely high socio-environmental diversity in the process of accelerated change. It covers an area of 7.8 million km^2, over 12 macro-basins, and 158 sub-basins, shared by 1,497 municipalities, 68 departments/states/provinces of eight countries: Bolivia (6.2%), Brazil (64.3%), Colombia (6.2%), Ecuador (1.5%), Guiana (2.8%), Peru (10.1%), Suriname (2.1%), and Venezuela (5.8%), in addition to Guiana French (1.1%). About 33 million people live in the Amazon, including 385 indigenous groups, in addition to some people in situations of "isolation." There are 610 natural protected areas and 2,344 and indigenous territories that occupy 45% of the Amazonian surface, not counting small, medium, and large rural owners, companies of various types, research and development institutions, as well as religious and civil society organizations (RAISG 2012).

2.1 *Evolution of Amazonian Areas Protection*

Amazonian regionalization beyond the political borders of the nation-state forms a conceptual and political challenge. The effort was published in 2009 and improved in the following ten years by the Amazonian Network of Georeferenced Socio-Environmental Information (RAISG), a consortium of civil organizations oriented toward socio-environmental sustainability supported by international organizations, joins one of the most outstanding advances in this regard (RAISG 2009). Figure 1 shows their most recent proposal. It includes a biogeographical regionalization, covering 6,983,273 km^2, and regionalization by river basins with an area of 8,449,318 km^2. However, the RAISG calculations since 2009 continue to use the political-administrative regionalization of 7,787,056 km^2.

The challenge of regionalization converges with other difficulties. The territory of Amazon faces the complexities in spatial-temporal analysis and diagnoses. Table 1 shows these difficulties based on indicators on the extent and population of the Amazon. First, the total population is updated every ten years in the Amazonian

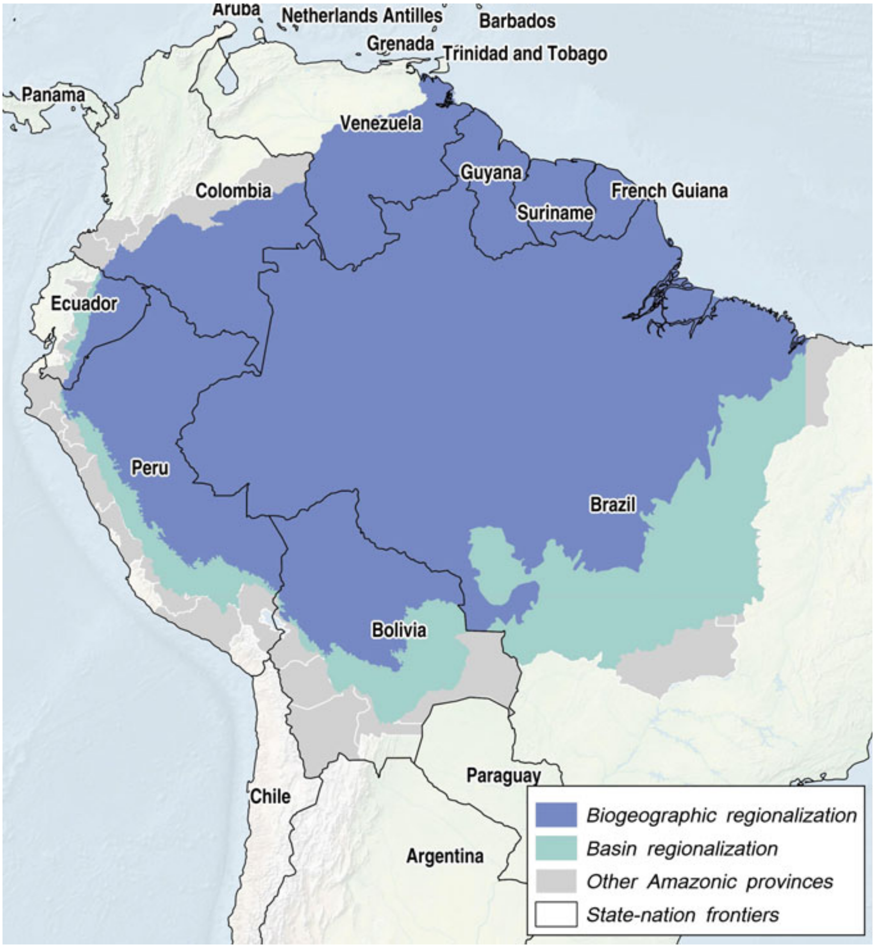


Fig. 1 Regionalization's limits and borders of the Amazon. *Source* drawn by the authors based on RAISG (2020)

countries; second, the methodologies used by each national system for counting the indigenous population are diverse and non-existent for some years. For this reason, the Economic Commission for Latin America and the Caribbean (ECLAC) had to make estimates of the indigenous population of Bolivia, Colombia, and Peru for the year 2010 based on figures from other years (ECLAC 2014).

Finally, the periodicity of the record and the methodological diversity is aggravated by regionalization problems that make comparison difficult such as the 1985 population (Domínguez 2001), with the record of 2009 and 2019 (RAISG 2009, 2019). The last two columns of Table 1 show that even with the RAISG base, different results can be obtained on Amazon's extent. In the first case, the calculation of each country's extension was made based on the regionalization by

Table 1 Data of total Amazonian and indigenous population in the Amazonian countries

Country	Total population 2010[1]	Total population 2019[1]	Indigenous population 2010[2]	Amazon population 1985[3]	Amazon population 2009[4a]	Amazonas population 2019[4b]
Bolivia[b]	10,048,590	11,513,100	6,216,026	600,000	1,233,727	6,572,024
Brazil	195,713,635	211,049,527	896,917	5,200,000	22,495,460	28,286,715
Colombia[b]	45,222,700	50,339,443	1,559,852	428,000	1,650,904	1,411,079
Ecuador	15,011,117	17,373,662	1,018,176	170,000	694,804	870,000
Guiana	749,436	782,766	ND	80,000	751,000	751,000
French Guiana[1]	208,171	259,865	ND		208,171	208,171
Peru[b]	29,027,674	32,510,453	7,021,271	1,850,000	3,675,292	4,076,404
Suriname	529,131	581,372	ND	ND	475,000	492,829
Venezuela[a]	28,439,940	28,515,829	724,592	25,000	1,907,721	2,231,932
Total	324,950,394	352,926,017	17,436,834	8,353,000	33,092,079	44,900,154

Source tabulated by the authors based on RAISG (2009, 2019); ECLAC (2014) and World Bank (2020). [1]World Bank (2020); [2]ECLAC (2014); [3]Domínguez (2001); [4a]RAISG (2009), [4b]RAISG (2019) (calculation made by RAISG based on political-administrative regionalization). [a]Official data on the indigenous population, 2011. [b]Indigenous population data estimated by ECLAC

hydrographic basins—in the second, according to each country's political-administrative divisions.

However, despite showing the first level of complexity in the data analyses and diagnoses for the Amazon (Table 1), it also allows us to trace general trends on Amazon's demographic and territorial dynamics, a topic that leads to the core of this section. In addition to the countries' population growth rate that shares Amazonian territory, Table 2 allows us to distinguish between the countries where

Table 2 Population growth and percentage of the total and protected Amazon territory

Country	Total growth (%)	Amazon growth 2009–2019 (%)	By country (%)	Amazon territory (%)	Protection area (%)
Bolivia	14.6	432.7	43.6	6.2	47.3
Brazil	7.8	25.7	58.8	64.3	26.3
Colombia	11.3	−14.5	42.3	6.2	83.0
Ecuador	15.7	25.2	46.7	1.5	45.9
Guiana	4.4	0.0	100	2.8	4.8
French Guiana	24.8	0.0	100	1.1	59.9
Peru	12.0	10.9	60.9	10.1	25.9
Suriname	9.9	3.8	100	2.1	15.9
Venezuela	0.3	17.0	49.5	5.8	66.3
Total	8.6	35.7		100.0	33.3

Source tabulated by the authors based on World Bank (2020), RAISG (2009, 2019) the Amazonian population grows above the national demographic increase, such as Brazil, Ecuador, Venezuela, and Bolivia, where trends are even observed migratory. From those countries where the Amazonian population decreases, such as Peru, Suriname, and Colombia, the trend toward depopulation is clearer.

In the same way, we relate these data with the amount of Amazonian territory shared by each country. The second reading of Table 2 allows us to see that 100% of the territory of French Guiana, Guiana, and Suriname are located on the Amazon. However, together they only represent 6% of the total. In an intermediate situation in Bolivia, Colombia, Ecuador, and Venezuela, with an Amazonian surface between 42 and 50% and the relative combined weight of 19.7%. Finally, the Amazonian territory of Brazil and Peru together represent 74% of the Amazon. Finally, the last column of Table 2 allows us to find that Brazil and Peru have the lowest percentages of protection, while Colombia and Venezuela have the highest percentages. From this perspective, Bolivia and Ecuador are in an intermediate situation, while the situation of Guiana and Suriname is diverse. In this sense, by 2018 the 33% of Amazonian territory has some type of protection by the nation-states, around of 2.5 from 7.7 million km^2.

Figure 2 shows the expansion evolution of Amazonian protection according to a conceptualization that includes four waves or phases defined by the distinctive character of each one. These phases were plotted on an illustrative map in Fig. 3. The expansion of the protected territories began in 1942 with the creation of the Tuni Condoriri National Park in the Murillo de La Paz province, Bolivia, with 91 km^2 in the upper Amazon basin. However, it was the “Law 2a of 1959 on the Nation’s forest economy and conservation of renewable resources” (República de Colombia 1959) which established the watershed for the protection of the lower basin: The Amazon Forest Reserve Zone comprises an area forest of 349 thousand km^2 in the departments of Amazonas, Caquetá, Guaviare, Guainía, and Vaupés, subject to a Forest Management Plan (art. 4), the regulation of forest exploitation by the government (art. 5) from Forest Management Plans (art. 6), and a soil study that would allow determining the sectors that could be used for agricultural activity (art. 3).

A few days later, Brazil joined this first a wave of protection of the Amazon with the Araguaia National Park creation, over an area of 5,586 km^2 of the basin of one of the most important tributaries of the Amazon. Two years later, Venezuela decreed the Imataca Forest Reserve between the State of Bolívar and the Federal Territory Delta Amacuro south of the Orinoco River’s mouth in an area of 37,485 km. Similarly, in 1961 Peru decreed the Cutervo National Park on two 82 km^2 polygons in the Andean department of Cajamarca. In just three years, Bolivia, Brazil, Colombia, Peru, and Venezuela exceeded 400 thousand km^2 of National Parks and Forest Reserves.

In the following 27 years, Brazil, Venezuela, Bolivia, and Peru managed to double the extension of protection to reach 800 thousand km^2 from the diversification of the mechanisms for creating protection, among which are the Bolivian Natural Areas of Integrated Management (1972), the Venezuelan Natural Monuments (1978), the Ecuadorian Recreation Areas and Fauna Production Reserves (1979), the Biological Reserves (1979), the Ecological Stations (1981)

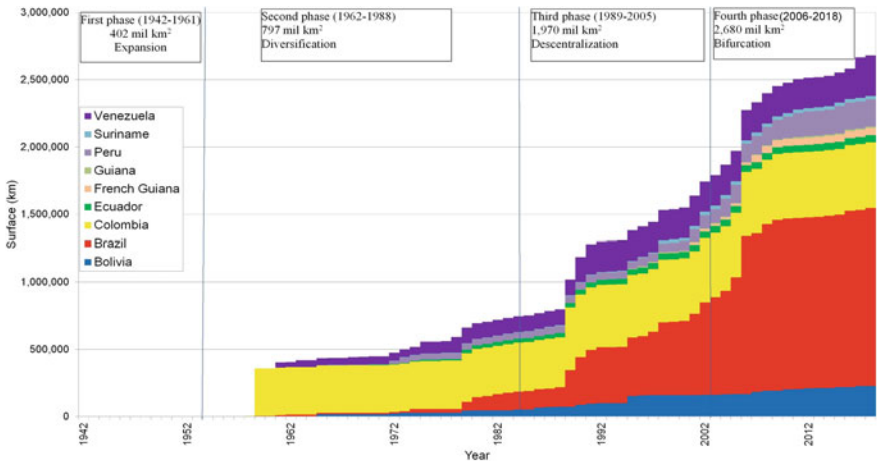


Fig. 2 Phase of the evolution of the protection of the Amazon 1942–2018. *Source* drawn by the authors based on RAISG (2020)

and the Brazilian Areas of Relevant Ecological Interest (1985), as well as the National Reserve (1972), the Historical and National Sanctuaries (1974), the Hunting Preserves (1977), and the Peruvian Protection Forests (1985). In this second wave, the strategies of three countries that had not previously participated were also integrated: the Natural Reserves of Wia Wia (687 km^2), Brinkheuvel (67 km^2), and Coppename Mouth (211 km^2) of Suriname in 1966, the Natural Site of Pointe Isére-Kanawa (13 km^2) of French Guiana and the Ecuadorian Protected Forests, which between 1970 and 1988 together added 4,086 km^2, a figure very similar to the Cayambe Coca National Park of (4,091 km^2) created in 1970.

The third wave reached an area of 1.9 million km^2 of protected areas, but more than the magnitude and speed of the growth of protected areas (more than a million km^2 in just 17 years) what characterizes this period is the importance it acquired the strategy for the creation of protected areas at the state and municipal level: 196 areas created compared to 12 in the previous period. In this framework, most of the parks and regional, state, and municipal are registered, as well as the Environmental Protection Areas (1989), the Sustainable Development Reserves (1990), the Extractive Reserve (1990), the Wildlife Refuge (2001) of Brazil, the Wildlife Reserve (1990), the Ecological Reserve (1994), the Scientific Reserve (1996), the Natural Landscape Heritage (2000), and the Watershed Protection Area (2001) in Bolivia. This is a particularly intense period of decentralization of protection and conservation in the Bolivian and Brazilian Amazon, although it was also promoted at the national level in other countries.

Finally, the current period could be characterized by the relative stagnation in the protection of the Amazon at all scales. Of the 172 areas decreed at the national level in the two earlier periods, it went to 90; while at the departmental scale of 196 it went to only 82. However, it is observed in terms of surface, the growth reaches

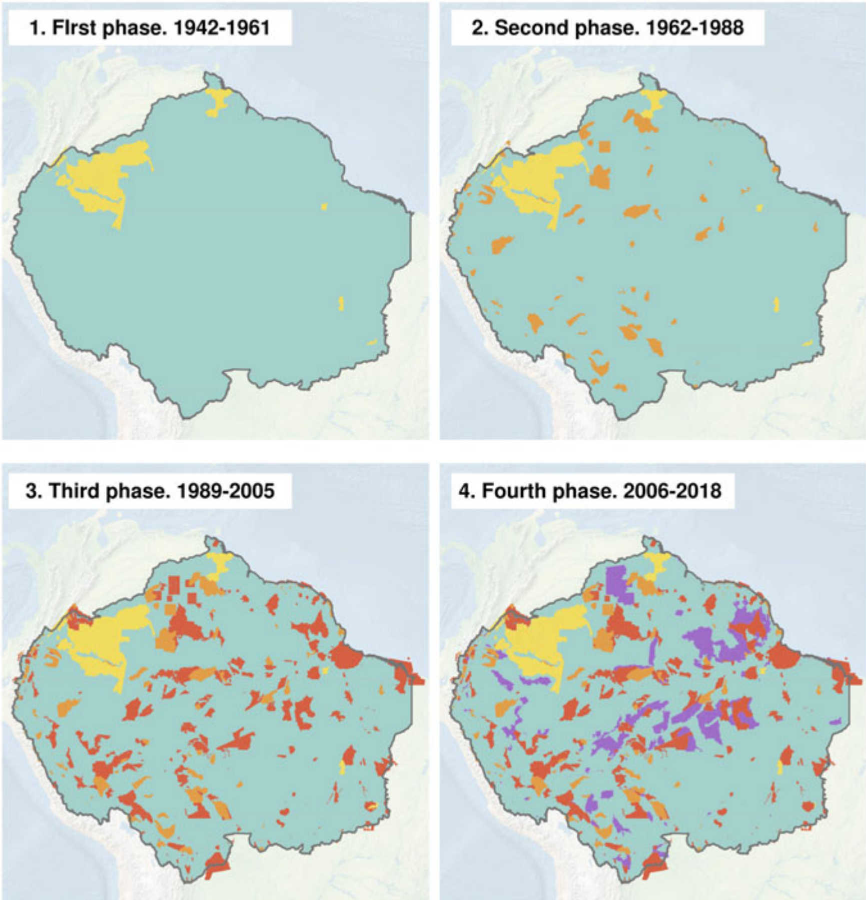


Fig. 3 Evolution of protection in the Amazon. *Source* prepared by the authors based on RAISG (2020), NaturalEarth

more than 710 thousand km in just 13 years. A novel aspect, in terms of protected areas creation, characterized this last period as a transition from biophysics elements protection to socio-environmental communities protection. This transition can be exemplified by the two new categories of the Ecuadorian government during this period: the Wildlife Refuge created in 2006 in the province of Zamora Chinchipe and the Morona Santiago Community Protection Area created in 2018. Another similar example is the Communal Reserves created in Peru since the earlier period but officially recognized since 2006, where forests are managed by indigenous communities with recognition from the state. However, the 16 Civil Society Nature Reserves created between 2014 and 2017 in the Colombian departments of Caquetá, Meta, Nariño, and Putumayo constitute an opposite example of this trend.

The cases of the Development Cooperative of Jima community, the limit of Ecuador, and the Yanesha Communal Reserve of Peru show that they are not properly protected areas focused on the communities that inhabit them. Rather the recognition by the state of the administrative-territorial carried out by social collectivities that conceive their territory as part of the common goods that sustain their community ways of life. On the other hand, the Colombian case forms a trend to the recognition of environmental protection from private property, which establishes a radically different and even contradictory conception of what was conceived as environmental conservation. In this sense, it is more right to characterize the last period as a bifurcation in which the state begins to delegate responsibility for environmental protection to both social collectives and private communities, without it being clear yet which will be the dominant trend.

2.2 Evolution of the Recognition of Indigenous Territories in the Amazon

In this section, the same exercise carried out with the natural protected areas is replicated for the analysis of the process of recognition of indigenous territories in the Amazon, which began in 1945 with the 47 km^2 of the Jarudore Indigenous Territory recognized by the Bororo ethnic group in Mato Grosso, Brazil. This experience was unique for 29 years until 1974 when the Peruvian state initiated a recognition policy. It included 88 Native Communities in the Loreto, Ucayali, and Cusco regions in pro of a current population of 66,104 people of eight ethnic groups, mainly Shipibo-Conibo, Machiguenga (Matsingenka), and Piro (Yine) over an area of 7,669 km^2. To this surface, another 19,334 km^2 were added in 1975, with which the current indigenous land structure of Peru was practically defined; in these two years, the Peruvian state recognized 20% of the 138 thousand km^2 of native communities in pro of 45% of the 600 thousand indigenous people whose lands are formally recognized today. Finally, in 1979 the Colombian state recognized 40 km as the Sibunduy Parte Alta Indigenous Reservation in the Putumayo department in pro of 314 people belonging to the Kamsa ethnic group.

With the incorporation of Colombia to the policy of recognition of indigenous territories in the Amazon, 51 thousand km^2 were reached in a period that lasted until 1981, when a recognized area of 62 thousand km^2 was reached in the first 37 years. In 1982, the second period of accelerated recognition of indigenous territories in the Amazon began, which is just 19 years went from 114 thousand to 1 million km^2 and from 474 thousand to 876 thousand people. Finally, between 2001 and 2016, a third wave occurred that reached 2.2 million km^2 and 1.2 million people. However, in this last period, 694 thousand km^2 and 229 thousand people are included in the Nationalities of Ecuador, the Indigenous Areas, Demarcated Indigenous Communities and Self-Demarcated Indigenous Territories of Venezuela, the Peasant Native Indigenous Territories of Bolivia, the Law Zones

Collective for Local Communities of French Guiana and the Indigenous Territories of Guiana and Suriname, of which the exact year of recognition is not available. Figures 4 and 5 show these three waves of recognition of indigenous territories in terms of surface area and population.

Regarding the area and the amount of population included in the indigenous territories, Brazil has 1.1 million km^2 of indigenous territory, distributed among 191 indigenous groups, although only six groups, among which 22,923 Yanomami stand out with 959 thousand km^2, concentrate 33% of these territories. As can be seen in Table 3, Venezuela has a self-recognized of 71% on the Venezuelan Amazon area as indigenous territories; 25 indigenous groups inhabit it, among which six ethnic groups predominate (Pemón, Yekuana, Yanomami, Piaroa, Warao, and E'ñapa) that concentrate 80% of the surface. Peru is the third most important

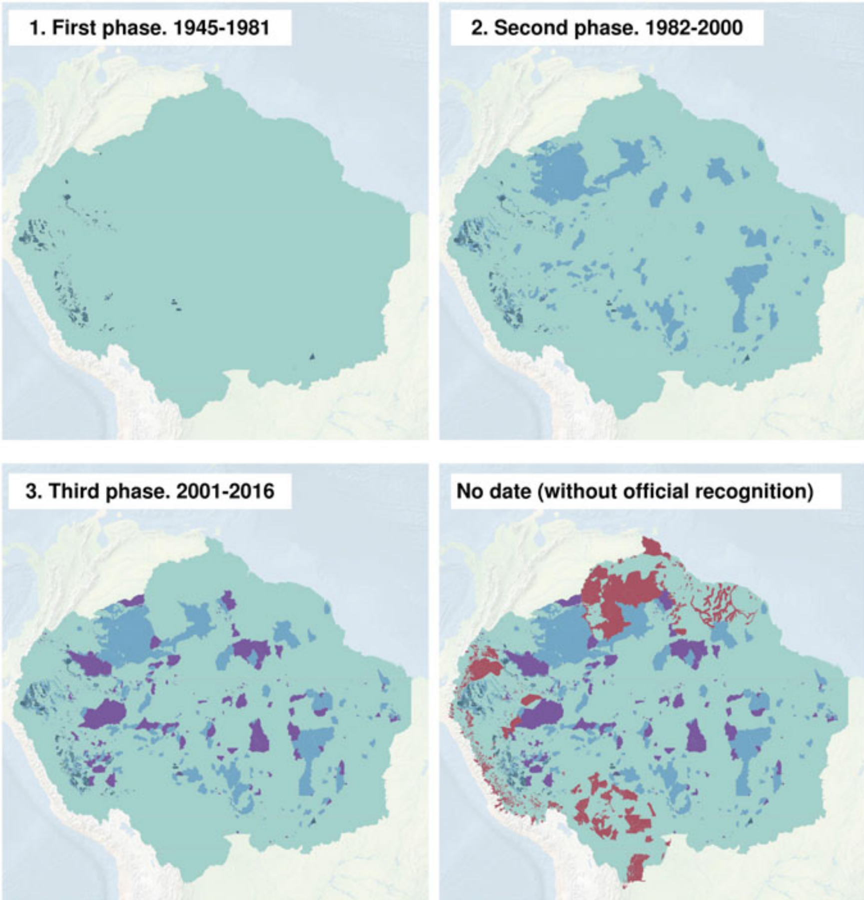


Fig. 4 Evolution phases of indigenous territories recognition in the Amazon 1945–2016. *Source* prepared by the authors based on RAISG (2020), NaturalEarth

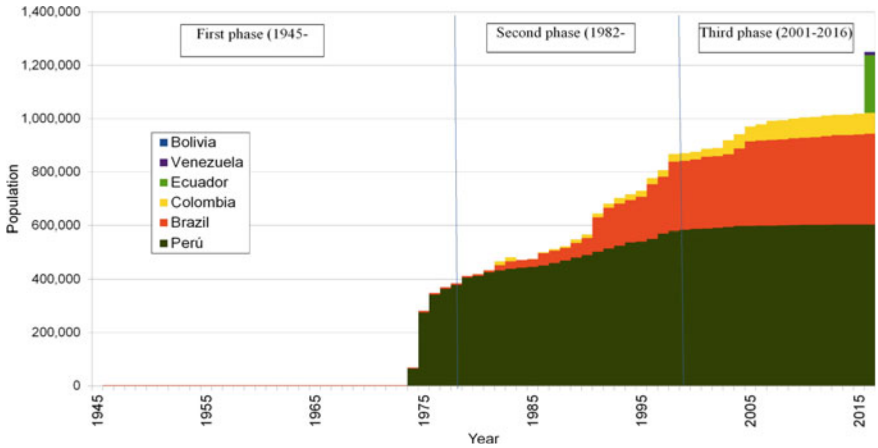


Fig. 5 Phases of evolution of the indigenous population in the Amazon 1945–2016. *Source* prepared by the authors based on RAISG (2020)

country and has 54 ethnic groups with more than 600 thousand inhabitants in recognized indigenous territories, among which the Aguaruna (Awajun), Asháninka, Mashco Piro, and Machiguenga (Matsigenka) ethnic groups stand out, which account for 20% from 35% of indigenous territories. In the case of Colombia, 6 of the 67 ethnic groups concentrate 72% of the indigenous territories and 46% of the population, among them the Witoto, Cubeo, Curripaco, Puinave Nuk, Cubeo, and Yacuna ethnic groups stand out. In Bolivia, the Guarayo, Guaraní Isoseño, Chiquitanos, Ava Guaraní, Itonamas, Yucarés, Mosetén, and Trinitario ethnic groups concentrate 50% of the indigenous territories, while in Ecuador, the Kichwa,

Table 3 Population and areas recognized as indigenous territories in the Amazon by country

Country	Amazon population 2019	Indigenous population (%)	Indigenous groups	Amazon surface (km^2)	Indigenous surface (%)
Brazil	6,572,024	5.14	191	5,006,316	23.10
Venezuela	28,286,715	0.04	25	453,915	71.78
Peru	1,411,079	42.78	54	782,820	35.96
Colombia	870,000	10.57	67	483,164	54.41
Bolivia	751,000	0.39	32	479,264	39.23
Ecuador	208,171	100	11	116,284	66.76
Suriname	4,076,404	ND	2	163,820	38.98
Guiana	492,829	ND	4	214,969	14.73
French Guiana	2,231,932	ND	16	86,504	8.27
Total	44,900,154	2.81	402	7,787,056	30.76

Source tabulated by the authors based on RAISG (2020)

Waorani, Shuar, Achuar, and Sapara ethnic groups concentrate 90% of the surface and 98% of the indigenous population considered. Finally, in the cases of Suriname, Guiana, and French Guiana, there is no information on the amount of the indigenous population that lives in indigenous territories.

2.3 The Andean–Amazon Region

The Andean region and the Amazon are intimately connected. Therefore, a co-dependency goes from the rivers coming from the Andes that drain their waters to the Amazon region and the aerial rivers that transport water to the Andes, having a beneficial climatic effect. However, these territories are being altered by the development of hydroelectric plants (Anderson et al. 2018), which go from the headwaters of the main rivers in the Andean region, this undoubtedly affects the connectivity of the Amazon and the inter-territorial interconnection, substantively threatening biodiversity and especially native and migratory species.

The Andean zone faces substantive problems related to the change in climatic seasonality, flow reduction in dry seasons with implications at the local level for common activities, extractive and exploitation activities, which has generated conflicts between locals and companies (Vuille 2013). Due to the increasing demand for energy and the abundant untapped potential, the construction of dams in the Andean–Amazon region has gained an important role, as many governments have chosen to design long-term energy plans; however, the lack of Strategic planning is presented as a challenge given the links between the Andes and the Amazon plain (Finer and Jenkins 2012). These actions may cause environmental damage in the upper basin of the rivers that threaten the diversity of the hydrographic basins that link The Andes and the Amazon, since the construction of 150 hydroelectric plants in this territory, considered as having a high environmental impact, is planned. This region provides a large amount of sediment, nutrients, and organic matter to the Amazonian plain, making this space one of the most productive ecosystems on the planet. Many species of fish travel many kilometers to spawn and reproduce near the Andean mountain range. These actions can give to the reduction of vegetation cover due to the construction of roads, electrical transmission lines and downstream floods, as well as changes in the yield of fish upstream and downstream, sedimentation of the reservoir, emissions of greenhouse gases, and mercury contamination (Forsberg et al. 2017).

3 Territorial Management and Governance of Indigenous Peoples

The discussion that comprises the forms of use and relationship with space has a direct link with the forms of use, recognition, and management of power. And when we deal with power, we inevitably associate it with an open field that refers to the idea of power and strength (Raffestin 1993). Power is related to the ability to impose a will or want and strength in the form of executing an order, directed by a person or emanating from a social group (Gonçalves 2009). Thus, in white, patriarchal, and western society, the state-organized civil society identifies a threat and a counterpoint to be removed. It dedicates its strength and power to isolating and blocking the initiatives and creative possibilities of social, union, and popular movements. It is clear that a vertical and hierarchical society exercises hegemony. Social relations are always developed either in the form of complicity or in the authoritarian way and obedience between a superior and an inferior (Chauí 2011).

3.1 Territorial Management

Thus carrying out the management of the territory also implies considering the asymmetric relations of power and the situation of domination in politics. Furthermore, political power is a type of relationship between subjects that needs to be completed with the definition of power as possession of the means that allow a programmed advantage or effect to be achieved. Therefore, to understand and exercise territorial management and governance in the first aspect, it is necessary to distinguish between governance and governability (Santos 1997). In theory, governability is related to ways of identifying absences and social problems. In this sense, it seeks to transform them into public policies that meet the demands in society, converging and solving the problems to be solved or at least to live with them (Kersbergen and Waarden 2004). But in practice, this is not what we find in reality, as it is common within the state to watch political interest groups from circumstantial party alliances that are convenient to a minority in the name of coalition and governability. In its turn, in the liberal perspective, governance is understood as the capacity of action that the state has for the development and implementation of public policies and achieving collective goals. In this context, governance reveals experiences of the public power in reversing clientelistic practices; that is, good governance helps dismantle interest groups (Gonçalves 2008).

When we focus our attention on power relations and the issue of management and territorial governance in the Amazon region, it is important to mention the Treaty for Amazonian Cooperation (TAC) signed between Brazil, Bolivia, Colombia, Ecuador, Guiana, Peru, Suriname, and Venezuela (OTCA 1978). This region comprises 40 million people occupying 40% of South American territory. It is home to the largest mega-diverse forest in the world, which is home to 20% of all existing species of fauna and flora (Carrasco 1978). The Amazon hydrographic basin has about 20% of the fresh water on the planet's surface. The Amazon hydrological cycle feeds complex aquifers and groundwater system, which can cover an area of almost four million km^2.

Formally, Amazonian regional cooperation was originated in 1978. The eight Amazonian countries in Brasilia signed the TAC with the goal of promoting the integral development of the region and the well-being of its populations, in addition to strengthening the sovereignty of the countries over their Amazonian territories. Subsequently, the legal instrument of a technical nature was reaffirmed in 1995 by the foreign ministers of the member countries, meeting in Lima, Peru, who agreed to create the Organization Treaty Cooperation Amazon (OTCA), to institutionally strengthen the OTCA and give international personality. In turn, the amendment to the treaty was endorsed and approved in Caracas, Venezuela, in 1998, allowing the establishment of the permanent OTCA secretariat in Brasilia. With this, we have a tool for the national states with resources and information to check the region and carry out projects in areas such as the environment, indigenous affairs, water resources, science and technology, health, tourism, and social inclusion. It is 42 years since the signing of the OTCA, and in 2010, the strategic agenda of Amazonian cooperation was revised with planning and delimitation of the organization's aims for the next decade (OTCA 2011). So far, we have described the management of the territory that was and is exercised hegemonically and holds the structure of the Western model of a modern colonial state.

3.2 Territorial Governance

Next, we will bring some perspectives. A little more different from the one presented above. These are experiences of territorial governance in the hybrid form of control between the state and indigenous communities and which are also being developed in the Amazon region exclusively by people from different organizations and indigenous nations. It is important to note that such experiences are not restricted to the border of a nation-state; on the contrary, they are referenced in community groups and associations that develop specific forms of dominance and government in their territories (Gonçalves 2008). We would like to draw attention to the experiences that emerged from meetings of exchanges of knowledge triggered by organizations and social movements around the end of the 90s in the region on the border between Brazil, Peru, and Bolivia (Diegues 2000) and were added later in more regions in Brazil (Gavazzi 2007). Such exchanges brought contributions both to the practices of handling natural assets and people and actions with the surroundings and territorial management.

The Indigenous Lands (ILs) tenure regime outlined in legal texts, although stated in less explicit terms than other South American Constitutions (Bolivia, Ecuador), in Brazil the idea of cultural pluralism, or multiculturalism, enjoys constitutional recognition, and indigenous peoples hold significant rights over their territories and natural resources (Lauriola 2013). The first Territorial and Environmental Management Plans for Indigenous Lands appeared initially in the Brazilian part of the Ethnomapping Workshops, and activities carried out by the state government of Acre in conjunction with the Association of the Movement of indigenous agroforestry agents (Correia 2007; Grupioni and Kahn 2013). The Ethnomapping project intended to promote territorial ordering, conservation, and the rational use of natural and agroforestry assets in the ILs, and to provide answers or at least minimize the serious conflict scenario experienced by some indigenous peoples with Peruvian loggers, traffickers, and others, in the border region, where there are many ILs and Conservation Units, both on the Brazilian side, on the Bolivian and Peruvian side. The themes dealt with in the Territorial Management Plans (Grupioni and Kahn 2013) seek to apprehend the specific realities of each indigenous community more generally, related to issues such as forest and floristic resources, hunting, fishing, agroforestry plantations, management and creation of wild and domestic animals, water resources, village organization, norms and rules including community rights and duties, community planning, environmental health, garbage, and basic sanitation, surveillance and inspection, culture, language issues, differentiated bilingual intercultural school education, ethnourism, communication, processing, community planning, monitoring deforestation, controlling the entry of outsiders into indigenous land, protection of isolated people, cross-border situation, climate change and environmental services, biopiracy, and review of indigenous land boundaries.

With some country variations for parents, national legislation recognizes ILs that are called native communities (Medeiros 2013), indigenous territories (Cavalcante 2016), indigenous reserves, or even indigenous safeguards (Bello 2011a). Although

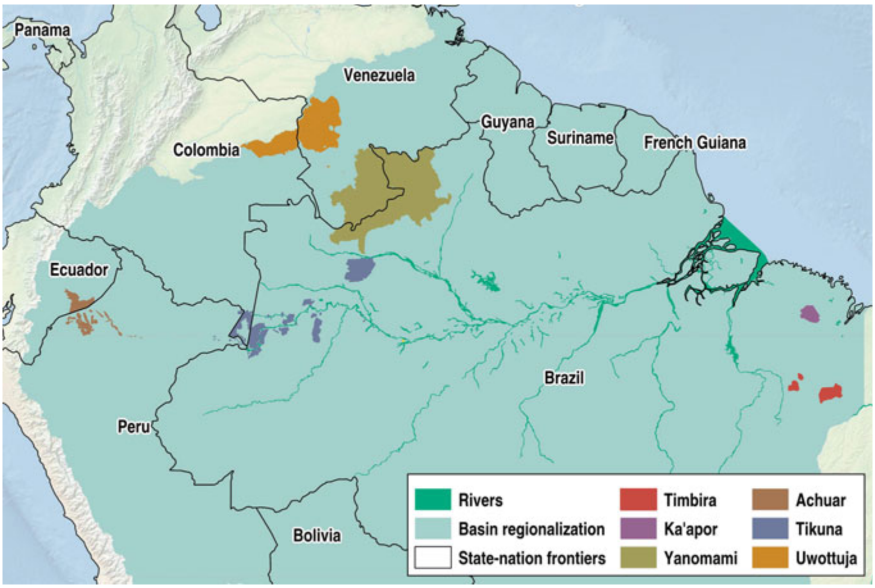


Fig. 6 Some indigenous peoples about territorial governance in the Amazon region. *Source* drawn by the authors based on RAISG (2020)

linked to a national state's legislation, they are spaces for the reproduction of life and which are inalienable for collective use and community practices guided by a special autonomy statute that follows custom, tradition, culture, and its own agenda. The ILs involves two complementary levels (Lauriola 2013): (1) full recognition of the collective dimension of indigenous territoriality, in forms and scales sufficient for their commons' status to be preserved; and (2) respect, understanding, value and support for local internal organizations, which empower indigenous juridical and political systems through adapted public policies set within a framework enabling juridical pluralism.

In this sense, we will bring some experiences of territorial governance in the Amazon region as a whole represented from the territorialities (Fig. 6): Ka'apor, Yanomami, Timbira, Achuar, Tikuna, and Piaroa. With this, we hope to illustrate that some peoples are carrying out on their own initiative the organization of their territories and the territories bordering their own since the state does not always assume its political-legal function.

3.2.1 Territoriality Ka'apor

The territory inhabited by the Ka'apor, in Alto Turiaçu Indigenous Land, in Brazil, was demarcated with an area of 530,524 ha (Camarinha 2019). It is formed by approximately sixteen local groups, in an area comprising seven municipalities located in two sub-regions of Maranhão: Gurupi and Pindaré. It constitutes the vast territory occupied by this ethnic group which, due to factors specific to the group and external to it, lead family units to make permanent changes or displacements within the territory, among them, by the constitution of marriage bonds, internal conflicts between family groups, conflict situations with invaders in the territory, search for food looking for nature goods such as fruit and seed collection, among other factors.

The Ka'apor give importance to the relations established with their territory, where the traditional knowledge acquired in relation to the forest turns them into guardians of their place of belonging. The local groups have different types of houses, most of which are characterized by a closed room made of clay, leaves of buriti, or babassu palms. However, some houses have only a cover of palm leaves with their sides fully open, as is the case of those present in the nuclei with a smaller population. They are houses built basically by family groups that carry out permanent displacement in the territory. In addition to the houses, the space of the nucleus, especially of the nuclei with a larger population, includes other constructions, such as the health unit post, the flour house, and the schools.

The local Ka'apor groups are constituted in their social organization by family units formed by uterine residences, determining the political power. Therefore, the number of chiefs will be determined by the number of residential units (Ribeiro 1996). It was found that in most residential units, there is a predominance of uxorilocal residence, where men are forced to leave their first home to join their wife's family members. Thus, residential units tend to have a political power of control and decision based on co-residence regarding the precept of descent. The author points out that the chief's political power is limited to arranging the marriages of his royal and classificatory sisters to men willing to marry in their family unit. In the same way, marriage contracts of the same model can occur, now with the father's sister's daughter and the sister's daughter.

The Ka'apor's relationship with their territory is guided by the reproduction of knowledge, environmental, and cultural practices aimed at the social reproduction of the group. The group has a particular relationship with all forms of life in its territory, giving them a social function in its defense. With that, they transform the sources of knowledge into elements that affirm a symbolic identity, but, above all, ethnic. Among the expressive cultural languages of the Ka'apor being is the art of featherwork historically developed by the group. In addition to birds, other nature beings are present in their lyrics, sounds, and handicrafts. Different cultural languages have great symbolic power that guides life projects in this society, as is the case with materials made by parents to be delivered to children after birth when they are embedded in them, something designed for the child's future when becoming an adult. In the case of boys, most of them receive bows, wooden-tipped arrows, in miniatures, to become good warriors. And, the girls receive a hammock, basket, sieve, to become able to make domestic utensils.

3.2.2 Territoriality Yanomami

The Yanomami inhabit a territory of approximately 22 million hectares between Brazil and Venezuela, north of the Amazon rainforest. There are approximately 32 thousand people who speak at least five different languages of the Yanomami linguistic family on 700 communities (Tillett et al. 2014). The communities are spread over environments ranging from "altitude fields," which are characterized by savanna vegetation located at more than 1,000 m altitudes, from the mountains covered with dense forests to the plains cut by meandering rivers and forest vegetation.

The Yanomami territories on the Brazilian side suffer from situations of conflict with farmers-ranchers who illegally occupied the interior of the reserve. Settlement projects impulsed by the government in the 1970s tried to promote the economic growth of the region, concentrating new populated cities on the eastern border of the Yanomami indigenous territory, and this resulted in an increase in the number of invasions by loggers and illegal fishermen (Barbosa 1993; Barni et al. 2015). This happens in a region of low population density of the Yanomami on a border of more than 750 km, making inspection very difficult. Another problem was the invasion by miners since the late 1980s in the Yanomami territories (Rocha and Andujar 2007). It is estimated that at the time, more than 40 thousand illegal miners (garimpeiros) worked in the central region of TI, in contrast to the 10,000 Yanomami that occupied it, and this caused a serious ecological and health impact (Bello and Tillett 2015).

The Yanomami's managed to articulate forms of resistance and defense of their territories. With support from organizations such as ISA (Instituto Socioambiental), HAY (Hutukara Associação Yanomami), Wataniba and HOY (Horonami Associação Yanomami) are developing essential monitoring actions for territorial management and governance (Benfica et al. 2017). Such territorial security and protection actions consist of systematizing and forwarding complaints of invasions to the responsible institutions. The basis of this process is a radio network implemented and maintained internally and coordinated by the natives. Due to the great distances that separate the communities from the communities' headquarters, the complaints arrive via radio and are forwarded to Fundação Nacional do Índio (FUNAI) and the Federal Police, on the Brazilian side, and stored in a database. Another strategy to hinder invasions is the distribution of the Yanomami to occupy more distant territories and on the borders of the indigenous territory. Thus, they can use resources in regions that are the gateway for invaders—garimpeiros, loggers, and fishermen. In the Ajarani region, the Territorial Management Project does activities to structure the collection and trade of Brazil nuts. The collection areas, which are at strategic points to prevent invasions, are being used frequently by the communities.

Finally, it is important to highlight the systematization and storage in a database of georeferenced information. The Yanomami georeferenced information system covers the Yanomami territory in both Brazil and Venezuela and has helped both in the surveillance and control of the territory as well as to guide the public policies and actions of national governments.

3.2.3 Territoriality Timbira

The Timbira peoples who belong to the Jê linguistic family live in Brazil, and in the states we now call Pará (Gavião Parkatejê and Kuykatejẽ), Maranhão (Krikati, Gavião Pykobjê, Canela-Apanjekra, Canela-Ramkokamekra, Krepynkatejê, and Krênjê) and Tocantins (Apinayé and Krahô) (Grupioni and Kahn 2013). Although in contact with non-indigenous society for more than 200 years, they retain their own language and political autonomy. It has a general population of approximately nine thousand people, living in more than 50 villages. Its territories represent important areas of preservation and conservation of the Cerrado. Unfortunately, it has been suffering from the gradual advance of the agricultural frontier in the region, plus development and infrastructure projects centered on the modern colonial model of destructive capitalism.

Among the main problems affecting the Timbira territories, we highlight the major works designed by the state, such as municipal, state, and federal highways (Transamazônica and Belém-Brasília), power transmission lines, railways of the Ferro-Carajá Project and North-South, waterway Araguaia-Tocantins, soy and eucalyptus monocultures, construction of hydroelectric plants (Estreito, Serra Quebrada, Santa Isabel, and Marabá) (Grupioni and Kahn 2013). This results in the growing change in indigenous territory, generating: soil losses and silting of rivers, contamination of the soil by the use of pesticides and chemical fertilizers, loss of extensive areas of fruit occurrence for collection, due to the flooding caused by dams (Grupioni and Kahn 2013). In turn, the advancement of the agricultural frontier disrupts the land network in the region, intensifying conflicts and heating up the land market. The big beneficiaries are the big soy producers who start to put pressure on the areas bordering the ILs and threaten food autonomy and local production. These impacts directly affect the well-being of the Timbira peoples, as they interfere with the communities' means of production.

In this context, the *Timbira Wyty Catë Association* created in 1994 and the *Centro de Trabalho Indigenista* play an important role in training and preparing young people for exchanges and in territorial governance. In the tradition of the autonomy of the Timbira peoples, educational activities are developed such as the training of young Timbira researchers using ethnomapping as a methodological tool to address the issue of nature in the Timbira Indigenous Lands (Grupioni and Kahn 2013). Participatory mapping is carried out within the scope of the Timbira School to be used as tools for discussion and reflection of problems and for the production of teaching materials also diagnosing and planning for territorial and environmental management of Indigenous Lands. In fact, they are treated in a complementary way to the traditional management strategies exercised for centuries by the Timbira, based on the practices and techniques of use and management of nature.

Among other territorial management actions practiced by Tibira, we highlight: monitoring the surroundings of indigenous territories, monitoring and reporting irregularities in major development work for the region and/or participating in the preparation of Environmental Impact Studies, specifically the power plants of Estreito, Santa Isabel, Serra Quebrada and the Araguaia-Tocantins Waterway and the Ferro-Carajás Project, among others (Grupioni and Kahn 2013). Also, the monitoring of land issues, regularization and review of boundaries of the Timbira Lands such as ILs Apinajé (TO) and ILs Kricati (MA) in the 1980s/1990s, ILs Canela (MA) and ILs Porquinhos (MA) in the 2000s and currently ILs Governador (MA). For a recovery of degraded areas, planting, and densification of areas with native species. The actions are priority strategies for guaranteeing the sustainability and integrity of territories, for strengthening traditional knowledge systems, ways of using nature and reproducing Timbira territoriality as a whole.

3.2.4 Territoriality Achuar

The territory of the Peruvian Amazon has concentrated environmental pressures, due to state concessions to extractive companies such as oil, mining, and logging companies (Martínez et al. 2007). In this context, the Achuar people had to reinvent strategies for the protection of their territory to the constitutional forms, promoting the implementation of life plans as a legal instrument to establish the guidelines of territorial management and governance before the state (Espinosa 2014).

The Achuar people occupy the national states of Peru and Ecuador, which leaves the people divided according to modern states, but they maintain and exercise their spatial continuity as a people. According to data from the Peruvian government (2007), there are an estimated 11,000 people. Likewise, the Ecuadorian government (2010) estimates 8,000 people, a total of 19,000 people from the Achuar people (Espinosa 2014).

In the Peruvian case, there are different forms of use, possession, management, access, and the administration that define the socio-economic relationship of the indigenous people with their habitat, maintaining territorial unity. This guarantees the protection of all elements: surface, subsoil, forest canopy, waters, and lakes, fauna, and flora, genetic resources, the different ecosystems, regardless of their economic classification (FENAP 2018).

In Peru, life plans have been drawn up as a form of governance and territorial protection. It was carried out with the participation of the majority of the Achuar communities. Interacting in the fieldwork and internal debates, with the support of local Achuarti Irúntramu (ATI) organizations in the area of the Huitoyacu River and tributaries of the Morona, the Achuar Chayat Organization (Orach) in the Huasaga River basin and the Federation of Native Communities of the Corrientes River (Feconaco) in the Corrientes River basin, all grouped in turn in the Federation of the Achuar Nationality of Peru (FENAP) participated in this process that culminated in early 2003 (FENAP 2003).

The Achuar people, starting from the elaboration of their systematized life plan, address critical issues such as territory, political organization, and civil and political rights, health, food and traditional medicine, identity and culture, education and economy (FENAP 2003). Proposals lay their foundations in the coordination bodies of the different communities and organizational bases to work under a common objective. Highlighting important details in their plan with a vision of the future includes those legal mechanisms that would allow them to achieve the proposed goals.

3.2.5 Territoriality Tikuna

Colombian legislation since 1991 includes the Indigenous Territory Entities (ETI), creating a figure of indigenous protection of national order. The areas targeted are indigenous reservations and associations that can access public resources within the framework of their own life plans, which must be incorporated and/or adjusted to the national development plans.

The Tikuna people are distributed between Colombia, Peru, and Brazil, which in sum exceeds a population of approximately 67,000 inhabitants. In Colombia, they are located south of the Amazon on the Cotuhé River, Ventura channel, Santa Lucía, Buenos Aires, and in the Leticia area of influence. They settle in the reservations of San Antonio de Los Lagos, San Sebastián, El Vergel, Macedonia, Mocagua, and Cothué-Putumayo, in the Department of Amazonas (ONIC 2016). The DANE census reported (2018) 13,842 people registering a significant increase compared to the 2005 data that 7,879 people were registered (DANE 2019).

Regarding life plans, they present limitations for describing its territory in the format of the surrounding society. The Tíkuna people think the territory is based on cosmological and ontological principles, whose perspective is poorly understood by western culture. In this sense, they had to adapt their understanding of the territory toward a less complex vision, in order to achieve a dialogue with society and the state. In order to be included in the design and implementation of socio-productive projects, within the discursive scheme of biodiversity, conservation, sustainable development, natural resource management, and others (Vieco Albarracín 2010), territorial governance is based mainly where the communities of each sector are included; this allows structured planning for each community.

The communities have been planned in sectors, assigning them productive activities (a) near Puerto Nariño of an artisanal productive nature; (b) area of influence of the Amazon river of a less the productive character of fish farming and livestock; (c) San Juan del Socó with tourist activities and raising small animals. This form of planning allows maintaining a difference between the reservations located in the Amazonian trapezoid and contributes to the construction and governance of their ancestral habitats.

3.2.6 Territoriality Piaroa

In Venezuela since 1999, the rights of indigenous people have been widely recognized, considering in the constitutional text, developing their main requirements, in their confirmation as subjects full of collective and specific rights with cultural and individual identities, different from the surrounding national society (Bello 2011b).

The Piaroa (*Uwottuja*) in the Amazon state of Venezuela has border with Colombia, living in this two countries but maintaining its cultural integrity, with a population of 19,293 people (INE 2011) and 1,127 inhabitants Colombian (DANE 2019). The organizational experience of the in Venezuela has allowed the government of its territories. Many situations in the face of the invasion of Piaroa territories by different projects and activities are not allowed in indigenous sacred places.

The life plan of the Piaroa in Venezuela was an ethno-cartographic experience that started parallel to the demarcation process and from an autochthonous work among indigenous inhabitants. This was a planning instrument for their future, aiming to safeguard their ancestral culture against the constant besiegement of territorial invasion for mining (Rodd 2018). These actions ensure the continuity of the generation indigenous and also guarantee the existence of the ecosystems where they live, self-managing, and conserving the natural resources of these ancestral territories (Morales and Quispe 2014). For practical purposes, the territory has been divided into five areas: Cuao, Autana, Sipapo, Guayapo, and Orinoco medium, according to this division, each space corresponds to a vital area for the survival of Piaroa culture. This territory represents large areas of land use: (a) forest, (b) water resources, (c) agrofood supply, (d) biological diversity as animals and phyto-medical resources (Aguilar Castro et al. 2014). From these proper characteristics, it is recognized that there is an ancestral property management that results in a proper territorial government built from community work in communities and actors that collaborate in systematization.

4 Amazonian Territory Pressures

The Amazon basin is home to rich biodiversity with many rare, endemic and unknown species, and this diversity is extremely vulnerable to large-scale human actions (Azevedo-Santos et al. 2016). The expansion of large territories of concessions for exploitation, exploitation and prospecting will aggravate the ecological and biodiversity disaster scenario in the Amazon. It will suffer irreversible losses in a short period of time on a wide scale with global impacts.

An example is the oil exploitation in territories of the western Amazon (Finer et al. 2008), the spills that have occurred have significantly affected freshwater biodiversity, ecosystem services and the livelihoods of local populations throughout the river bed. The constructions of large dams in Brazil have affected local populations and their livelihoods on a high-impact scale.

The Amazon biome is intimately related to natural and anthropic actions (Claudino-Sales 2019), however, the presence of fire at such alarming scales has as its exclusive source the anthropic action, in that sense, and heat sources are closely related to agribusiness, mining and the logging sector.

These impacts imply the need for changes at many levels in Amazonian countries. Measures are needed to provide alerts to environmental authorities and development planners. Implementing a system to monitor water quality and pollution levels is a minimal first step in promoting political action. The Amazonian countries must establish sustainable limits to the geographical expansion of extractive and energy activities. Development plans should avoid concessions for exploration, prospecting and exploitation in hydrographic bases and stretches of rivers that provide essential services (e.g., fishing, wetlands, nutrient cycling) or that have high endemic biodiversity.

More importantly, fundamental changes are needed in the decision-making process to arrive at decisions that involve the voice of local populations from a timely, free, and informed perspective. These decisions must be made with information on environmental and social impacts in hand and with institutional mechanisms for the democratic discussion of the issues involved before making the decision to implement a project in practice. Unfortunately, this is not the case yet in any of the Amazonian countries. The recent history of Amazonian hydroelectric dams provides clear examples of the lack of such a procedure and order of events in Brazil (Fearnside 2014, 2015). The authorities of the Amazonian countries must reconsider the unprecedented development schemes envisaged for the Amazon basin, which will cause major changes in hydrology, land use, and water quality. The international community could and should actively participate in these agendas, particularly as the Amazon provides services on a global scale (for example, the climate).

4.1 Ecosystem of Amazonia

The Amazon as a whole presents the ecological, sociological, and cultural diversity that links different actors and indigenous populations, extractivist, quilombolas, riverside, among others (Antunes et al. 2019). The Amazonian biodiversity exploitation is palpable at every step, and day after day it is clear that biological diversity is rapidly disappearing (Nobre et al. 2016). Biodiversity in the Amazon is threatened by a model of exploitation prevailing, which does not adequately consider its intrinsic characteristics. Globalization accentuates the agriculture advance that is reducing the forest mass. The destruction of habitats is the main cause of the loss of biodiversity (Pasquis 2006).

In the Amazon, the general condition of the ecosystems is still relatively good on average. However, unsustainable economic activities, weak cross-sector planning, and mounting pressure fronts advancing carry critical threats to the biome. The importance ignored and the idea that Amazon was an empty space has allowed colonization and occupation policies to multiply. The lack of knowledge of the specificities of this particular region caused the large numbers of populations that arrived there, and in some cases ambitious agricultural projects, to install unsuitable production systems. This process much affected local socio-environmental systems. Numerous conflicts for land or for access to natural resources arose and acculturation of local populations caused traditional knowledge to begin a lost more rapidly than biodiversity itself.

Currently, biodiversity in the Amazon region is being lost at a high rate. One example of this is the recent alarming rates of deforestation. This means that many unique ecosystems and endemic species have become extinct and irretrievably lost (de Area Leão Pereira et al. 2019). The change in the use of the Amazonian land due to the growth of economic activities, at the adoption of new forms of extractive development, the infrastructure construction, and the establishment of human settlements, are only a small part of its transformation (RAISG 2012). The situation has led to a significant change in the use of its natural resources, causing deforestation processes that result in the fragmentation of the landscape and the loss of biodiversity throughout the region. The result is the loss of environmental goods and services, which have as a final result fewer development opportunities for the populations settled in the region (Siqueira-Gay et al. 2020).

4.2 Biodiversity Loss

Biodiversity is essential for human well-being, but biodiversity has declined throughout human history. Species loss and ecosystem degradation are likely to accelerate even more in the coming years (Johnson et al. 2017). The loss of environmental biodiversity is critical at a global level, and conservation strategies have been seriously affected, mainly due to the lack of socio-spatial data that evidence threats to biodiversity (Joppa et al. 2016). Research indicates a high chance of sharp declines in biodiversity due to habitat reduction to low levels in the landscape. On the other hand, scientific evidence indicates that the development of anthropic activities minimizes biodiversity in landscapes with little contact or little fragmentation.

The Amazon rainforest is possibly the most the species-rich terrestrial ecosystem in the world, a product of geology (lifting of the Andes), it had a fundamental impact on the Amazonian landscape creating drainage patterns and a large influx of sediments throughout this territory, this process enriched the Amazon regions mainly the western Amazon (Hoorn et al. 2010). Amazon rainforests have disappeared at an accelerating rate in the last 50 years due to deforestation into areas open to agriculture, posing a high risk of irreversible changes in biodiversity and ecosystems. Climate change presents other risks to the stability of the forests. Studies suggest that "tipping points" should not be transgressed: 4 °C of global warming or 40% of the total deforested area (Nobre et al. 2016).

The hydroclimate variability in the Amazon is fundamental to understanding its interrelationships and the relationship between the impacts of climate change and people perceptions at different scales (Becerra et al. 2020). In this sense, according to scientific data demonstrating the coherent variability of rainfall in tropical–subtropical South America, the variability of rainfall on an orbital the scale between western and eastern Amazonia exhibits a quasi-dipole pattern. However, during the last ice age, the records imply a modest increase in the amount of precipitation in the western Amazon but a significant drying in the eastern Amazon, suggesting that greater biodiversity in the western Amazon, contrary to the "hypothesis of refuge," is maintained in relatively stable climatic conditions. In contrast, glacial–interglacial climate disturbances (Cheng et al. 2013) could have been cases of less than the gain of biodiversity in eastern Amazonia, where forests may have been more susceptible to fragmentation in response to big changes in the hydroclimate.

The increase in deforestation dramatically increases the probabilities of classifying species as threatened and so in decline, and its effects are mainly high in little-intervened territories, already fragmented forests have greater effects on biodiversity (Betts et al. 2017). In this sense, it should aim to increase efforts to protect intact forests to cut deforestation rates and avoid a wave of extinction on a global scale.

The Amazon and its diversity are being threatened as a result of extractive and energy activities (Azevedo-Santos et al. 2016), creating a real biological and river deterioration in the region, with important effects on local populations. Examples of extractive and energy activities in protected natural areas that overlap with indigenous territories—or not—are clear in Brazil due to the large dams construction, mining activities, and expansion of the agricultural frontier, in Ecuador oil spills, in Venezuela the Mining activities (legal and illegal), just to cite a few examples, in this sense, these activities would be much affecting ecological services and environmental flows as well as the local livelihoods of the populations that live in the vast Amazonian territory.

4.3 Effects of Deforestation and Extractive Activities on Local Livelihoods

From the point of view of policies for solving the issue of deforestation and other extractive actions in the Amazon, they have focused mainly on reducing deforestation as a biodiversity conservation strategy; however, little has been considered the impacts anthropogenic in forests, where selective logging, smaller-scale (controlled) forest fires can be considered locally. This new approach allows knowing the effects on primary forests and evaluating the disturbances to which they are subjected, as well as knowing the loss of forests (Barlow et al. 2016). Considering this scenario, it is possible to show that there is an urgent need for the application of pertinent and adequate policies not only as direct actions to keep up forest cover but also to consider the hyper ecosystem diversity of the Amazon.

The cultural and linguistic diversity of the Amazon may be at risk, many linguists have described that the loss of the world's languages may be between 50 and 90%. It is also highlighted that there is a strong link with biological diversity, although this may vary much in each region, although the strong geographical agreement between biological and linguistic diversity in many areas advocates some form of functional connection (Gorenflo et al. 2012). It is interesting how languages and regions with high biodiversity can coexist with one or more specific conservation priorities, here defined as endangered species and protected areas, which mark particular locations important for maintaining both forms of diversity. However, in the Amazon, many protected areas are subject to strong pressures and threats that hinder their purpose (Paiva et al. 2020).

Oil and gas concessions now cover vast swaths of the western Amazon, including protected areas and indigenous territories. The Yasuní Initiative—ITT, Ecuador's innovative proposal to leave close to one billion barrels of oil locked beneath the Yasuní National Park, is the first major effort to reverse this trend. We give a concise description of the initiative, including an in-depth look at its widely praised goals of protecting biodiversity, about indigenous people' territory, and combating climate change. We also discussed the persistent caveats of the proposal, such as technical issues on the generation of financial resources to replace lost oil revenues. We conclude that the Yasuní—ITT Initiative is a breakthrough that could set a precedent to prevent damage to oil and gas development in sensitive areas (Finer et al. 2010).

4.4 Agricultural Land-Use Changes

The Amazon basin is home to a mega-diversity of terrestrial and aquatic plants and animals. The mechanisms that sustain this biodiversity are the fluctuations of the water level, the fluvial dynamics, and the intense flow of genes due to the permanent integration of the climatological, geomorphological, and biological components of the system (Tundisi et al. 2014). The Amazon rainforest is the largest reserve of plant and animal diversity on Earth, and it has been subject to especially high rates of land-use change, mainly for cattle grazing. This conversion has had a strongly negative effect on biological diversity, reducing the number of plant and animal species and homogenizing local communities (Rodrigues et al. 2013).

The construction of reservoirs in Brazil and other Amazonian countries will interfere with the ecological dynamics of this ecosystem by changing fundamental hydrological and hydro-social processes. Furthermore, the construction of reservoirs in the Andean–Amazon foothills can interrupt connectivity with the lower Amazon ecosystem (Tundisi et al. 2014). It is there where there is an impact with large-scale reaches defined by the change in river flow, the migration of fish and other animals, and the amount of water available to the communities that live near the main rivers.

More than one hundred hydroelectric dams have already been built in the Amazon basin, and many proposals for the construction of more dams are under consideration. The cumulative negative environmental effects of existing dams and proposed dams, if constructed, will trigger massive hydro-physical and biotic disturbances that will affect the floodplains, estuary, and sediment column of the Amazon basin (Latrubesse et al. 2017). The dam environmental vulnerability index was introduced to quantify the current and potential impacts of dams in the basin. The scale of the foreseeable environmental degradation indicates the need for collective action among nations and states to avoid long-range cumulative impacts. Institutional innovations are needed to assess and avoid the possible impoverishment of Amazonian rivers.

Indigenous people have experienced substantive changes that harm the provision of important ecosystem services severely impacting their traditional livelihoods, and these showed in the supply of raw materials, food and medicinal resources; however, the demand for food and raw materials has been exponentially increased, generating in the Amazon territory a change in the spaces of exploitation and strong pressures on the reserve of ecosystem services (Ramirez-Gomez et al. 2015). These pressures do not come only from local people but from large corporations associated with food production, oil exploitation, mining exploitation, among others. This reveals that the generations of income, the change in subsistence practices and consumption patterns have changed in the Amazon, it is necessary to strengthen management strategies based on the existing ecosystems used by the Amazonian inhabitants.

5 Sustainable Development of Amazonian Territories from Indigenous People

The literature surrounding the sustainable development theme has generated a conceptual fan that enriches the debate and generates new heterogeneous conceptualizations around the economic theme, with emphasis on the forms of capital and the provision of natural resources (Arrow et al. 2004). This is where important areas of knowledge converge to create new paradigms and concepts that sustainably define the new reality surrounding environmental development.

The concept of a bio-based economy is promoted in the light of oil, gas, and carbon reserves that are expected to run out quickly. Bioeconomy is a term that originated in the 1960s, mainly to reconcile the biological bases of economies; later, it was at the beginning of 1970 when the term that represented a concern that the unlimited growth in the series would be compatible with the basic laws of nature (Bonaiuti 2014). Bioeconomy could boost the transition to a more sustainable economy by addressing some of the world's major challenges, including food security, climate change, and scarce resources.

Bioeconomy approves new resources building on renewable biomass. Through this, the introduction of innovative and efficient production technologies in the use of resources and the transition to a sustainable society helps to reduce the use of limited fossil resources, thereby contributing to the mitigation of climate change (Zilberman et al. 2018). The great current world trends, in the framework of the globalization of the environmental problem, are orienting themselves in a credible and irreversible way to the environmentally sustainable production, to the biotechnology, and to the business with eco-efficiency (Brack Egg 2018). However, within this the context it is essential to consider the social movements and development of local communities that are the basis for the maintenance and strengthening of various initiatives.

The Amazonian case can host a sustainable based economy, which has an important component of ethics, society, and nature. A new economy that recognizes the limits of ecosystems and they guide development (society–nature relationship), and promotes innovation understood as "improving, above all, how energy, materials, and diversity itself are obtained and transformed into products," substituting transactions that propitious deforestation with transactions capable of "guaranteeing permanence and regeneration of the services that ecosystems provide" (Abramovay 2012). The Amazon territory can host a sustainable economy (Pinasco 2015), which improves the quality of life of its inhabitants, generating profits from a sustainable approach, adapted to global demands from a local approach (Fig. 7).

According to this vision, and economic performance adjusted to sustainability considerations is possible, evaluating prices, adjusting appropriate and pertinent policies, adapted to local needs, so that the populations are significantly the beneficiaries. It is necessary to consider the interactions of resource dynamics with macroeconomic considerations (Arrow et al. 2004). It is, therefore, necessary to

Fig. 7 Sustainable economy approaches. *Source* authors

have strong institutions that are capable of managing windfall profits from the commercialization of products (Van der Ploeg 2011). To achieve these goals and develop a robust bioeconomy, research in agricultural and resource economics is essential for the development of policies that guide the evolution of the bioeconomy (Zilberman et al. 2018).

5.1 Natural Resources of the Amazon

The people of the Amazon have traditional and ancestral knowledge that has undoubtedly enriched the landscape. They have domesticated plants and animals for their consumption, as well as the use of the products of the forest to make their homes, different hunting and fishing arts. This has allowed them to survive, maintain, and inherit their culture. However, the multiple pressures on the Amazonian territory for exploitation are growing rapidly in issues such as the expansion of the agricultural frontier, oil, hydroelectric plants, mining, logging, and mega-projects (Little 2013). A series of threats loom over this territory that undoubtedly drastically alters the panorama. Legislation in many Amazonian countries has made it possible to accelerate some mega-projects, generating significant pressure on the Amazonian territories.

To know the experiences of sustainable use of resources is to enter a world governed by infinite possibilities of action and of doing that has been plagued by multiple successes and mistakes that have laid the foundations for discussion and allows addressing the issues from another field or concept. Possibilities of sustainable use (Wearn et al. 2012). In this sense, the Amazonian countries have not given sufficient importance to the potential of biodiversity in their territories and have not yet discovered its value to achieve sustainable economic, social, and ecological development (Brack Egg 1996). Over time, some communities in Amazonian countries with the support of allies have made interesting advances in relation to the sustainable use of biodiversity and Amazonian genetic resources and have positive experiences in various aspects (Brack Egg 2018).

In this sense, the Amazonian countries face a decisive challenge to take advantage of biodiversity resources based on the social, economic, and environmental development of their countries and of the inhabitants of their respective Amazonian territories. This challenge implies urgent decisions in the near future, which in some cases they must be agreed as a united bloc of the Amazonian countries given their common interest (OTCA 2011). The delay in decisions may result in industrialized countries winning the race to take advantage of the resources of Amazonian biodiversity, to strengthen their economic position, and that the retribution for Amazonian countries is minimal, with clear technological and economic disadvantages.

For different countries, the formulation and implementation of new policies that take into account the socio-environmental specificities of the Amazon are gradually building an institutional political a framework that proposes to lay the foundations for the integral development of the Amazon. Thus, the strengthening of social actors in the sustainable management of natural resources is prioritized, and an increasingly relevant status is given to biodiversity as a strategic component of development.

In this context, indigenous organizations have been strengthened, regionally or nationally, Coordinator of Indigenous Organizations of the Amazon Basin (COICA) and its associated national organizations, particularly in processes of management and order of the territory (territorial management) at the same time as the Civil society gained political prominence around the issues of defense of the environment and indigenous populations in the Amazonian context.

On the other hand, there are communities, local governments, sub-national governments, corridors, networks, and thematic tables that have been promoting territorial management initiatives toward sustainability, making visible improvements in the quality of life of local populations. In this sense, initiatives imposed by the Amazon biome are visible (Pinasco 2015).

The Bolivian case presents a synergy between the municipality and its allies, where the producer organizations make a symbiosis and generate a land-use plan that leads to the empowerment of the organizations and they believe that they improve access to production, but it goes further thereby proposing climate change strategies, supported by the beauty of its ecosystems, creating productive spaces for its population through tourism as a window.

In the Colombian case, there are experiences in strengthening indigenous autonomy and traditional forms of land management (Rivas 2019), guaranteeing the conservation of diversity and local sustainable use, based on traditional knowledge that becomes a vehicle for the implementation of rational epistemology and logic. On the other hand, grassroots organizations manage municipal parks in order to ensure the supply of water resources for local populations, this municipality of Belén de Los Andaquíes is a municipality with a great diversity of flora, fauna, landscapes and water resources, which make it worthy of the title of being one of the most biodiverse municipalities in the department, not only because it belongs to the Amazon, but it was also declared a green water protector municipality (Coronado Bustos and Santos González 2016). In this municipality, important processes of grassroots social organization are highlighted and recognized, which shows a strengthening social capital, being one of the most representatives municipalities in this type of action.

In this regard, Brazil has managed to establish the Mondé-Kawahiba ethno-environmental corridor, which occupies the states of Rondonia, Amazonas, and Mato Grosso (Santos and Mendonça 2016), where indigenous peoples, municipal governments, and NGOs have converged, they have carried out a territorial management process, which aims to reduce poverty, protect socio-environmental services, and improve quality of life, through the strengthening of local governments in coordination with protected natural areas and indigenous peoples, based on the economic development and cultural appreciation of indigenous peoples and local communities.

Brazil has made important advances in sustainable development programs through the mapping of biodiversity and in work with genetic resources through Instituto Nacional de Pesquisas da Amazônia (INPA), Centro Nacional de Recursos Genéticos (CENARGEN), and the Museu Paraense Emílio Goeldi. The works on pijuayo or pupunha (*Bactris gasipaes*), on Amazonian tropical fruits, and on fisheries are recognized throughout the world (quote). In addition, it has advances in the isolation of active principles and alligator farms (Dumith 2012). Even the vast coastal area of the Brazilian Amazon is used by mangrove fisherman of crabs and shrimp (Fernandes et al. 2018), whose waste can be transformed to obtain biopolymers such as chitin and chitosan (Tovar et al. 2018). Biopolymers used for biotechnological and environmental applications (Tovar-Jimenez et al. 2020). In this country, the experiences of extractivism, through the Extractivist Reserves, are important and are opening interesting possibilities for the sustainable use of biodiversity by local inhabitants.

The Venezuelan case the indigenous populations maintain the use of their agricultural technologies that has been inherited from generation to generation, and that serves as a basis for the conservation and protection of forests, sacred places, ultimately their culture (Morales and Quispe 2014). This territory presents serious threats as a result of illegal mining and extractivist policies. However, its cultural identity has allowed the creation of spaces for organizational strengthening for the defense and control of its territory, through the self-demarcation of its habitats and territories.

The Ecuadorian experience based on the Sumaco Biosphere Reserve has been organized through cacao and its cocoa table (Moreno et al. 2011). They have managed to consolidate strategic alliances, through space for dialogue and coordination of actions, where not only producers are integrated, but also public and private entities, which resulted in the management of fine aroma cacao in the Sumaco Biosphere Reserve.

In the Peruvian case, governance of natural resources has been proposed in the Pichanaki Model Forest process, in the Central Forest of Peru, through the characterization of indigenous peoples, local governments present in the territory (Buendía Martínez 2018). The actors are distinguished in the organization of agricultural producers; independent farmers; state institutions related to the environmental and agricultural sector; sanitation institutions; commerce; political authorities and local communities.

Environmental entities have an increasingly global approach, systematically addressing the environmental problem of water resources, biodiversity, and climate change (Pasquis and Mikkolainen-Del Aguila 2014). The rights of nature are also recognized, and the right of citizens to a healthy environment is identified as one of the fundamental conditions for human life. In this way, an "Amazonian" institutionality is progressively being strengthened at the same time that the levels of governance are being improved.

5.2 Sustainable Management of Natural Resources

The knowledge and understanding of the process of regeneration of the forest and the use of its diversity of species and ecosystems has guaranteed a sustainable management of the Amazonian environment by the indigenous groups that have inhabited it since ancient times.

Amazonian indigenous groups have developed adaptive models to the Amazonian environment, within a cultural framework with a high capacity to regulate human activity. These subsistence models are based on the multiple and extensive use of natural spaces (for the collection of resources: fruits, hunting, and fishing) and on the intensive use of transformed cultural spaces (cultivation areas and home gardens), guaranteeing the maintenance ecological diversity (Walshburger 1990). The indigenous peoples of the Amazon show patterns of adaptation to the natural environment (Fig. 8).

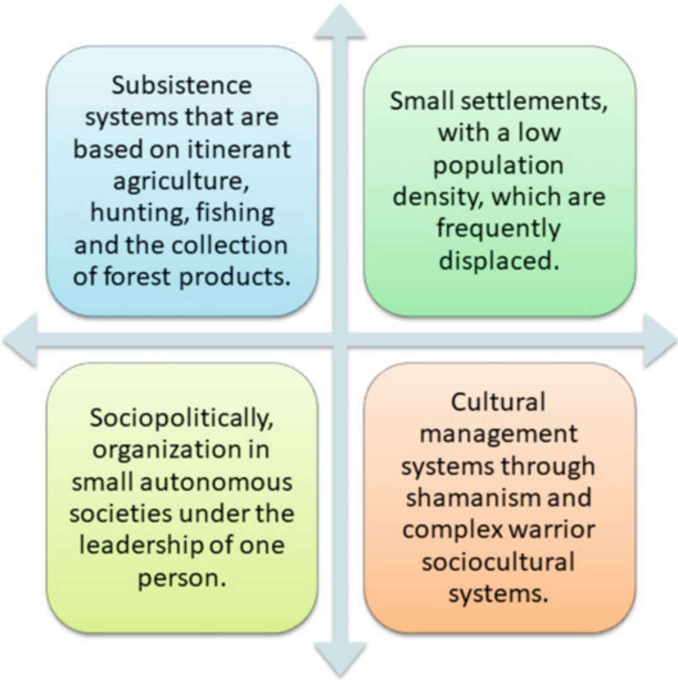


Fig. 8 Characteristics of the adaptation patterns of indigenous communities to the Amazonian environment. *Source* authors

Both the production and use of natural resources systems and the socio-cultural dynamics of indigenous groups respond adaptively to the ecological limitations of the Amazonian environment, which may be (a) the intrinsic poverty of the soil that limits agricultural production; (b) the scarcity of arable land or hunting territories, which generates inter-ethnic competition; (c) the general scarcity of animal protein in the environment. The combination of these factors according to the intensity determines the density and permanence of the towns; it is worth noting that the spatial heterogeneity of the Amazon has different soil levels, water quality, patterns of flooding of forests, precipitation and many other factors that determine a complex mosaic of habitats made up of different animal and plant species.

Considering this characterization, some elements are raised, which can increase the vision of an optimal use of the Amazon from a holistic approach (Álvarez and Shany 2012), in which they consider (a) productive conservation, conservation as a business, that is, recover resources of wild flora and fauna and conserve them productively for people, generating income; (b) adaptive management, simple management measures designed and progressively adopted by the communities themselves with the support of technicians, following the participatory research model; (c) ecosystem approach, conservation of large landscapes, especially basins and complete ecosystems, including prioritized ecological processes, such as

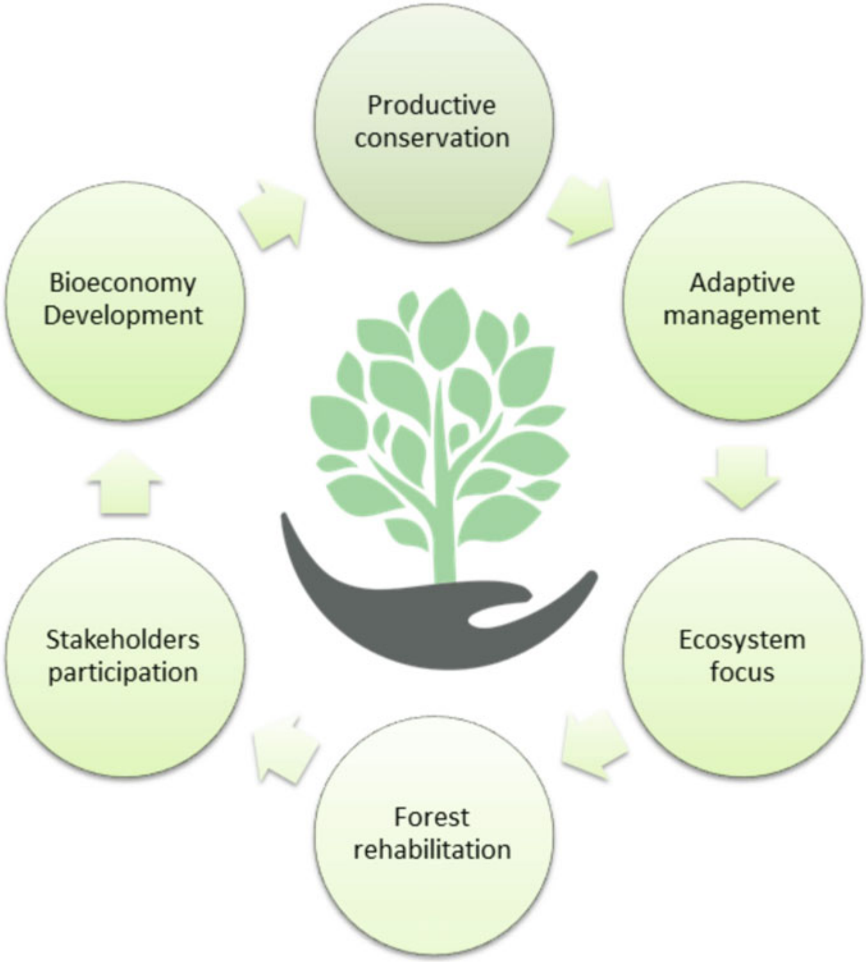


Fig. 9 Holistic approach to the optimal use of the Amazon. *Source* authors

seasonal migrations of fish, and conservation of source areas; (d) use and profitability of the standing forest, prioritize the generation of income from managed wild resources versus change of forest use; (e) participation of all actors, from duly consulted organized local communities to private companies, public institutions, and decision-makers; (f) development of complete productive chains, adding value to biodiversity products and articulation to the market; (g) adaptive management, decisions taken locally, and progressive adaptation of institutions and regulations according to the capacities of the communities. Figure 9 shows an illustrative scheme of this consideration.

Considering these elements, traditional systems of use can be rescued, modernized, and disseminated for implementation by the same local populations. The effort to synthesize local knowledge and experiences is vital in this regard, in addition to the development of new systems suited to the environment of the region. This implies a close work between official entities, in charge of science and technology, with local people and private companies, in the broadest sense.

There are aspects that refer to decisions to direct the sustainable use of biodiversity. Much has been insisted rather on forbidding the use of resources, rather than on promoting their management and sustainable use. For example, in several countries the closures of flora and fauna species, with the possibility of exporting them live or as processed products, have not been accompanied by initiatives to establish crops, hatcheries, or similar actions for the benefit of the region's inhabitants.

The use of biodiversity, from a sustainability perspective, is an opportunity for Amazonian countries, such as ecosystem services, forest resources, aquatic resources far from the destruction of areas and with minimal or few alterations unlike what happened in the past. There are alternative approaches for taking advantage of the Amazon "Pertinent," without neglecting the socio-economic benefits for the inhabitants of the Amazon regions. This proposal is innovative in the framework of the new world context.

In these territories, the hydrological resources, are essentials for supply on rural and urban populations, especially on fisheries. In some countries (Brazil, Colombia, and Peru), there is a constant improvement of technology that has been developed for the use of fishery resources. The potential of breeding species for food and ornamental purposes (aquariums) must be considered, both for local, regional, national, and international markets. Certainly, some meat-producing species (such as paiche or pirarucú, among others) are not only of local and regional interest but also international.

The use of forest products other than wood is an activity of certain local importance, as is the case of the chestnut or Brazil nut for Brazil, Bolivia, and Peru. Also, the use of Copo azu (*Theobroma grandiflorum*), Acai (*Euterpe oleracea*), Moriche (*Mauritia flexuosa*), Pupunha (*Bactris gasipaes*) is some products adapted to the conditions of the Amazon. The potential of Amazonian crops has been little valued locally since there are dozens of plants that produce exotic fruits, perfumes, aromas, oils, drugs and ornamentals, among others, that have not been considered in development programs with a vision for the future. Likewise, the potential of biodiversity (flora and fauna species) as a supplier to the national and international industry of new pharmacological products, cosmetics, chemicals, and others derivatives has been scarcely perceived by the Amazonian countries, putting them in a very weak position compared to the industrialized countries.

The countries have concentrated their efforts on promoting and fostering Amazonian development based on systems and products "imported from abroad," but not on seeking the true possibilities of the region. These have remained indifferent or very timid in exploring them and seeking their integration into the national economy. We advocate for a new development paradigm, far from attempting to reconcile maximized conservation versus the intensification of traditional agriculture and the expansion of hydroelectric capacity, in which we research, develop, and scale a high-tech innovation approach that sees the Amazon as a global audience well of biological assets that can allow the creation of high-value innovative products, services, and platforms through the combination of advanced digital and biological technologies (Nobre et al. 2016).

The debate on regional development has focused on trying to reconcile the maximization of conservation with the intensification of traditional agriculture. The large reductions in deforestation in the last decade open opportunities for an alternative model based on seeing the Amazon as a global public good of biological assets for the creation of high-value ecosystem products and services (Nobre et al. 2016).

5.3 Genetic Resources in the Amazon Bioeconomy

First, it is necessary to understand that a large part of the Amazonian biodiversity, especially genetic resources and plants with great pharmacological potential, is not exclusive to a single country, but rather is shared resources. This implies that their conservation and the recognition of the intellectual rights of the Amazonian inhabitants must be dealt with in conjunction with regional agreements. The exit of genetic resources, for example, can be very much legislated in one country, but not in the neighbor, which allows the leakage of resources to the outside without any benefit for the inhabitants and the countries.

The importance of the genetic resources of domestic plants is increasing in relation to the wild and primitive species and varieties of cultivated plants such as corn, wheat, barley, potato, rice, tomato, and others (cocoa, papaya, achiote, vanilla, and many others). This aspect of genetic resources has an international network through FAO and the Consultative Group on International Agricultural Research (CGIAR). This network, integrated for 13 institutions, has offices in Latin America the International Center for Tropical Agriculture (CIAT, Cali, Colombia), the International Potato Center (CIP, Urna, Peru) and the International Center for Corn and Wheat Improvement (CIMMYT, El Batán, Mexico).

The International Board for Genetic Resources (IBPGR, Rome, FAO) is giving increasing importance to the plant genetic resources of Latin America and has an office for South America at CIAT; a Seed Management Unit (SMU) at CATIE-Costa Rica, and Taxonomic and Ecogeographic Studies in Cucurbits at UNAM-Mexico. The IBPGR promotes national, regional, and international programs on genetic resources and supports actions of (i) characterization, evaluation, and documentation; (ii) germplasm exchange; (iii) training and research; (iv) work networks by crops; (v) inter-institutional relations, and (vi) publications.

Sustainable development is established as a production model, whose goal is to keep natural resources, based on three premises: (a) human well-being, actions on issues such as health, education, housing, security, and protection of the rights of childhood; (b) ecological well-being, actions around the care and preservation of air, water, and soil; and (c) the interactions established through public policies in matters of population, equity, distribution of wealth, economic development, production and consumption, and the exercise of government (Alcocer 2007).

5.4 Economic Development in the Amazon

In the economic line, we find that the main productive sectors of the Amazon depend directly on their endowment in natural resources such as agriculture, mining, forestry, and hydrocarbon production, more to other activities such as illicit crops and the illegal trafficking of wild fauna and flora. However, the region shows very different production systems in terms of scale, production processes, formality, and market articulation. For example, in the agrarian sector, on the one hand, there has been a significant increase in monoculture agriculture (soy) and intensive livestock farming on deforested lands, while on the other we find huge areas of family farming and extensive livestock farming. We can see a similar situation in the mining sector.

As is known, mining exploitation has always been a major threat to the aquatic and terrestrial ecosystems of the Amazon, and gold mining, the most widespread, is even more destructive on a small scale, given that a greater proportion of industrial operations are subject to increased regulation (UNEP 2009). In the area of hydrocarbons, the Amazon has large deposits of oil throughout the basin, although the exploitable fields are mainly concentrated in Ecuador, the country with the highest record of exploitation of the resource. The gas and oil fields of the rest of the area are concentrated in the Amazon foothills of the four countries. It should be noted that in the past, some oil exploitation areas were ruled out due to their inaccessibility, but the high prices of oil and natural gas have allowed exploration work to be reactivated.

In terms of road infrastructure and given the need to respond to the needs to make the best use of the potential of natural resources in the region, a good number of initiatives are proposed for accessibility and development of the area, which will entail impacts on forests and biodiversity (RAISG 2012).

Is it necessary then to ask the dichotomy in reference to the natural resources of the Amazon, are these positive for the region, on the contrary, are they substantively negative? Both scenarios can be evaluated by pointing to the positive scale, recognize that based on coherent and adequate fiscal rules are based on the well-being of the population to take advantage of the extraordinary gains in developed resources and developing economies. However, the costs are industrialization, growth prospects not consistent with the Amazon, fragile institutions, and the rule of law with questions, and financial development that is still growing (Van der Ploeg 2011).

Analyzing the macro-level of sustainable development for the Amazon can offer a more refined point of view on the economy of the region and enables a quantitative consideration for environmental policies, a detailed approach is necessary at the micro-level (countries and regions) to develop strategies and relevant sustainable development policies. Microeconomic approaches to sustainability must recognize heterogeneity between locations and between people considering economic and biophysics factors. In order to guarantee adequate sustainability (Barbier 2016), the protection of biodiversity and support special locations and ecosystems (Biosphere Reserve, National Parks) are needed.

At the end of the 90s, there were strong movements to strengthen sustainability in its applicability, since it sought to become a solid sustainability strategy, it was then proposed to show specific restrictions to make sustainable economic development, having as a vision that could be mainly controversial for groups seeking to keep intact environmental and social services (Brown and Shogren 1998). The civil society experience through its different forms has established criteria for the preservation and protection of biodiversity to sustainable development adjusted to the Amazon region.

Interestingly, there is a difference between the popular notion of sustainability that develops policies that aim to meet specific conservation goals and can be socially costly, and the notion of sustainable development that aims to improve well-being subject to environmental and social constraints (Zilberman 2014). On the other hand, the importance of suggesting that there is an explicit consideration of irreversibility effects in the evaluation of sustainability should be emphasized to avoid excessive investment and excessive depletion of natural resources (Wesseler 2015).

6 Concluding Remarks and Future Considerations

The analysis of demographic dynamics in the Amazon to the growth of natural protected areas and the recognized indigenous territories in the last 60 years forms a recently opened field of study thanks to the database available. The results of this analysis show that there are three phases in the environmental protection of the Amazonian territory and three phases of recognized indigenous territories. Regarding environmental protection, the first phase (1942–1961) corresponds to a sudden expansion of the protected territory, 405,660.8 km^2 in just 19 years. The second phase (1962–1988), in which 797,060.6 km^2 of environmental protection were reached, corresponds to the diversification of the protection mechanisms adopted by various countries, such as the Integrated Management Areas (Bolivia), the Natural Monuments (Venezuela), the Recreation Areas and Production and Fauna Reserves (Ecuador), Biological Reserves (Brazil) and Protection Forests (Peru). The third phase (1989–2005) corresponds to the decentralization of protection mechanisms. During this period, the departments and municipalities were the main ones in charge of expanding environmental protection, reaching the figure of 1,970,005.6 km^2. Finally, the current phase (2006–2018) shows a contradictory trend in which the state gradually delegates responsibility for environmental protection, both to organized communities and to private owners. In this way, the environmental protection of the 2,680,785.3 km^2 of Amazonian territories can be divided between state protection (57%), departmental-municipal (28%) and community-private (13%). Subsequent comparative studies will be able to determine the effectiveness and the main problems that each type of environmental protection presents.

The recognition of indigenous lands in the Amazon has not clearly distinguish the expansion phases. However, the data available on the Indigenous Territories of Brazil, the Indigenous Reservations of Colombia and the Native Communities of Peru show a first phase (1945–1981) in which territorial rights were recognized for 434,005 people out of a total of 62,310.1 km^2. The second phase (1982–2000) reaches 876,223 inhabitants and 1,052,065 km^2; while the third phase (2001–2016) incorporates a population of 1,250,966 and 2,254,040.3 km^2. In this sense, the differences on the growth of environmental protection, either by the state at any of its three scales, also by the community or private entities. While the growth of recognition of the Amazonian indigenous territory shows that the relations of Power are unequal even between the different types of territorial management and governance.

The experiences of political autonomy and governance from Ka'apor Yanomami, Timbira, Achuar, Tikuna, and Piaroa territoriality show the community organization of social processes. Such processes based on territorial management plans that are dynamic, interactive, and participatory, and that help to define the specific goals, goals, and activities planned by indigenous communities. If the communities are not organized and mobilized, the autonomies and forms of resistance and defenses in the territory will not happen. Although protected natural areas and indigenous territories are subject to pressures such as urban and agricultural expansion, and infrastructure projects (roads, highways, dams and land division), mining, illegal logging, cattle ranching, among others, the effects of extractive activities that fiercely an attack such a sensitive and highly diverse territory must be countered in many ways.

Respect to Amazonian cultures should be deepened, promoting mechanisms to guarantee social equity and inclusive opportunities to lower poverty (design indexes for evaluation of Amazonian population's development). Also, promoting the knowledge traditional allows lower the vulnerabilities of Amazonian environments, and fostering adaptation measures in the face of climate change. It is necessary a participatory management that includes local actors, supported by governance instruments designed at the local level with the people, as well as activating and about the mechanism of earlier, free, and informed consultation of projects that may be developed within their territories.

Agree to these considerations is necessary to develop a dynamic economy own. This aim to generate work networks, based on value chains, adjusted to the potentialities of the territories, which are fair competitive activities within the local framework, and national and international markets with responsibility, solidarity, and social justice. It considers the management and conservation of biodiversity and ecosystem services, which allows resilience and adaptation to climate change, as well as the recovery of degraded areas that allow guaranteeing productive activities.

References

Abramovay R (2012) Muito além da economia verde, 1st edn. Abril, Planeta Sustentável, São Paulo

Aguilar Castro V, Bustillos L, Pinilla N (2014) Plan de vida como expresión de los derechos territoriales del pueblo Uwottüja de la cuenca del Sipapo. In: Morales C, Quispe M (eds) Teärime Siri'koi Aerime Suititi El Territorio Uwottüja, 1st edn. OIPUS-WATANIBA, Bogotá, pp 75–95

Alcocer BF (2007) Desarrollo sustentable. Revista del Instituto de Investigaciones Legislativas del Senado de la República "Belisario Domínguez"

Álvarez J, Shany N (2012) Una experiencia de gestión participativa de la biodiversidad con comunidades amazónicas. Rev Peru Biol 19:223–232

Anderson EP, Jenkins CN, Heilpern S et al (2018) Fragmentation of Andes-to-Amazon connectivity by hydropower dams. Sci Adv 4:eaao1642. https://doi.org/10.1126/sciadv.aao1642

Antunes AP, Rebêlo GH, Pezzuti JCB et al (2019) A conspiracy of silence: subsistence hunting rights in the Brazilian Amazon. Land Use Policy 84:1–11. https://doi.org/10.1016/j.landusepol.2019.02.045

Arrow K, Dasgupta P, Goulder L et al (2004) Are we consuming too much? J Econ Perspect 18:147–172. https://doi.org/10.1257/0895330042162377

Azevedo-Santos VM, Garcia-Ayala JR, Fearnside PM et al (2016) Amazon aquatic biodiversity imperiled by oil spills. Biodivers Conserv 25:2831–2834. https://doi.org/10.1007/s10531-016-1192-9

Barbier EB (2016) Sustainability and development. Annu Rev Resour Econ 8:261–280. https://doi.org/10.1146/annurev-resource-100815-095227

Barbosa RI (1993) Ocupação humana em Roraima. II. Uma revisão do equívoco da recente política de desenvolvimento e o crescimento desordenado. Bol Mus Par Emílio Goeldi 9:177–197

Barlow J, Lennox GD, Ferreira J et al (2016) Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. Nature 535:144–147. https://doi.org/10.1038/nature18326

Barni PE, Pereira VB, Manzi AO et al (2015) Deforestation and forest fires in Roraima and their relationship with phytoclimatic regions in the Northern Brazilian Amazon. Environ Manage 55:1124–1138. https://doi.org/10.1007/s00267-015-0447-7

Becerra MJ, Pimentel MA, De Souza EB et al (2020) Geospatiality of climate change perceptions on coastal regions: a systematic bibliometric analysis. Geogr Sustain 1:209–219. https://doi.org/10.1016/j.geosus.2020.09.002

Bello LJ (2011a) El reconocimiento constitucional de la existencia de los pueblos y comunidades indígenas y de los derechos originarios sobre las tierras que ocupan. In: Bello LJ (ed) El Estado ante la Sociedad Multiétnica y Pluricultural: Políticas Públicas y Derechos de los Pueblos Indígenas en Venezuela (1999–2010), 1st edn. Iwgia, Copenhague, pp 35–86

Bello LJ (ed) (2011b) El estado ante la sociedad multiétnica y pluricultural: políticas públicas y derechos de los pueblos indígenas en Venezuela (1999–2010), 1st edn. Iwgia, Copenhague

Bello L, Tillett A (2015) Minería en la Amazonía Venezolana: Derechos Indígenas y Ambientales. El Caso del Pueblo Yanomami, 1st edn. Wataniba, Caracas

Benfica E, Hernández M, Becerra Ruiz J (2017) Garimpo ilegal nos Territorios Yanomami e Ye'kwana (Brasil-Venezuela). Rede de Informação Geográfica Binacional Yanomami e Ye'kwana
Betts MG, Wolf C, Ripple WJ et al (2017) Global forest loss disproportionately erodes biodiversity in intact landscapes. Nature 547:441–444. https://doi.org/10.1038/nature23285
Bonaiuti M (2014) Bio-economics. In: Degrowth: a vocabulary for a new era, 1st edn. Routledge/Taylor & Francis Group, Abingdon/Oxon, pp 53–56
Brack Egg A (1996) Biodiversidad, biotecnología y desarrollo sustentable en la amazonia, Ecuad. DEBATE 37:196–209
Brack Egg A (2018) Biodiversidad amazónica: potencialidades y riesgos. Glob Bus Adm J 2:100–111. https://doi.org/10.31381/gbaj.v2i2.2203
Brown GM, Shogren JF (1998) Economics of the endangered species act. J Econ Perspect 12:3–20. https://doi.org/10.1257/jep.12.3.3
Brundtland GH (1987) Our common future—call for action. Environ Conserv 14:291–294
Buendía Martínez O (2018) Bosque modelo Pichanaki, una herramienta para el manejo sustentable de los recursos naturales en la Selva Central del Perú. Dissertation, Universidad Nacional Agraria La Molina
Camarinha HM (2019) Entre o voo e pouso de Yapucani e os repertórios musicais xamanísticos do povo Ka'apor. Dissertation, Universidade Federal de Santa Catarina
Carrasco JP (1978) El Tratado de Cooperación Amazónica. Nueva Soc 37:19–25
Cavalcante TLV (2016) "Terra indígena": aspectos históricos da construção e aplicação de um conceito jurídico. História São Paulo 35:1–22. https://doi.org/10.1590/1980-436920160000000075
Chauí M (2011) Democracia e cultura: o discurso competente e outras falas. Cortez, Sao Paulo
Cheng H, Sinha A, Cruz FW et al (2013) Climate change patterns in Amazonia and biodiversity. Nat Commun 4:1411. https://doi.org/10.1038/ncomms2415
Claudino-Sales VD (2019) Riscos socioambientais no norte do país: incêndios na amazônia brasileira. Rev Casa Geogr Sobral RCGS 21:22–32. https://doi.org/10.35701/rcgs.v21n3.655
Coronado Bustos JT, Santos González LL (2016) Determinantes del desarrollo económico local del municipio de Belén de los Andaquíes, departamento del Caquetá. Dissertation, Universidad Autónoma de Manizales
Correia CDS (2007) Etnozoneamento, etnomapeamento e diagnóstico etnoambiental: representações cartográficas e gestão territorial em terras indígenas no estado do Acre. Dissertation, Universidade de Brasília
DANE (2019) Población indígena de Colombia. In: Censo Nacional de Población y Vivienda CNPV: Departamento Administrativo Nacional de Estadística (DANE)
de Area Leão Pereira EJ, Silveira Ferreira PJ, de Santana Ribeiro LC et al (2019) Policy in Brazil (2016–2019) threaten conservation of the Amazon rainforest. Environ Sci Policy 100:8–12. https://doi.org/10.1016/j.envsci.2019.06.001
Diegues AC (2000) Os saberes tradicionais e a biodiversidade no Brasil, 1st edn. NUAUP-USP; PROBIO-MMA; CNPq, Sao Paulo
Domínguez C (2001) ¿Se urbaniza la Amazonia? El anillo de poblamiento amazónico. Iniciat. Amaz. Rev. Trimest. Los Países Amazon
Dumith RDC (2012) A importância da gestão compartilhada e das áreas marinhas protegidas para o sistema socioecológico da pesca artesanal: O caso das reservas extrativistas marinhas. GeoTextos 8:97–121. https://doi.org/10.9771/1984-5537geo.v8i2.6281
ECLAC (2014) Los pueblos indígenas en América Latina. Avances en el último decenio y retos pendientes para la garantía de sus derechos. Síntesis. CEPAL, Santiago. https://repositorio.cepal.org/handle/11362/37050
Espinosa O (2014) Los planes de vida y la política indígena en la Amazonía peruana. Anthropologica 32:87–114
Fearnside PM (2014) Impacts of Brazil's Madeira river dams: unlearned lessons for hydroelectric development in Amazonia. Environ Sci Policy 38:164–172. https://doi.org/10.1016/j.envsci.2013.11.004

Fearnside PM (2015) Brazil's São Luiz do Tapajós dam: the art of cosmetic environmental impact assessments. Water Altern 8:373–396

FENAP (2003) Plan de vida consolidado del pueblo achuar del Pastaza

FENAP (2018) La Federación de la Nacionalidad Achuar del Perú (FENAP). In: Fed. Nac. Achuar Perú FENAP

Fernandes ME, Oliveira FP, Eyzaguirre IA (2018) Mangroves on the Brazilian Amazon coast: uses and rehabilitation. In: Makowski C, Finkl C (ed) Threats to mangrove forests. Coast Res Libr, vol 25. Springer, Cham. https://doi.org/10.1007/978-3-319-73016-5_29

Finer M, Jenkins CN (2012) Proliferation of hydroelectric dams in the Andean Amazon and implications for Andes-Amazon connectivity. PLoS ONE 7:e35126. https://doi.org/10.1371/journal.pone.0035126

Finer M, Jenkins CN, Pimm SL et al (2008) Oil and gas projects in the western Amazon: threats to wilderness, biodiversity, and indigenous peoples. PLoS ONE 3:e2932. https://doi.org/10.1371/journal.pone.0002932

Finer M, Moncel R, Jenkins CN (2010) Leaving the oil under the Amazon: Ecuador's Yasuní-ITT initiative. Biotropica 42:63–66. https://doi.org/10.1111/j.1744-7429.2009.00587.x

Forsberg BR, Melack JM, Dunne T et al (2017) The potential impact of new Andean dams on Amazon fluvial ecosystems. PLoS ONE 12:e0182254. https://doi.org/10.1371/journal.pone.0182254

Gavazzi RA (2007) Plano de gestão territorial e ambiental da Terra Indígena Kampa do rio Amônia. Com. Pró-Índio Acre, 82 p

Gonçalves CU (2008) Geografia Política e Poder na Gestão do Território. Rev Fragm Cult Rev Interdiscip Ciênc Humanas 18:251–263. https://doi.org/10.18224/frag.v18i2.608

Gonçalves CU (2009) A importância da agências de mediação no ordenamento territorial dos assentamentos rurais. GEOgraphia 6:89–105. https://doi.org/10.22409/GEOgraphia2004.v6i11.a13471

Gorenflo LJ, Romaine S, Mittermeier RA, Walker-Painemilla K (2012) Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. Proc Natl Acad Sci 109:8032–8037. https://doi.org/10.1073/pnas.1117511109

Grupioni LDB, Kahn M (2013) Gestão Territorial e Ambiental em terras indígenas na Amazônia brasileira: os percursos da Rede de Cooperação Alternativa, 1st edn. Rede RCA

Guevara Romero ML, Téllez Morales MBR, Flores Lucero MDL (2015) Aprovechamiento sustentable de los recursos naturales desde la visión de las comunidades indígenas: Sierra Norte del Estado de Puebla. Nova Sci 7:511–537

Hoorn C, Wesselingh FP, ter Steege H et al (2010) Amazonia through time: Andean uplift, climate change, landscape evolution, and biodiversity. Science 330:927–931. https://doi.org/10.1126/science.1194585

INE, Instituto Nacional de Estadistica (2011) Resultados población indígena XIV censo de población y vivienda 2011. Gerencia general de estadísticas demográficas instituto nacional de estadística. Caracas

Johnson CN, Balmford A, Brook BW et al (2017) Biodiversity losses and conservation responses in the Anthropocene. Science 356:270–275. https://doi.org/10.1126/science.aam9317

Joppa LN, O'Connor B, Visconti P et al (2016) Filling in biodiversity threat gaps. Science 352:416–418. https://doi.org/10.1126/science.aaf3565

Kersbergen KV, Waarden FV (2004) 'Governance' as a bridge between disciplines: cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy. Eur J Polit Res 43:143–171. https://doi.org/10.1111/j.1475-6765.2004.00149.x

Latrubesse EM, Arima EY, Dunne T et al (2017) Damming the rivers of the Amazon basin. Nature 546:363–369. https://doi.org/10.1038/nature22333

Lauriola VM (2013) Indigenous Lands, commons, juridical pluralism and sustainability in Brazil: lessons from the Indigenous Lands of Raposa Serra do Sol. J Latin Am Geogr 12(1):157–185. https://doi.org/10.1353/lag.2013.0000

Liang J, Crowther TW, Picard N et al (2016) Positive biodiversity-productivity relationship predominant in global forests. Science 354:aaf8957. https://doi.org/10.1126/science.aaf8957
Little P (2013) Megaproyectos en la Amazonía. Un análisis geopolítico y socioambiental con propuestas de mejor gobierno para la Amazonía, 1st edn. RAMA-ARA-DAR, Lima, Perú
Marengo A (2006) On the hydrological cycle of the Amazon basin: a historical review and current state-of-the-art. Rev Bras de Meteorol 21:1–19
Martínez MO, Napolitano DA, MacLennan GJ et al (2007) Impacts of petroleum activities for the Achuar people of the Peruvian Amazon: summary of existing evidence and research gaps. Environ Res Lett. https://doi.org/10.1088/1748-9326/2/4/045006
Medeiros AKM (2013) Direitos indígenas entre fronteiras: cidadania, presença e mobilidade ticunas na tríplice fronteira do Brasil, Colômbia e Peru. Dissertation, Universidade do Estado do Amazonas
Morales C, Quispe M (eds) (2014) Teärime Siri'koi Aerime Suititi El Territorio Uwottüja, 1st edn. OIPUS-Wataniba, Bogotá
Moreno A, Flores J, Aguirre P (2011) La Mesa del Cacao Fino de Aroma de la Reserva de Biosfera Sumaco Análisis de Impactos del Programa GESOREN—GIZ
Nobre CA, Sampaio G, Borma LS et al (2016) Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc Natl Acad Sci 113:10759–10768. https://doi.org/10.1073/pnas.1605516113
ONIC (2016) ONIC—Tikuna. In: Organ. Nac. Indígena Colomb. https://www.onic.org.co/pueblos/1149-tikuna. Accessed 25 Sept 2020
OTCA (1978) Tratado de Cooperación Amazónica. Brasilia
OTCA (2011) Agenda Estratégica de Cooperación Amazónica. Aprobada en la X Reunión de Ministros de Relaciones Exteriores del TCA, 1era edn. BMZ-DGIS-GIZ, Lima, Perú
Paiva PFPR, de Lourdes Pinheiro Ruivo M, da Silva Júnior OM et al (2020) Deforestation in protect areas in the Amazon: a threat to biodiversity. Biodivers Conserv 29:19–38. https://doi.org/10.1007/s10531-019-01867-9
Pasquis R (2006) Conservation de la biodiversité en Amazonie: une approche régionale. BOIS For Trop 290:61–72. https://doi.org/10.19182/bft2006.290.a20300
Pasquis R, Mikkolainen-Del Aguila P (2014) BioCAN Alianza de autoridades ambientales y de la sociedad civil para la conservación de la biodiversidad amazónica. Lecciones aprendidas y retos para el futuro, 1st edn. Comunidad Andina, BioCAN, Formin Finlandia, Finlandia
Pinasco R (2015) Gestión Territorial Sostenible en la Pan Amazonía y Gran Chaco. Reflexiones, aprendizajes y desafíos para su sostenibilidad, 1st edn. Avina, Skoll, AMPA, ARA, Moyobamba
Raffestin C (1993) Por Uma Geografia do poder, 1st edn. Atica, Brasilia
RAISG (2009) Amazonia 2009 protected areas and indigenous territories, Amazon geo-referenced socio-environmental information network. Instituto Socioambiental, Sao Paulo
RAISG (2012) Amazonía bajo presión, 1st edn. Instituto Socioambiental, Sao Paulo
RAISG (2019) Amazonía 2019 Áreas protegidas, Territorios indígenas. Instituto Socioambiental, Sao Paulo
RAISG (2020) Datos cartográficos. https://www.amazoniasocioambiental.org/es/mapas/. Accessed 1 July 2020
Ramirez-Gomez SOI, Torres-Vitolas CA, Schreckenberg K et al (2015) Analysis of ecosystem services provision in the Colombian Amazon using participatory research and mapping techniques. Ecosyst Serv 13:93–107. https://doi.org/10.1016/j.ecoser.2014.12.009
República de Colombia (1959) Ley 2 de 1959. Sobre economía forestal de la Nación y conservación de recursos naturales renovables, Año XCV, Congreso de Colombia, Bogotá
Ribeiro D (1996) Diários índios: Os urubus-kaapor. Companhia das Letras
Rivas MLV (2019) Indigenous communities of colombian amazon trapeze: social imaginaries and tourism. Via. Tourism Rev. https://doi.org/10.4000/viatourism.3474
Rocha J, Andujar C (2007) Haximu: o massacre dos Yanomami e as suas conseqüências. Casa Amarela

Rodd R (2018) Piaroa shamanic ethics and ethos: living by the law and the good life of tranquillity. Int J Lat Am Relig 2:315–333. https://doi.org/10.1007/s41603-018-0059-0
Rodrigues JLM, Pellizari VH, Mueller R et al (2013) Conversion of the Amazon rainforest to agriculture results in biotic homogenization of soil bacterial communities. Proc Natl Acad Sci 110:988–993. https://doi.org/10.1073/pnas.1220608110
Santos MHDC (1997) Governabilidade, Governança e Democracia: Criação de Capacidade Governativa e Relações Executivo-Legislativo no Brasil Pós-Constituinte. Dados 40. https://doi.org/10.1590/S0011-52581997000300003
Santos AMD, Mendonça A (2016) Conflitos territoriais no Corredor Etnoambiental Tupi-Mondé Rondônia-Mato Grosso. Terra Plur 10:251–265. https://doi.org/10.5212/TerraPlural.v.10i2.0006
Siqueira-Gay J, Sonter LJ, Sánchez LE (2020) Exploring potential impacts of mining on forest loss and fragmentation within a biodiverse region of Brazil's northeastern Amazon. Resour Policy 67:101662. https://doi.org/10.1016/j.resourpol.2020.101662
Subramaniam A (2008) Amazon River enhances diazotrophy and carbon sequestration in the tropical North Atlantic Ocean. PNAS 105:10460–10465
Tillett A, Senra EB, Becerra Ruiz J et al (2014) Território e Comunidades Yanomami Brasil-Venezuela 2014
Tovar GI, Gómez M, Obediente V et al (2018) Extracción biotecnológica de quitina del desecho de camarón para la producción de quitosano como bioestimulante en semillas de melón. Agronomía Trop 68:71–86
Tovar-Jimenez GI, Belén Hirsch D, Villanueva ME et al (2020) Chitin blends, interpenetrating polymer networks, gels, composites, and nanocomposites for adsorption systems: environmental remediation and protein purification. In: Gopi S, Thomas S, Pius A (eds) Handbook of chitin and chitosan, vol 3, pp 135–175. Elsevier. https://doi.org/10.1016/b978-0-12-817966-6.00005-4
Tundisi JG, Goldemberg J, Matsumura-Tundisi T, Saraiva ACF (2014) How many more dams in the Amazon? Energy Policy 74:703–708. https://doi.org/10.1016/j.enpol.2014.07.013
UNEP (2009) Perspectivas del Medio Ambiente en la Amazonía: GEO Amazonía. PNUMA, Panamá
Van der Ploeg F (2011) Natural resources: curse or blessing? J Econ Lit 49:366–420. https://doi.org/10.1257/jel.49.2.366
Vieco Albarracín JJ (2010) Planes de desarrollo y planes de vida: ¿diálogo de saberes? Mundo Amaz 1:135–160
Vuille M (2013) Climate change and water resources in the tropical Andes
Walshburger T (1990) Sistemas indígenas de uso de la selva, ¿Una alternativa para la Amazonia? Colomb Cienc Tecnol 8:3
Wearn OR, Reuman DC, Ewers RM (2012) Extinction debt and windows of conservation opportunity in the Brazilian Amazon. Science 337:228–232. https://doi.org/10.1126/science.1219013
Wesseler JHH (2015) Agriculture in the bioeconomy: economics and policies
World Bank (2020) Population, total. The World Bank data. https://data.worldbank.org/
Yang SS, Saatchi L, Xu Y et al (2018) Post-drought decline of the Amazon carbon sink. Nat Commun 9. https://doi.org/10.1038/s41467-018-05668-6
Zilberman D (2014) The economics of sustainable development. Am J Agric Econ 96(2):385–396. https://doi.org/10.1093/ajae/aat075
Zilberman D, Gordon B, Hochman G, Wesseler J (2018) Economics of sustainable development and the bioeconomy. Appl Econ Perspect Policy 40:22–37. https://doi.org/10.1093/aepp/ppx051

Melgris José Becerra is a researcher at the Landscape and Environmental Planning Study Group (GEPPAM) and MSc student in Environmental Sciences (2019–2021), Federal University of Pará (UFPA), Brazil. He achieved his degree in geography in 2008 in the Central University of Venezuela (UCV), Venezuela. Becerra is a member of the Commission for Latin American and Caribbean Studies of the International Geographical Union (IGU-UGI) and of steering committee for Young and Early Career Geographers' Taskforce (IGU-YECG). His research interests are in indigenous peoples, territoriality, climate change, coastal, and riverine populations. He has been Editorial Board Member at Bol. Geo. Crit. Latinoamericana since 2018 in the Latin American Council of Social Sciences (CLACSO) and has published papers in English, Spanish, and Portuguese in national and international journals.

Jorge Adriàn Flores Rangel is Ph.D. in geography at National Autonomous University of Mexico (UNAM), Professor in the Faculty of Global Studies of the Universidad Anáhuac and Expert in linkage between political geography, geoecology, landscape and industrial metabolism cartography in both rural and urban spaces; design of social and environmental impact assessment for road infrastructure. Experience in research projects related to fragmentation of forests, social land tenure, regional and urban development, mapping of infrastructure networks. His recent interest relies on collaborative mapping, collaborative GIS, urban mapping and cartography of urban expansion. He is Author of Cartography of Real Estate Tsunami on Mexico City, and coauthor of geovisualizers of the Peninsula de Yucatan and Electric Energy Networks in Mexico in the context of Geocomunes Collective.

Claudio Ubiratan Gonçalves is Associate Professor since 2008 at the Federal University of Pernambuco (UFPE), Brazil. He is a graduated in geography in Universidade Federal Fluminense (1999), Master in Development, Agriculture and Society (CPDA) in Universidade Federal Rural do Rio de Janeiro (2001) and Ph.D. in geography in Universidade Federal Fluminense (2005), Brazil. He is member of the Association of Brazilian Geographers and Coordinator of Laboratory of Studies and Research on Agrarian Space and Peasantry (LEPEC/UFPE-CNPq), Brazil. Gonçalves has published papers in geography topics with emphasis on Territorial and Environmental Planning, and he is an expert in Economic and Regional Geographies, Social Movements, Rural and Popular Education, Conflicts and Development Territorial, Food Autonomy, Settlements Rural, Political Ecology, and Agroecology.

Gabriel Ibrahin Tovar is a doctoral researcher at the Institute of Chemistry and Drug Metabolism (IQUIMEFA) in the University of Buenos Aires, Argentina. Tovar achieved his BSc. in chemistry and BSc. in environmental science in 2017, and following this he was trained as a young researcher in the Venezuelan Institute for Scientific Research (IVIC), Venezuela. His research interests are environmental chemistry and Global Environmental Change, nanocomposites, food chemistry, bioavailability—in vitro studies, photodegradation of pollutants, wastewater treatments, and ecology. Professor Tovar is a reviewer for the Journal of Environmental Chemical Engineering and author for a number of well-known journals including Geography and Sustainability, Journal of Industrial and Engineering Chemistry, Nano-Structures and Nano-Objects and Environmental Nanotechnology, Monitoring and Management.

Territorial Planning and Regionalization in Brazil: Empirical Consolidation and the Role of the National Development Bank

Pablo Ibanez, Gustavo Westmann, and Fabiola Lana Iozzi

1 Initial Remarks

Brazil has a long tradition in the regional debate, which dates back to the nineteenth century when the first proposals for the regional division of the Brazilian space were presented (Magnano 1996). Even though there were no formal institutions dealing with regional issues at the time, understanding and dividing the national space was already a concern. It was during the twentieth century, especially after the 1940s, when the federal government started to make more decisive efforts to organize the administration of the State. This effort was based on not only the political division of the states of the federation but also the regions with particular characteristics and challenges that required to be addressed by different public policies.

What happened in Brazil was not isolated from what was being developed in other countries, as development planning based on the idea of the region was already a reality in several capitalist and socialist countries (Egler 1995). For instance, in Western universities and governments, several researchers were seriously working on regional issues, aiming to identify spaces with particular characteristics and propose alternate ways of State action that would mitigate socioeconomic differences between diverse localities.

In the Brazilian case, the French influence was of great relevance both for regional studies at universities and for State planning. Regional planning agencies

P. Ibanez (✉)
Laboratory of Economic and Political Geography (LAGEP), Federal Rural University of Rio de Janeiro (UFRRJ), Seropédica, Brazil

G. Westmann
Head of the Trade and Investment Office, Embassy of Brazil to India, New Delhi, India

F. L. Iozzi
Visiting Scholar at School of Public Health, University of São Paulo, São Paulo, Brazil

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_5

were gradually created, such as the Superintendency for the Development of the Northeast (SUDENE), and several political and financial institutions were mobilized to build a State apparatus with the objective of reducing regional inequalities (Balbim and Contel 2013). From a practical point of view, however, the results were not so much expressive. The two most impoverished regions of the country in most indicators remain the Northeast and the North, the main focus of these policies. The only region that actually presented a comparatively significant development process more was the Midwest, essentially due to an occupation based on agricultural expansion, a fact that made it the leading producer of several commodities that Brazil currently produce and export (Frederico 2015).

In the last few decades, the debates on regional development in Brazil have oscillated between diverse and even conflicting approaches, emphasizing regional policies and institutions. For example, during Fernando Henrique Cardoso's governments (1994–2002), the traditional regional policies focused on the superintendencies were replaced by Development Axes (Portugal and Silva 2020), relegated as a secondary priority and not effective practical results. While during Lula and Dilma's governments (2003–2016), the issue of regional development was taken more assertively, despite the lack of long-term and more sustainable strategies (Karam 2013). At that time, one of the institutions that became central to the government's regional policies was the National Bank for Economic and Social Development (BNDES), which established discussion groups, policy proposals, and financing mechanisms directly aimed at reducing regional inequalities in Brazil. Analyzing its role and the results of its performance in the last decades is the central objective of this article. To this end, the text was divided into two parts. The first, being responsible for presenting the historical perspective of regional development in Brazil, incorporated concrete policies and their singularities. The second focused on analyzing the disbursements of the BNDES. Whether or not, they have singularly contributed to reducing regional inequalities in Brazil.

2 Regional Issue and Development Policies: The Brazilian Case

As recalled by Diniz (2009), until the Second World War, the issue of regional planning was mostly linked to the theories of location, presented in the classic studies of Christaller, Von Thünen, Weber, and Losch. Such experiences were sparse and essentially limited to examples in the extinct Soviet Union, especially after creating the National Planning Commission, in 1928. Another example of effective regional planning, despite incipient, was related to the creation of the Tennessee Valley Authority, amid the New Deal reforms, in the USA, which had the prerogative to drive forward a region composed of six states in that country.

Only after Second World War, regionally based planning started to be used more systematically in several countries, gaining strength within the scope of the

National States. In the context of developmentalism, the State presented itself as a privileged agent in the conduction of projects that would result in economic growth, increase employment rates and overcome socio-spatial inequalities (Piquet and Ribeiro 2008).

To Balbim and Contel (2013:36), in this period, the influence of social organizations, large private corporations, and the State itself became very present in all nations' political scope, directly influencing the debates around proposals for the regionalization of territories. From a theoretical point of view, the French authors François Perroux and Jaques Bodeville were responsible for elaborating the concept of 'programming-region' or 'pilot-region,' the basis of most policies developed with regard to regional planning, including in Brazil.

Regional planning in Brazil has been characterized by different moments of empirical, theoretical, and bureaucratic consolidation, making it difficult to circumscribe such a process into specific phases that are faithful to the country's history. There is a relative consensus among researchers, nevertheless, that the period that took place between the 1930s and the 1950s, especially after the creation of the Brazilian Institute of Geography and Statistics-IBGE (1934) and the proposals for regionalization that followed, consolidated the national concern about the regional character of the territory. This happened in spite of the fact that the attempts to coordinate, control, and plan were more restricted to diagnoses, proposals, and sectoral measures in the economic field (Magnago 1995:68).

Regardless of the efforts promoted at the time, it is possible to affirm that the first great historical moments of intervention for regional planning in Brazil started in the 1950s and it was strongly linked to the ideals of the Economic Commission for Latin America (ECLAC). Practically, the ECLAC 'dominated the analysis of Latin American economies' growth processes and guided many of the economic policy proposals in that period' (Piquet and Ribeiro 2008:50). During that period, the scenario of social, economic, and urban inequalities that had been accentuated during the industrialization process became further critical. It exhibited a strong concentration of wealth in Brazil's Southeast region, especially in the city of São Paulo, which stressed the need to create more effective mechanisms of regional action (Siqueira 2013:67). The regional imbalances with the growing social tensions were experienced in the Northeast part of the territory. It also placed the issue on the national security agenda, leading to the creation of the Northeast Development Superintendence (SUDENE) in 1959.

Notwithstanding the advances promoted in the 50s in terms of regionalization, it was only after the advent of the centralization of power during the military period that the regional question was broadly included in the Brazilian national planning. Two years after the 1964 coup d' etat,[1] the military integrated the North region of the country in their national project by creating the Amazon Development Superintendence-SUDAM (1966), which would later be summed to the region's

[1]On March 31, 1964, army troops set off to Rio de Janeiro and launched a coup d'état long plotted by the military forces. The new regime would last 21 years.

industrialization efforts centered in the Manaus Free Trade Zone. In 1967, the Midwest Development Superintendence (SUDECO) and the South Development Superintendence (SUDESUL) were also created.

According to Vainer (2007:11), while regional development planning agencies distributed tax incentives among local and national elites, most regional strategic decisions were still taken by agencies representing macro-sectors of infrastructure, such as companies in the electricity sector (Eletronorte, Furnas, Eletrosul, among others). In a complementary way, major logistical projects were implemented by the central government, including the Transamazônica highway, with the scope of promoting the national integration and the dynamization of the development process of that area.

The successive oil crises in the 1970s, followed by pressures for democratization and a drastic reduction of the financing capacity of the State, had serious impacts in the 80s, known by several scholars as the 'lost decade,' when the exhaustion of the military's centralized planning model was put in evidence. Such reality led to an unavoidable decentralization process in the country and to the stagnation of the regional development policies implemented until then, also favoured by an international context characterized by neoliberal precepts advocating for a diminished role of the State.

To Pacheco (1998:20), this scenario was further aggravated by the global integration processes that created new interregional complementarities, even though autonomous engagements with the international market dynamics were not yet articulated in Brazil. Indeed, Brazil was so insulated from the global economy that the stagnation of regional development mechanisms and policies was rather determined by the crisis in the State's public finances than by the challenges imposed by the international insertion.

The foundations for a new period that would follow in the 1990s were, however, being laid: administrative decentralization, a decrease in the emphasis on regional planning, and a weak performance of the State in modernizing its industrial and technological policies. Allied to these transformations, the commercial opening that took place since the beginning of the 1990s led to a broader insertion of the country in the ongoing globalization process, further shaking the foundations of the planning model previously sustained. From a regional point of view, the superintendencies lost importance, and the proliferation of subnational investment attraction policies increasingly gained more space.

In order to regulate the new planning practices in Brazil, the 1988 Constitution created the Pluriannual Plans (PPAs), whose main objectives include a preoccupation with explaining the regional distribution of government targets and expenditures, and offering further transparency to the application of resources and to the results obtained. In its Article 165, § 7, the Constitution establishes that the definition of the PPA and the annual budgets must, among other functions, be oriented to reducing interregional inequalities, according to population criteria. However, the problem created is that its text is not clear about which regions the Constitution refers. A first indication is found in Article 35 of the ADCT—CF 1988, which states that the provisions of art. 165, § 7, will be progressively enforced, within a period of up to ten years, by distributing the resources among the existing macroeconomic regions (Fig. 1).

An issue that remained, in this context, is that such macro-regions are the same adopted by IBGE in 1970, which no longer reflect the challenges of regionalization in the country. It is also necessary to remember that the constitutional mandate requires states, municipalities, and the federal district also to practice the planning system outlined in the Constitution (IPEA 2018). In these cases, it continues unclear, which would be the parameters of the regionalization to be adopted.

In a context of stabilization and internal adjustments, the 90s represented a moment of inflection in Brazil, both in regional planning and in the industrial policies that supported it. At that stage, prevailed the view that the public sector should regulate markets' functioning, offer public goods and services, and promote competition where market mechanisms were not efficient and/or effective (Campanário and Silva 2004:16). The regional development policies were overlapped by the so-called National Integration and Development Axes. The regional development superintendencies were extinguished and replaced by development agencies, closer to the idea of regulation rather than to intervention itself.

The lack of effective regional policies from the federal government resulted, according to Araújo (1999), in a fiscal war between states and municipalities, which contributed to consolidate 'focuses of dynamism,' further increasing regional disparities. In federative contexts in which competition between government entities is accentuated, the fiscal war tends to reduce the efficiency of the national tax system while cumulative distortions in the territorial allocation of resources tend to crystallize. These issues, combined with a disarticulated Brazilian international insertion, served more to a competitive disintegration, since, relegated to market forces, investments tended to be oriented to the country's most dynamic areas.

Such reality gradually raised awareness about the need to renew and strengthen policies with a national-territorial dimension, considered essential pillars for assuring the country's development and political-federative cohesion (IPEA 2018). Indeed, strategies and policies aiming to reduce the Brazilian interregional development disparities imply negotiated and generally complex political solutions in an environment of federative relations that must be driven by the State in association to regional and local stakeholders.

Regardless of the persisting challenges, there is a certain consensus in the literature that since the first term of President Lula's government (2003–2006), regional planning in Brazil was resumed. A fact that corroborates this assertion is President Lula's attention to the then emptied Ministry of National Integration (MI), which had its structure reinforced with highly specialized technical staff, especially in the Secretariat for Regional Development Policies. Throughout 2003, this Secretariat was dedicated to the reformulation of the MI's regional programs, to recreating the regional superintendencies, to the establishment of a National Regional Development Fund, and to the discussion on a new National Regional Development Policy-PNDR, aiming to supplant the traditional macro-regional perspective and to propose a multiscale approach, based on the territorial diversity of Brazil (Karam 2013).

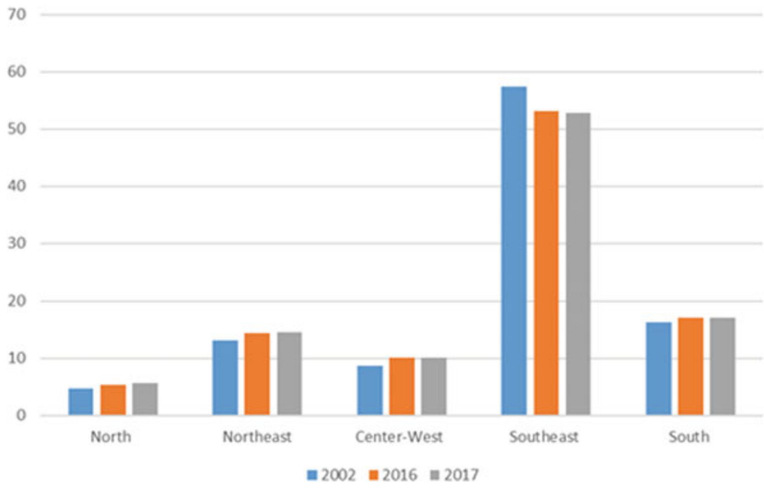


Fig. 1 Brazilian GPD by region

Even though the PNDR presented a robust legal framework (Decree 6047, of 2007), various factors did not contribute to its consolidation as an effective State policy. Indeed, the Ministry of National Integration was soon disintegrated, loosing legitimacy to guide the debate on regional development in Brazil. In addition, the lack of integration between programs and policies of a territorial nature under the responsibility of the federal government remained, as well the absence of the necessary instruments to make the multiscale integration of vertical and horizontal efforts feasible.

In 2008, another important effort to strengthen the regional debate was the development of a broad study about the territorial dimension of planning, guided by the Ministry of Planning, Budget, and Management-MPOG. The document contributed to answering some important questions such as how the productive capacity and infrastructure should be distributed, how the structure of the national territory should be in twenty years from now, and the territorial impacts of new technologies (MPOG/CGEE 2008:13). Notwithstanding the richness of the technical details presented in the study and the team's expertise, the proposals contained in the document were not incorporated into the government planning of the following years.

Such a scenario confirms that Brazilian regional planning has been characterized by the coexistence and overlapping of distinct diagnoses, disjointed priorities, weakness or absence of coordination structures, and superposition of strategic areas and territorial dimensions. Such characteristics, combined with insufficient inter-ministerial coordination and a federative pact that is not always cooperative, often result in political fragmentation, eventually leading to disharmonious regional and sectoral policies.

In order to address such contradictions and more effectively contribute to the national regionalization strategies, especially after 2007, the Brazilian federal government started making increased use of the National Bank for Economic and Social Development (BNDES), which is currently one of the largest development banks in the world, to finance projects in the least developed regions and to offer specific credit lines to entrepreneurs willing to initiate projects in those areas.

The use of the BNDES to support regional policies is one of many other existing instruments available to the central government in promoting country's least integrated regions. Other instruments include tax exemptions, training of the workforce, economic integration to value chains, and support to tourism, to name just a few. Any attempt to present a complete analysis of the entire set of tools to support the least developed areas of the country, their effectiveness, and their intrinsic relations are, however, faded to fail, as each reality will lead to different conclusions. In any case, a broader analysis of the role of the BNDES in supporting regionalization strategies can be illustrative of the signs of progress, failures, and challenges ahead and may contribute to better guide regional policy planning, decision-making, and implementation in the years to come.

3 The Role of the National Bank for Economic and Social Development—BNDES in Brazil's Regional Policies

The Brazilian Development Bank (BNDES) is the principal financing agent for development in Brazil, in all segments of the national economy. Since its foundation in 1952, the BNDES has played a fundamental role in stimulating the expansion of industry and infrastructure in the country and currently supports technological innovation, exports, sustainable socio-environmental development, and public modernization administration. The Bank offers financing mechanisms to Brazilian companies and public administration entities, enabling investments in all sectors.

The Bank has two integral subsidiaries: FINAME and BNDESPAR. Together, the three companies comprise the BNDES System. FINAME's resources are earmarked for financing purchase, sales operations and exports of Brazilian machinery and equipment, and imports of goods of the same nature produced overseas. BNDESPAR is a business corporation, which carries out capitalization operations of undertakings controlled by private groups.

The role of the BNDES in regional and territorial development is mostly related to productive, infrastructure, and logistics investments and financing, but not restricted to them. Due to Brazil's accelerated urbanization process, which is often faster than the expansion of infrastructure supply and public services, several micro-regions concentrate on social problems that directly affect the welfare of its inhabitants. The reason for which credit lines to assist states and municipalities aimed at improving the quality and the scope of public services, such as sanitation, mobility, and management, are also part of the attributions of the Bank (Lastres et al. 2014).

The main contribution to the capillarity of financing occurred with creating the BNDES Card at the end of 2002, an electronic credit instrument aimed mainly at supporting micro, small, and medium-sized enterprises. With such an instrument, it was possible to expand the number of beneficiaries and support entrepreneurs in more distant localities, constituting a tool of deconcentration of the Bank's disbursements, both in relation to regions and size of companies (Lastres et al. 2014). Citizens in almost all municipalities in the country, including those located in the North, Northeast, and Midwest regions, which are historically the least developed in Brazil, were benefited from the BNDES Card by 2014.

Especially from 2007 onward, the Bank has more effectively and transparently included the regional issue in its corporate planning, strategies, and organizational structure. It aimed to mitigate inter and intraregional imbalances and focus on the regions that do not contain large structural investments to deconcentrate development in the territory. In order to do so, the Bank has incorporated to its institutional framework a series of specialized units to contribute to the formulation of a development agenda for the territory with the objective to guide, among others, the investments in territorial and environmental planning; urban, social, environmental, and cultural infrastructure; modernization of public management; education and training; and economic development, with the mobilization of productive and innovative arrangements (Lastres et al. 2014).

In addition, the BNDES has developed actions to reinforce partnerships with state and municipal governments, supporting their planning and execution systems. The partnership with states was embodied in a financing line created at the end of 2009, which aims to promote integrated and long-term development in their territories, encouraging participatory planning processes, and offering privileged financial conditions, criteria, and support structures to less developed regions of the country. To this end, coordinated and continuous actions capable of stimulating and mobilizing local participation and protagonism are of utmost relevance, as well as the creation of more contemporary evaluation tools to assess the impacts of these policies.

Beyond increasing the total amount of financing to regions that have traditionally been less covered, the Bank also has been developing strategies to prevent that these resources continue to migrate to the most developed regions in the forms of acquisitions of high value equipment, goods and services or of bringing more qualified workforce from these areas. Indeed, only this way the Bank can effectively contribute to the mitigation of inter and intraregional inequalities in Brazil.

Notwithstanding important advances verified in the role of the Bank in promoting regional development, it still has been struggling with contradictions inherent to the Brazilian society, which often limit the range and scope of its activities. By holding over USD 160 billion in total assets, the BNDES has not only been an object of desire to be instrumentalized by different governments, but also influenced by the programs of the government of the day, thus eventually affecting its performance, results, and the continuity of its strategies (Figs. 2 and 3).

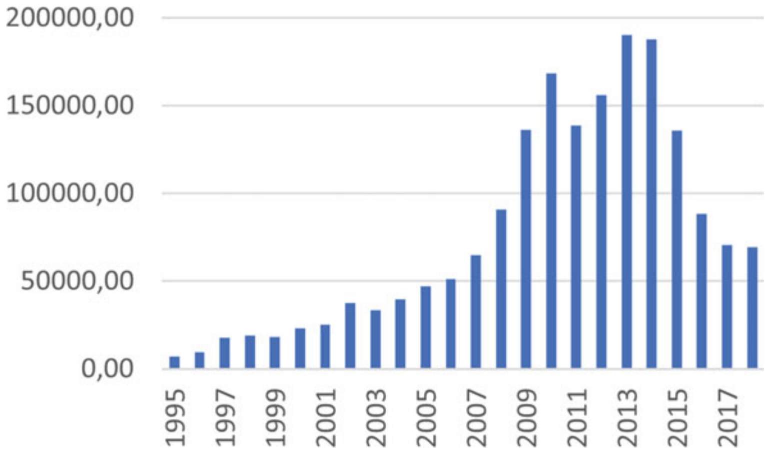


Fig. 2 Total BNDES disbursements (1995–2018)

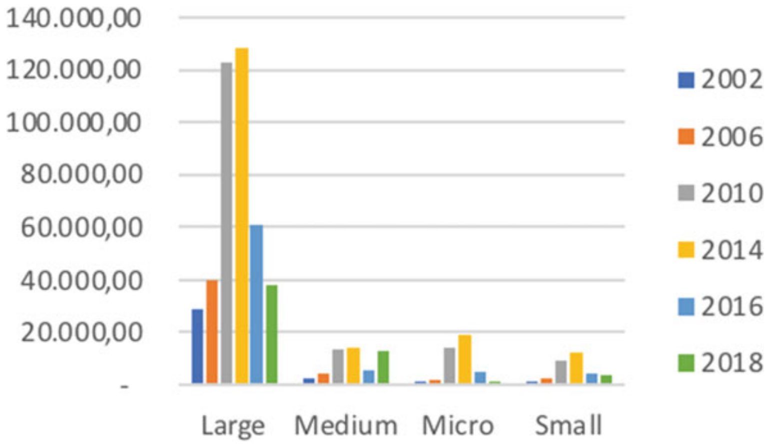


Fig. 3 BNDES disbursements by size of companies benefited (2002–2018)

As regional planning in Brazil has been characterized by different moments of empirical, theoretical, and bureaucratic consolidation, so have been the Bank's actions in this regard, reflecting inconsistencies in its policies to different regions throughout its history, often related to a misleading understanding of the concept of development itself. In practice, most development analysis in Brazil remain based on a linear approach, perceived as the primary goal of every country, achievable by the adoption of the right sets of policy instruments. This linear perspective, which continues to justify most regional strategies in Brazil, is famously schematized by Rostow (1959), who places development as the process through which countries or, in the case, regions, pass from a condition of underdevelopment to a condition of development, but does not take into consideration that development is a matter of perspective, thus cannot be predefined by general standards equally applicable to all realities.

Regardless of these considerations, it is undeniable that the BNDES has been playing a relevant role in promoting regional integration and regional development in Brazil. According to the strategic planning of the Bank to the triennial 2020–2022, however, no institution is capable of promoting development alone, the reason for which the Bank reaffirmed the commitment to articulate partnerships for the sustainable development of the country, in the search for a collective engagement toward the proposed goals. The document presents, in this sense, specific results to be delivered to the Brazilian society by 2022, including the expansion of access to services, the reduction of social and regional inequalities, the deconcentration of investments in sanitation, the creation of jobs, and the promotion of competitiveness, productivity and regional development in the sectors of goods and services, all with direct impacts in the country's regional policies.

Based on the analysis of the disbursements of the Bank, however, it becomes clear that the Southeast region, the richest in Brazil, continues to receive substantially more resources, followed by the South. It is true that the Northeast and the Center-West regions gradually started to receive further resources in the last years, but the discrepancy in absolute number in comparison to the richest areas of the country remain abyssal, with eventual oscillations in the balance sheet associated to specific mega-projects, some of them in the context of the Growth Acceleration Plan, which was created by President Lula and gained central importance during the first term in office of President Rousseff.

The reasons behind such reality are complex and would demand deeper discussions on the topic. It can be said, however, that, in part, this results from the lack of capacity of local governments and entrepreneurs in the more depressed regions to present projects and proposal to be financed by the Bank, but that is not enough to justify the existing imbalance. Indeed, Brazilian economy has always been concentrated on the Atlantic Coast of the country, more specific in the States of São Paulo, Rio de Janeiro and Minas Gerais. In the lack of broader incentives to investments in other regions, investors, both national and international, have always privileged these centers when deciding on new strategies, thus demanding support from the BNDES to projects those areas more often. Moreover, Brazil has an enormous infrastructure deficit, which inhibits investments in the least articulated cities, creating a vicious cycle that depend of more coordinated efforts and regional programs to be overcome.

The gradual deconcentration of the Bank's disbursements throughout the recent years apparently reflected a more coherent strategy, in line with the objective to reduce the regional imbalance. However, even though the South, Northeast and Center-West regions received proportionally more resources from the BNDES since 2010, most of those resources were destined to very specific projects and large agriculture projects, associated with higher technology farming techniques, which do not necessarily contribute to promoting local development in a more effective way. On the other hand, one cannot deny that there were important infrastructure and energy projects in these regions and increasing investments in productive units due to the lower costs of land and workforce (Figs. 4 and 5).

After the political turmoil which started during the second Dilma's election in 2014, the role of the BNDES sharply decreased due to the country's instability and the reorientation of the socioeconomic role of the Bank in promoting development. Such reality raised questions, once again, about the future of regional development policies in Brazil, and the role of the Bank in reducing regional imbalances, as the social and economic gap inside the country continues to increase, with the concentration of wealth in the Southeast region and the North highly marginalized by the federal government and the private sector.

As of 2020, the fluctuations in domestic politics and the delay of structural reforms have unmasked past vices and revealed the persistence of important challenges, which must be promptly overcome to allow the reduction of the country's regional imbalances. Among the greatest challenges is the fact that the regional policies developed in recent years were articulated by restricted groups of bureaucrats and politicians, not necessarily based on the nation's most authentic values and lacking the support of multiple social actors on a more solid basis.

The denial of the 'Lulista' agenda by President Bolsonaro and its recent replacement by a Western Christian vision, led by an authoritarian and more radical political elite, does not appear to be bringing positive results to Brazil in this regard. Regional policy needs to be supported by a modern and responsible analysis of the reality of the country, based on solid debates, data analysis and with the participation of multiple internal actors and social support, which objectively takes into account the gains and losses that each region can take within the framework of Brazil's federative pact.

The current pessimism and dissatisfaction with the State of affairs in Brazil only contribute to polarizations, which, in turn, feedback. The solutions to the current regional development crisis in the country should reside in the formation of an economic-financial system capable of carrying out sustainable development (in its three pillars), which is more inclusive and less unequal. The responses to the socio-cultural crisis should rely on deepening and guaranteeing social rights, as well as civil rights, especially for the most vulnerable populations, such as women, blacks, indigenous peoples, and the LGBT community. However, all of these responses demand the strengthening of tolerance, solidarity, and respect for plurality, values that seem to be out of fashion in Brazil at the present.

4 Final Remarks

Unlike the regional development policies developed in Brazil during the 1960s and 1970s, in the last decades, the country has implemented relatively more limited and restricted strategies, which had the BNDES as one of their main agents, acting in a clear and objective manner toward promoting regional development. In addition to that, the increasing importance of the Bank's role in national development as a

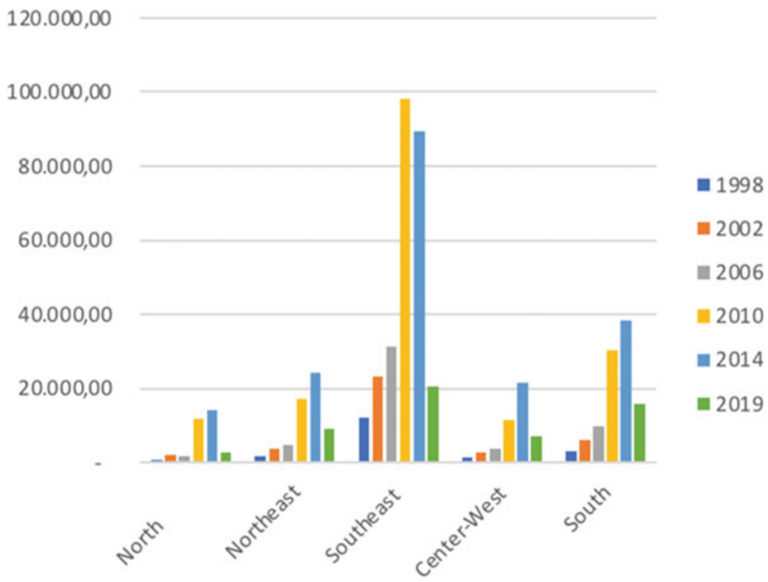


Fig. 4 BNDES disbursements by region ($)

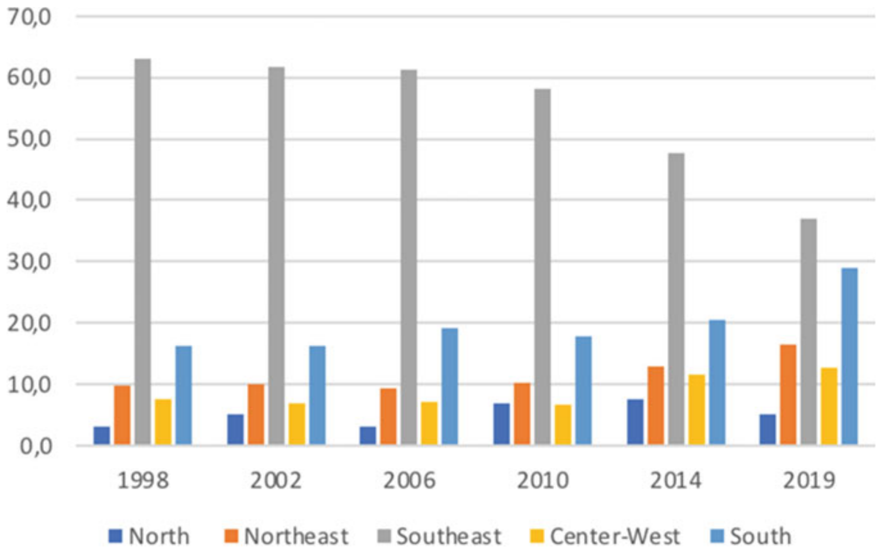


Fig. 5 BNDES disbursements by region (%)

whole was also verified, especially after 2008, when it started to provide support for local governments and entrepreneurs to overcome the international crisis that emerged that year.

Specifically, in relation to the regional issue, it was possible to notice a change in the Bank's resources allocation, with the decrease of the Bank's disbursements to the Southeast region, the most developed in Brazil, and a gradual increase in disbursements oriented to other regions. Based only on the disbursements of the Bank, however, it is difficult to evaluate if it indeed played a central role in reducing the participation of the Southeast over recent years and promoted regional development in the most impoverished areas of the country. Regardless of that, it is possible to affirm that, although regional imbalances are historical and partly structural, from the lack of infrastructure to school evaluation indicators, such changes in the disbursements of the Bank are extremely important and must be continued so that BNDES' role in Brazilian national development also contributes to mitigating the country's profound regional inequalities.

References

Araújo TB (1999) Por uma Política Nacional de Desenvolvimento Regional. Revista Econômica do Nordeste, Banco do Nordeste 30(2):1–30 (in Portuguese)

Balbim R, Contel FB (2013) Região e regionalização: subsídios teóricos para o ordenamento territorial e o desenvolvimento brasileiro. In: Boueri R, Costa MA (eds) Brasil em desenvolvimento: Estado, Planejamento e Políticas Públicas. IPEA, Brasília, pp 25–47 (in Portuguese)

Campanário MDA, Silva MMD (2004) Fundamentos de uma nova política industrial. In: Fleury MTL, Fleury A (eds) Política industrial. Publifolha, São Paulo (in Portuguese)

Diniz CC (2009) Celso Furtado e o desenvolvimento regional. Nova econ Belo Horizonte 19:2 (in Portuguese)

Egler CAG (1995) Questão Regional e Gestão do Território no Brasil. In: Castro IE, Costa PCG, Correa RL (eds) Geografia: conceitos e temas. Bertrand Brasil, Rio de Janeiro, pp 207–238 (in Portuguese)

Frederico S (2015) Economia política do território e as forças de dispersão e concentração no agroengócio brasileiro. GEOgraphia (UFF) 17:68–94 (in Portuguese)

IPEA—Institute of Applied Economic Research (2018) Challenges of the Nation. Ministry of planning, development and management of Brazil, 1, Brasília

Karam RAS (2013) A questão regional na era Lula. Uma análise de ideias, atores e interesses. Beco do Azougue, Rio de Janeiro (in Portuguese)

Lastres HMM et al (2014) O apoio ao desenvolvimento regional: a experiência do BNDES e oportunidades para avanços. Revista do BNDES 42 (in Portuguese)

Magnago AA (1995) A divisão regional brasileira—uma revisão bibliográfica. R Bras Geografia, Rio de Janeiro 57(4):64–92 (in Portuguese)

MPOG/CGEE (Ministério do Planejamento, Orçamento e Gestão/ Centro de Gestão e Estudos Estratégicos) (2008) Estudo da dimensão territorial para o planejamento. MP, Brasília (in Portuguese)

Pacheco CA (1998) Fragmentação da nação. Unicamp/Instituto de Economia, Campinas (in Portuguese)

Piquet RPS, Ribeiro ACT (2008) Tempos, ideias e lugares: o ensino do planejamento urbano e regional no Brasil. Revista Brasileira de Estudos Urbanos e Regionais 10(1):49–59 (in Portuguese)

Rostow WW (1959) The stages of economic growth. Econ Hist Rev New Series 12(1):1–16. https://doi.org/10.2307/2591077

Siqueira H (2013) Dinâmica regional brasileira (1990–2012). In: Brandão C (ed) Pacto federativo, integração nacional e desenvolvimento regional. Editora Fundação Perseu Abramo, São Paulo

Portugal R, Silva AS (2020) História das políticas regionais no Brasil. IPEA, Brasília (in Portuguese)

Vainer CB (2007) Planejamento territorial e projeto nacional. R.B. Estudos Urbanos e Regionais 9 (1) (in Portuguese)

Pablo Ibanez He is graduated in Geography from the State University of Campinas (2002), and Master's (2006) and PhD (2012) in Human Geography from the University of São Paulo. He is currently an adjunct professor at the Federal Rural University of Rio de Janeiro and a researcher linked to the research groups: Welfare in Health, Development and Territory, at the Faculty of Medicine of the University of São Paulo; Research Center on Public Policies and Territory, at Fluminense Federal University; and Group of Studies and Research on Politics and Territory (GEOPPOL), from the Federal University of Rio de Janeiro. He was a visiting researcher at Fudan University, Shanghai. He has experience in the research area, with emphasis on geopolitics, political, economic, and regional geography, acting mainly on the following themes: science, technology, and innovation; regional development, regionalization, and decentralization; analysis of public policies, industrial, and innovation policies; development and territory.

Gustavo Westmann is presently the head of the Trade and Investment Office at the Embassy of Brazil to India and the former economic counsellor at the Embassy of Brazil to Indonesia and Brazilian Commercial Attaché to Italy. He did Bachelor in Law and in International Relations, Master in Diplomacy (Rio Branco Institute/Brazil), Master in International Public Affairs (LUISS-Italy), and Master in Public Policy (UC Berkeley/USA). He is PhD candidate at JGU, India. He is the author of the book New Perspectives on Brazilian Foreign Policy and several other articles and a producer and director of the movies Brazil: a time to build (2018) and Rocinha's Via Sacra: art and violence in the Brazilian favela (2019).

Fabiola Lana Iozzi is Geographer and Master in Geography (Environmental Analysis and Territorial Dynamics) from the State University of Campinas (Unicamp, in 2006). She did PhD in Sciences (Department of Preventive Medicine at the Faculty of Medicine) from the University of São Paulo (USP, in 2014), with a PhD internship at the Institute of Geography at the University of Buenos Aires, Argentina (2012), and a post-doctorate by the National School of Public Health Sérgio Arouca of the Oswaldo Cruz Foundation (Ensp/Fiocruz, in 2016). She is currently an independent researcher, with experience in the area of human geography, regional planning, public policy and public health, working mainly on the following themes: regional planning; regionalization and decentralization; uses of territory; spatial production circuits; analysis and evaluation of public policies; health systems and policies; development and health; health science, technology, and innovation.

Erosion and Coastal Structures in Brazilian Metropolises: The Case of Fortaleza and Its Inequalities

Eduardo Lacerda Barros, Davis Pereira de Paula, Renan Gonçalves Pinheiro Guerra, and Jader de Oliveira Santos

1 Introduction

Coastal erosion is a natural process that can result from several factors, including anthropic intervention. This process can occur both along the coastline and in hydrographic basins by directly interfering with sand transport along the coast and resulting in an imbalance in the supply of sediments to nearby beaches, causing the coastline to recede. It is important to note that natural (e.g., promontories) and artificial (e.g., groins) structures can alter coastal conditions (e.g., waves), resulting in an increase or decrease in the drift transport that supplies beaches. Numerous studies have been conducted that deal with coastal erosion on sandy beaches (e.g., Stive 2004; Zhang et al. 2004; Leatherman 2018; Luijendijk et al. 2018; Sinitsyn et al. 2020; Vousdoukas et al. 2020), including reports that have investigated the application of different methods and scales for the analysis of coastal processes.

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

E. L. Barros (✉) · R. G. P. Guerra
Ceará State Secretariat of Environment (SEMA), Environment Chief Scientist Program, Fortaleza, Brazil

D. P. de Paula
Laboratory of Coastal and Oceanic Geology and Geomorphology (LGCO), Ceará State University (UECE), Fortaleza, Brazil

J. de Oliveira Santos
Department of Geography, Ceará Federal University (UFC), Fortaleza, Brazil

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_6

Recently, coastal erosion has reached proportions that far exceed coastal management's response capacity, generating problems on a global scale. Luijendijk et al. (2018) highlight that 24% of the world's beaches are under erosion, with 48% currently stable and 28% under accretion. Although this appears to be a small percentage, the figure represents a critical situation because of the potential damage to structures and populations resulting from coastal erosion. This situation is expected to worsen because of the increase in the average sea level that is anticipated in association with climate change. Coco et al. (2014) point out that while the short-term recession may be associated with anthropic effects, the long-term recession of beaches is probably associated with climate change, ultimately affecting the supply of sediments to the beaches.

Coastal erosion management is a relevant topic that has been discussed in a variety of settings. Rangel-Buitrago et al. (2020) highlight five main strategies for dealing with coastal erosion: coastal protection, accommodation, planned retreat, the use of ecosystems for coastal protection, and sacrifice (leaving the coast to erode). The use of rigid structures to protect the coasts has so far been the primary option in Brazil. In many cases, this remains the only strategy that is used to deal with the problem. Despite this, some instances in soft structures, such as the artificial flattening of beaches by beach nourishment, can be observed on the Brazilian coast (such as Fortaleza-CE, Rio de Janeiro-RJ, Jaboatão dos Guararapes-PE, and Balneário Piçarras-SC).

The problems associated with coastal erosion in Brazil are not different from those observed around the rest of the world, mainly when centered on coastal metropolises with high populations and diverse activities associated with tourism, where ports, industry, and services are under constant development. Therefore, the challenge is to manage the erosion occurring in Brazil's coastal metropolises, such as Florianópolis-SC, Rio de Janeiro-RJ, Salvador-BA, Recife-PE, and Fortaleza-CE, where urbanization is consolidated, and socio-environmental and territorial conflicts are rife.

Morais et al. (2018) indicated in their study that 30% of the coast of Ceará is under active erosion, 17% has erosive tendencies, 10% is in progradation, and 43% is currently stable. In the cases of coastal erosion identified in Ceará, the coastline along the city of Fortaleza has undergone several changes due to coastal erosion, which was initially responded to by the manufacture of rigid structures. However, the intervention used has changed significantly over the last 20 years, with substantial investment in coastal protection solutions that use sand to construct soft structures that can contain the advance of the sea. One notable example of this method is the artificial beach nourishment of Iracema Beach, carried out at the beginning of the twenty-first century and 2020. This work aims to identify and analyze how the structures that stop the advance of the sea were designed in each of the regions in Fortaleza and how the structures interact with the local social, political, and economic environment. The neighborhoods within the city of Fortaleza are depicted in Fig. 1, emphasizing the coastal areas of the city and the structures used for coastal protection.

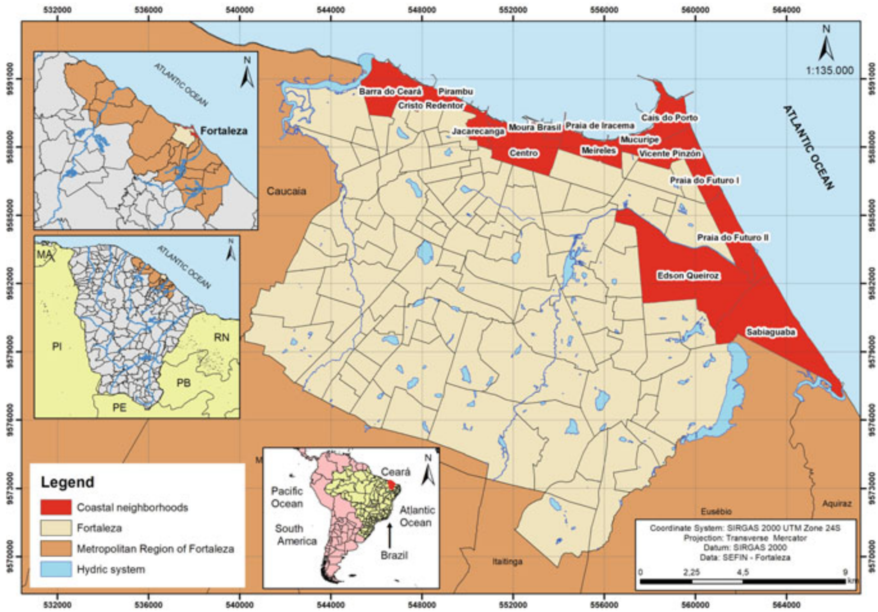


Fig. 1 Location map of the study area with an emphasis on the coastal neighborhoods of Fortaleza. *Source* Data base SEFIN—Fortaleza

2 Coastal Management in Brazil and the Coastal Erosion Prevention and Protection Guidelines

Brazil deems coastal management as a public policy that is addressed by several different levels of decision-making bodies. It includes crucial participants such as government institutions, civil society, the productive sector, and other entities that directly or indirectly affect or are affected by decisions involving the management of the coast.

Coastal management is legally based on the use of planning and execution mechanisms provided by GERCO to regulate the multiple interactions between the ecological, economic, and social components. The mechanisms that makeup GERCO are anchored in the legal frameworks of Law No. 7.661/88 and of Decree 5.300/04 that institute and regulate the National Coastal Management Plan (PNGC). The construction of the coastal management policy has historically assumed distinct stages that are involved in the construction of mechanisms to be used for management and the systematization of scientific knowledge (Fig. 2). The latter is an attempt to subsidize the institutional efforts by considering the evolution of the global climate change impact scenario, with emphasis on the intensification of erosion and flooding processes (Brazil 2018a).

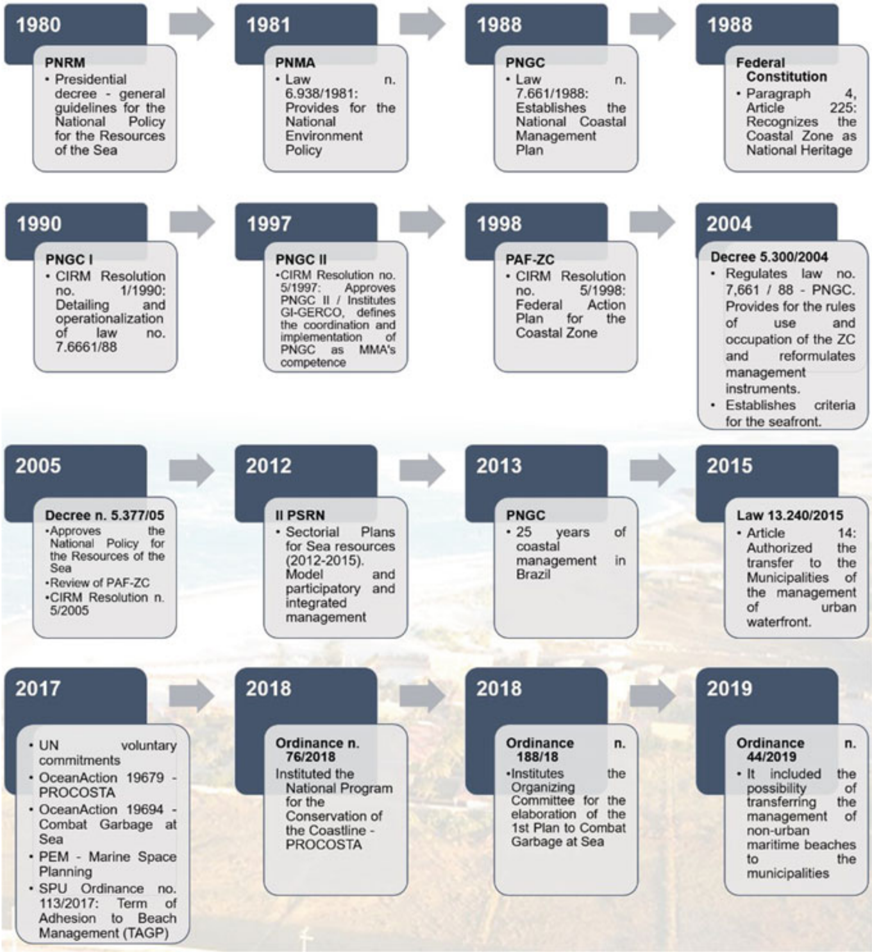


Fig. 2 GERCO history in Brazil

It is in this context that the necessary basis established for the idealization of the National Coastline Conservation Program (Procosta[1]). Procosta was conceived as a strategy with which a permanent coastal zone planning and management program could be established with a local character, seeking to solve the critical problem of the lack of reliable data available on a national scale (Brazil 2018a). As a prelude to the actions suggested by Procosta, a strategic document was produced with the premise

[1]A estrutura do Procosta está compartimentada em quatro Projetos lógicos e interdependentes: Projeto Alt-Bat; Projeto Projeção de Linhas de Costa Futuras e Identificação de Perigos; Projeto Riscos Costeiros e Estratégias de Adaptação; e Projeto Monitoramento e Gestão para a Conservação da Linha de Costa. Mais informações em Brasil (2018).

of using sustainable interventions for mitigating and preventing coastal erosion, called the Coastal Erosion Prevention and Protection Guidelines (Brazil 2018b).

The guidelines indicate the different responses required to achieve the development of alternative methods or structures aimed at coastal protection in a vital effort to regulate a deal with various states and municipalities. Until the production of this guide, no document managed to acquire federal aid in guiding the possible measures and solutions that could be utilized to mitigate the adverse effects of coastal erosion.

There are few references or technical regulations that describe the processes involved in the institutional arrangement and guidelines for constructing rigid interventions on the coast of Brazil or monitoring the impact of these structures (Brazil 2018b). Single studies that describe the advantages and disadvantages of specific alternatives are more common, as are studies detailing the cumulative impacts of these interventions on the dynamics of the coast.

Thus, technical initiatives that direct the minimum guidelines for the completion of structures can protect the coastline and prevent erosion should be encouraged. Such initiatives would contribute to the optimization of public resources invested in protecting the coastlines, as well as in structuring the governance between institutions with a regulatory function for interventions in the coastal zone.

In view of this reality, coastal management assumes an essential role in the integration of the methods used and in the broad participation of those responsible for the management of the Brazilian Coastal Zone. It should be clarified that coastal management methods do not generate results in the short term. As a result, integrated coastal management in Brazil is generally considered irrelevant by society and is consequently not adhered to or treated as relevant by governments. Therefore, changes must be evaluated to foster new mechanisms for institutional articulation and mechanisms by which coastal management can operate in Brazil.

3 Fortaleza: An Artificial Coastline Over Time

The coastal zone of Ceará is classified by Morais (2000) and Pinheiro et al. (2016) as a sandy, straight coast that includes features such as dunes, lagoons, salt flats, and cliffs that are present in the Barreiras Formation. Dating from the tertiary-quaternary, the coastal zone also presents outcrops from the Precambrian and the Cretaceous in some areas.

The city of Fortaleza is located in the coastal zone of the state Ceará, in a remarkable context that is due to the presence of Precambrian rocks, which are found on the coasts in the form of morphological features called promontories or rocky spikes Fig. 3. Such features are fundamental in elaborating the coastline's current configuration, as these features control the performance of the hydrodynamic processes in these locations via their effects on the diffraction and refraction of the waves. The coast of Ceará have a greater tendency to erosion and progradational tendencies because of the drift current that flows predominantly from the east to the west in this state (Morais 2000).

The climate of the city of Fortaleza is controlled by the Intertropical Convergence Zone (ITCZ), with the highest levels of precipitation during the first half of the year, resulting from its location in the southernmost part of the Atlantic and the northeast trade winds. In the second half of the year, the southeast trade winds become predominant and push the ITCZ toward the north, decreasing precipitation levels in the region (Paula 2012). Paula (2012) points out that the wind speed averages between 3.0 and 4.3 m/s, varying throughout the year. Classification with the Koppen scheme (1948) indicates that the area has a hot and humid tropical rainy climate—AW.

The tides in the state of Ceará are classified as semidiurnal tides, with average amplitudes of 3.2 m (Morais 1981; Maia 1998), but they can reach 4 m in some areas as pointed out by Lacerda Barros (2018). Paula (2012), when studying Fortaleza, identified amplitudes that range between 2 and 4 m. Sea waves are predominant in the state of Ceará, producing 80% of the waves in the area with a period varying between 1 and 9 s, while the other 20% are swell-type waves with a period of 10 s (Carvalho et al. 2007).

Regarding the morphodynamic stages observed on these beaches, Pinheiro et al. (2016) suggest that the beaches in the metropolitan region of Fortaleza, as well as in the city of Fortaleza, are predominantly modified by the tides (RTR > 3). The beach profiles have a reflective configuration in the upper portions, accompanied by escarpments, and are dissipative in the lower portions. These beaches, therefore, include the characteristics that classify them reflective plus low tide ridge (R + LTR), with the central section of the city predominantly composed of medium sand.

Albuquerque et al. (2009), when calculating the morphodynamic stage of Praias do Futuro, Cofeco, and Porto das Dunas, observed that waves dominate these beaches.

Paula (2012) and Guerra (2014) point to the recurrence of storm events that cause flooding in the roads near the central sector of the coast of Fortaleza, which lies mainly between Barra do Ceará and Cais do Porto; this is due to the entry of waves moving in N and NNE directions and can cause local erosive events that lead to damage to the heritage buildings.

The process of artificialization of the coasts of urban areas has triggered severe consequences to the sedimentary balance, causing a gradual and accelerated scenario in which the coastal zone has been modified. Over the last few decades, the implementation of physical structures has expanded, minimizing the effects of coastal erosion in the coastal metropolises. This process has become increasingly apparent in the city of Fortaleza since the second half of the twentieth century. Klein et al. (2005, 2009), Alfredini and Arasaki (2009) and Brazil (2018) point out that the main function of physical structures is to interfere with the action of the waves and the longitudinal transport of sediments, thereby reducing the impacts of erosion via stabilization or progradation.

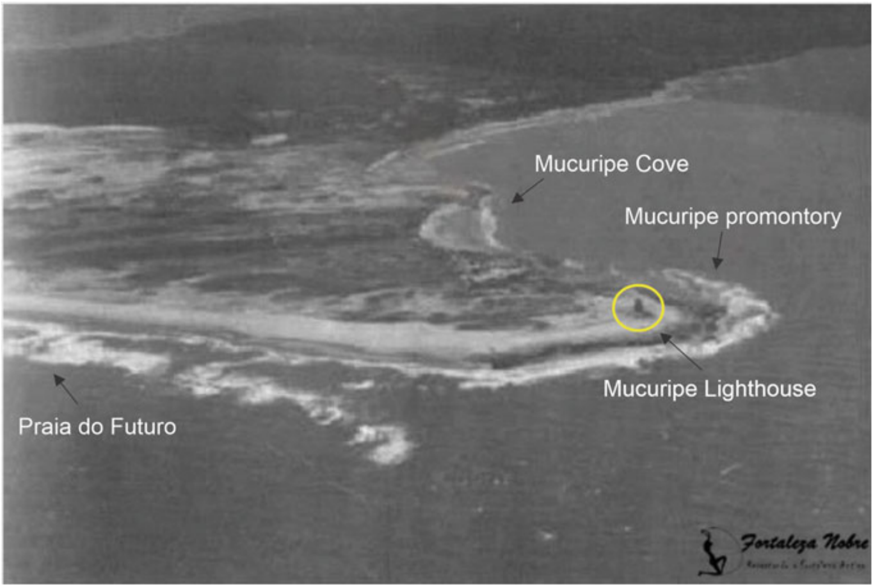


Fig. 3 Mucuripe promontory, an area where the port of Mucuripe built in the late 1930s. Highlight for the presence of the Mucuripe lighthouse, built in the second half of the nineteenth century. *Source* Fortaleza Nobre

The coastline of the city of Fortaleza, which extends over a total of 34 km, presents a series of coastal structures built to contain and/or minimize the impact of coastal erosion and the ports that have been under development since 1875. When analyzing the coastline of this city in the current context, it was possible to identify 39 structures such as areas of beach nourishment, breakwaters, groins, ripraps, and jetties. Such structures are exemplified in Fig. 3, with more details given in Table 1. There are 21 groins, 10 ripraps, 4 breakwaters, 3 areas of beach nourishment, and 1 jetty. Thus, approximately, 60% (18.9 km) of the city's current coastline has been modified, with most of the alterations in the northern section of the city. To better understand the extent of these changes, if the lengths of the structures that have been built on the coast of Fortaleza were combined in a linear fashion, they would reach a length of approximately 14.3 km, which represents approximately 42.3% of the total coastline of the city.

Like most of the coastal protection sites around the world, groins are the predominant structures used for coastal protection in Fortaleza. However, this solution has undergone a decline because of the damage caused by these structures due to their position (Fig. 4a). Groins are rooted to the beach and are built so that they extend transversely from the post-beach, directly affecting the transport of sediments in the area and leading to the accumulation of muddy sediments or erosion. Groins are either constructed singly or in groups (groins field); the latter option is used when the intention is to create or recover a strip of beach quickly (Alfredini

Table 1 Coastal structures on the coast of Fortaleza

Coastal neigborhood[a]	Amount of structure per neighborhood	Extension of structures (m)	Total extension of structures by neighborhood (m)	Beach nourishment	Breakwater	Groin	Riprap	Jetty
Barra do Ceará	9	210,29	1.736,60	0	0	0	7	2
		33,21						
		40,66						
		221,26						
		253,29						
		257,91						
		111,71						
		180,035						
		427,92						
Cristo Redentor	2	787,25	947,2	0	1	1	0	0
		159,95						
Pirambu	5	247,34	1.612,03	0	0	3	2	0
		197,94						
		792,85						
		261,79						
		159,37						
Jacarecanga	2	420,94	511,64	0	1	1	2	0
		90,70						
Moura Brasil	4	825,49	1.612,03	0	1	1	2	0
		361,95						
		331,91						
		92,68						
Centro	2	782,54	970,93	0	1	1	0	0

(continued)

Table 1 (continued)

Coastal neigborhood[a]	Amount of structure per neighborhood	Extension of structures (m)	Total extension of structures by neighborhood (m)	Beach nourishment	Breakwater	Groin	Riprap	Jetty
		188,39						
Praia de Iracema	2	299,71	1.006,10	0	0	1	1	0
		706,39						
Meireles	5	26,25	2.414,07	2	0	3	0	0
		862,25						
		288,58						
		87,85						
		1149,26						
Mucuripe	3	323,47	630,63	0	0	0	2	1
		63,58						
		243,58						
Cais do Porto	5	38,00	2.790,64	1	1	2	1	0
		79,97						
		70,52						
		1707,70						
		894,45						
Totals	39	14.279,13		3	4	21	10	1

Notes The neighborhoods Vicente Pinzon, Praia do Futuro I, Praia do Futuro II, Edson Queiroz e Sabiaguaba do not have coastal structures in their respective areas; [a]Division of neighborhoods according to IPLANFOR (*Source* IPLANFOR 2019) and Arasaki 2009). In general, this type of construction works rapidly and does not require the use of the latest technology. These strategies have been used in Brazil largely without any technical discussions concerning their positive (coast stabilization) or negative (drift saturation) repercussions.

Ripraps are the second-most predominant type of structure found on the coastline of Fortaleza. Alfredini and Arasaki (2009) point out that this type of structure, which is adhered to the beach via a longitudinal construction, can be used provisionally or permanently and is definitive structures that seek to protect urban developments such as roads or other infrastructure that is positioned along the shoreline.

In the specific case of Fortaleza, such structures are generally in the form of blocks of rock that follow the coastline; however, these structures can also be in the form of beach walls with deflecting shells, beach walls with gabions, or as concrete beach walls (Paula et al. 2013, 2014, Paula 2015) (Fig. 4b).

Breakwaters are shelter-structures built to create a protected area against the action of the waves and promote a calm zone in which boats can dock (Alfredini and Arasaki 2009). In Fortaleza, jetties are associated with both the port structures in Mucuripe and the naval regions of Ceará (INACE), with important productive arrangements for the local economy and the Pirambu neighborhood, allowing fishermen to anchor their rafts (Fig. 4c).

The aim of beach nourishment is to artificially feed beaches with sediments that are compatible with the local hydrodynamic conditions, using deposits that are usually from locations that are close to the site of installation (Verhagen 1992; Finkl and Khalil 2005; Alfredini and Arasaki 2009). According to Hartog et al. 2008 and Alfredini and Arasaki (2009), this type of work allows the stabilization or extension of beaches in areas that suffer from severe erosion and can even result in the creation of new beach areas; this type of intervention can also be associated with groin fields (Fig. 4d).

In Fortaleza, beach nourishment is carried out on the tourist coasts, where there are high concentrations of more affluent residents and higher economic gains (Santos 2004).

According to Dean and Dalrymple (2004) and Brazil (2018), projects that involve the replenishment of beaches are the best options for mitigating areas of erosion. These structures are the least harmful and allow the creation of new leisure space. Lins-de-Barros et al. (2019) point out that such an option has already been widely used in several coastal regions, both in Brazil and around the world, such as in the Copacabana and the Flamengo in Rio de Janeiro.

This type of intervention has been widely used in Europe since 1951. The practice started in Germany (Hanson et al. 2002) and is common in countries such as the Tuscany region of Italy (Anfuso et al. 2011; Pranzini et al. 2018), Nice in France (Anthony et al. 2011), Holand and the Aveiro, Region of Portugal (Sronkhorst et al. 2017), the UK (McFarland et al. 1994), and in the Barcelona region of Spain since 1986 (Lechuga 2003). These methods have also been used in Israel (Bitan and Zviely 2020), in the USA as protection against hurricanes and storms in the Atlantic and Gulf of Mexico since the 1920s (Campbell and Benedet

2006), in China and on the Asian peninsula (Cai et al. 2011), in Australia (Cooke et al. 2012), and on Durban Beach in South Africa (Corbella and Stretch 2012).

The jetties installed on the edge of the city are mainly in place to allow the rectification of port channels while channeling rivers and other watercourses, as is the case used to stabilize the mouth of doing Riacho Maceió in Fortaleza (Fig. 4e).

All the above-mentioned structures are located spatially across 10 of the 15 coastal neighborhoods in Fortaleza, which is inhabited by 239,663 people, according to IBGE (2020) and IPLANFOR (2019). It represents 73% of the entire population that lives in the coastal neighborhoods of Fortaleza.

The structures that have been built for containment are concentrated in the westernmost neighborhoods of the city (Barra do Ceará, Pirambu, Cristo Redentor, and Moura Brasil) that have a high population density and the worst social and human development index (HDI) indicators in the city. Thus, such neighborhoods are framed by the Participatory Master Plan of Fortaleza (PDF) as Special Zones of Social Interest (ZEIS) and are destined for the development of urban and land-regulated low-income housing settlements (Table 2).

Figure 5 shows the types and concentration of the containment structures used in the city of Fortaleza. Notably, 23% of them are in the stretch that comprises the neighborhood of Barra do Ceará, in which the largest number of groins and ripraps in the city are concentrated. The neighborhoods of Pirambu, Meireles, and Cais do Porto are next in terms of the percentage of structures on the coastline, with approximately 13% of the structures in the city. Only the neighborhoods located in the east-southeast portion of the coast do not present any type of structural change in their coastline, covering 40% (14.7 km) of the city's coastline. These sectors have so far been spared the urbanization that has occurred in the rest of Fortaleza, especially the Sabiaguaba, which comprises a mosaic of nature conservation units.

According to the Shore Manual Protection and USACE (2002), coastal structures and the recovery of artificial environments, they can also protect and recover natural environments such as dunes, beaches, or cliffs. In addition, these objectives can also be associated with the protection of the urban infrastructure that is built on the coastline.

However, it is notable that in many of the sites where protective or recovery structures have been built, either by public services or private initiatives, it brings damages to heritage buildings as a result of erosion is avoided at any cost. There is little or no integration between the different participants that are interested in preserving the coastal zone. Rigid structures are the most widely used. Many of these structures are known to be effective, with questions mainly surrounding the impacts, especially those on the coastal dynamics whose effects are felt beyond the site of construction (Nordstrom 2014).

Precisely for this reason, over recent decades, the development of new approaches that are aimed at minimizing both the negative impacts and the use of rigid infrastructure has led to the so-called "building with nature" initiative, and efforts have been made to minimize the use of rigid structures at all costs (De Vriend et al. 2014).

Fig. 4 Coastal structures on the coastline of the city of Fortaleza. **a** Groins in the Pirambu neighborhood; **b** Ripap installed in the Moura Brasil neighborhood; **c** Breakwater built in the Pirambu neighborhood; **d** Praia de Iracema Beach Nourishment; **e** Jetty in the Maceió stream, of the Mucuripe neighborhood

The idea is based on using the dynamics of environmental resources, providing an opportunity for using natural dynamic processes instead of simply mitigating the impacts caused by the coastal infrastructure. Several studies have pointed to new alternatives and their implications in several regions. One such initiative is the sand motor developed by Dutch researchers and acts as a sand pocket that is gradually eroded due to coastal processes' action, slowly supplying sediment to the adjacent areas (De Vriend et al. 2014).

3.1 *The Paradox of Coastal Structures: Protect or Recover?*

When analyzing the different types of structures that have already been presented in the literature, coastal structures are generally divided into two main categories when discussing their purposes, protection structures and restoration structures. Structures with dual purposes, such as beach nourishment, are also common. Fortaleza includes both categories, as seen in Table 3.

Structures that are designed to protect the coast can be classified according to their structural typology; whether constructed to reflect or dissipate wave energy, all

Table 2 Socio-spatial data of the coastal neighborhoods in Fortaleza

Neighborhood	Ranking HDI	Human development index (HDI)	Population	Population density (hab/km^2)
Barra do Ceará	101	0,215707870	72.423	16.921
Cristo Redentor	89	0,253841671	26.717	22.451
Pirambu	95	0,229828725	17.775	31.741
Jacarecanga	36	0,448187913	14.204	11.273
Moura Brasil	77	0,284686078	3.765	8.964
Centro	23	0,556689243	28.538	5.836
Praia de Iracema	7	0,720062247	3.130	5.906
Meireles	1	0,953077045	36.982	13.955
Mucuripe	4	0,793081592	13.747	15.801
Cais do Porto	98	0,223566183	22.382	8.199
Vicente Pinzon	64	0,331471934	45.518	14.496
Praia do Futuro I	73	0,291364499	6.630	3.994
Praia do Futuro II	114	0,167904366	11.957	3.602
Edson Queiroz	57	0,350300888	22.210	1.605
Sabiaguaba	84	0,267301809	2.117	209.81
Total			328.095	

Source IBGE (2020), IPLANFOR (2019)

are in the form of vertical walls, ripraps, and breakwaters. The sedimentary balance effects are associated with the negative sedimentary balance that results from wave turbulence and the interaction/reflection of waves at the base of a structure, causing excavation of the sediments at the base of a structure and the lowering of the profile (Brazil 2018).

Finally, ports and naval structures, which are designed to protect vessels from the waves and to divert the current of a river or an estuary, respectively, are also present on the coastline of Fortaleza. The effect of these structures is similar to the "sediment trap"-type structures, which can cause a positive balance to sum barlamar and a negative balance to the upstream of the structures (Brazil 2018). In Fortaleza, the longitudinal current moves from east to west.

The majority of such structures are breakwaters, which are intended to create a sheltered area for vessels in the naval area of Ceará (INACE), and in the port region of Mucuripe, the latter of which was pointed out by Vasconcelos (2005) as being one of the first major coastal structures carried out in Fortaleza. There is also a channel for the Maceió stream in the same region.

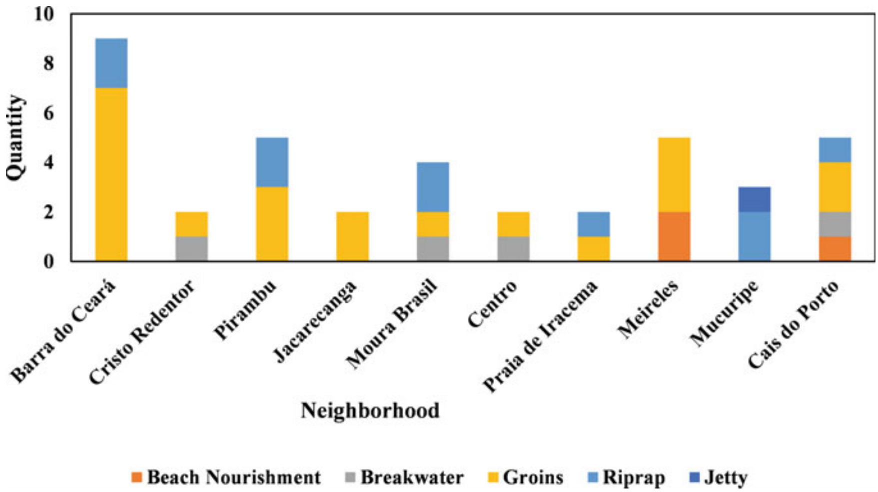


Fig. 5 Type and concentration of coastal structures by neighborhood in the city of Fortaleza

In contrast, the second classification, which includes structures used to recover areas of the beach, can be subdivided into sediment traps and mechanisms that are used for the addition of sediment. Sediment traps are mainly used to retain sand available for longitudinal or transverse transport in the submerged and subarea portion of the beach, promoting a positive sedimentary balance when barking the structure and in some cases negative to the sum (Brazil 2018). These structures include groins, breakwaters, and fences against which vegetation is planted.

Regarding traps, groins are the main alternatives and the only structures that are generally used for this purpose. These structures were designed, planned, and constructed when no modeling technology was available to predict the possible impacts accurately. These structures are currently regarded to be the least suitable for recovery (Table 3). The alternative is associated with the addition of sediments by artificial feeding or sediment transposition; both options allow erosion in the coastal cell to be kept in balance, that is, negative in the area of deposit and positive in the area receiving sediments (Brazil 2018).

In this case, Fortaleza stands out, with three areas that have passed through a grounding process, with one area in the region housing the Mucuripe Harbor (Brazil 2015), one in the region of Praia de Iracema, built in 2000 and further expanded in 2019, and the most recent made in 2019 in the region of the Meireles neighborhood of Av. Beira-mar. The interventions in the stretches that comprise Praia de Iracema and Av. Beira-mar are now protected from momentary floods. Another advantage is the expansion of the area available for leisure.

Analysis indicates that recovery structures are the most numerous, corresponding to 62% of the total, with protective structures comprising 38%. As for the type, structures that serve as sediment traps are the majority at 54%, followed by the structures that lead to the reflection and dissipation of wave energy at 25%. Port and

Table 3 Purpose, typology, function, and effect of coastal structures installed along the coast of Fortaleza

Purpose	Recovery		Protection	
Structural type	Addition of sediment 1. Beach nourishment 2. Sedimentary transposition	Sediment trap 1. Groins 2. Breakwater 3. Fences or planting vegetation	Port structures/ naval industry/ others 1. Breakwater* 2. Jetties**	Reflection and/ or dissipation of wave energy 1. Seawall 2. Riprap 3. Breakwater
Function	Add or maintain sediment within the coastal cell	Retain sediments that are available for longitudinal or transverse transport in the submerged and subarea portion of the beach	*Intended to protect vessels from sea waves **Divert/ channel the current of a river or an estuary	Protection of roads, walkways, etc. against wave action reflecting or dissipating wave energy
Effect in the sedimentary balance	Keeps the erosion in the coastal cell in balance, negative in the deposit area and positive in the upstream	Positive to sum of the structure, but can be negative to the upstream of the structure	Effects similar to those observed in the "sediment trap"-type structures, which can cause a positive balance to sum and a negative balance to the upstream of the structure	Negative as a result of wave turbulence and wave interaction/ reflection at the base of the structure. Excavation of the base of the structures. Demotion of the profile
In the Seafront ff Fortaleza (Number of structures by type)				
Beach nourishment	3	–	–	–
Breakwater	–	–	4	–
Groin	–	21		
Riprap	–	–	–	10
Jetty	–	–	1	–

Source Adapted from Klein et al. (2005), Alfredini and Arasaki (2009), Brazil (2018)
*Intended do protect vessels from sea waves
**Divert/channel the current of a river or an estuary

naval structures account for 13%, and, finally, structures in which sediment is added represent 8% of the total (Fig. 6).

Recovery structures in the form of groin fields that act as sediment traps are mainly concentrated between the neighborhoods of Barra do Ceará and Moura Brasil (Fig. 7). Figure 8 shows the layout of the coastal structures installed on the coast of Fortaleza and their respective purposes, types, and functions.

Kraus and McDougal (1996), Griggs (2005, 2010) point out that the impacts caused by artificialization of the coastline must be taken into account when assessing and approving the installation of these structures, as any and all structural interventions allocated on the coastline must initially take into account the real objectives of the structures, the local hydrodynamic characteristics, the impacts on neighboring areas, and their medium to long-term behavior.

Any type of structural protection built on the beach, at the base of a cliff, or on sand dunes will involve building a human-made structure in a natural area. The most immediate effect is the loss of some of the beach; how much is lost depends directly on the width of the beach and the size of the structure (Griggs 2010). Another recurring problem in using these structures is the possible reduction in access to the beach, which will depend on the type of construction used and can prevent access to the beach either temporarily or permanently (both laterally and vertically) (Griggs 2010; Lacerda Barros 2018).

Fletcher et al. (1997), Griggs (2005), and Sadeghi et al. (2018) point to the decrease in the sedimentary input that is caused by the protection of beaches and cliffs and ends up influencing erosion in other areas and the erosion in adjacent beaches as a direct consequence of the installation of structures that are built to fix the coastline. Such processes are called passive erosion and active erosion. Structures such as groins, which are classified as sediment traps, end up retaining sedimentary material that is transported by coastal drift, which occurs from east to west in Fortaleza, and as a consequence, interrupts the supply of sediment to the westernmost beaches of the city.

The impacts described above can easily be observed when analyzing the effects of the structures built on the coastline in the city of Fortaleza. In general, what is most obvious is the loss of beach that has been caused by the construction of ports in the region, as well as the construction that has taken place in the areas surrounding Porto, do Mucuripe, an area that was previously dune fields (Morais 1980, 1981; Maia 1998; Paula 2014).

The growth of tourism and coastal holidays has redefined the relationship that the city and its townspeople had with the sea in the second half of the twentieth century. The city started to construct new leisure areas (Dantas 2009, 2011). Beach tourism leads to different arrangements in the urban occupation and redefines values, changing intervention requirements.

The western part of the city is essentially composed of impoverished neighborhoods. It gets sediment trap-type structures with spikes belonging to an older and cheaper technique. Newer recovery structures are installed in the affluent neighborhoods at the east of the city center. It includes the beach nourishment in Praia de Iracema and Praia do Meireles, using modern techniques that demand a more significant financial resource input.

The dynamics of the coastline of Fortaleza suggest two distinct periods in the history of the city and its relationship with the coast, as directly marked by the influence of the structures in the port sector of the city and the urbanization process that has unfolded over time. It could be said that there is a current and pre-term

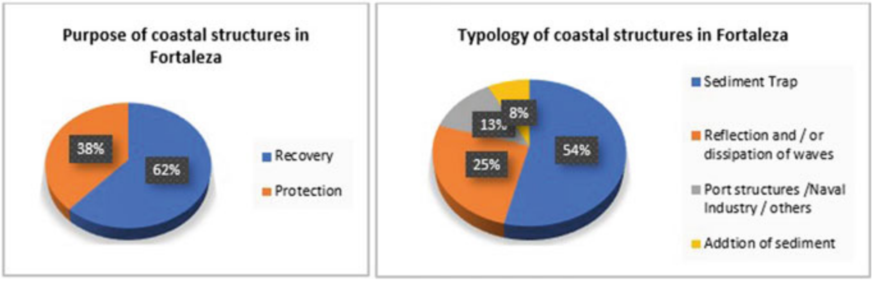


Fig. 6 Situation of coastal structures on the coast of Fortaleza regarding the type and purpose of the structures

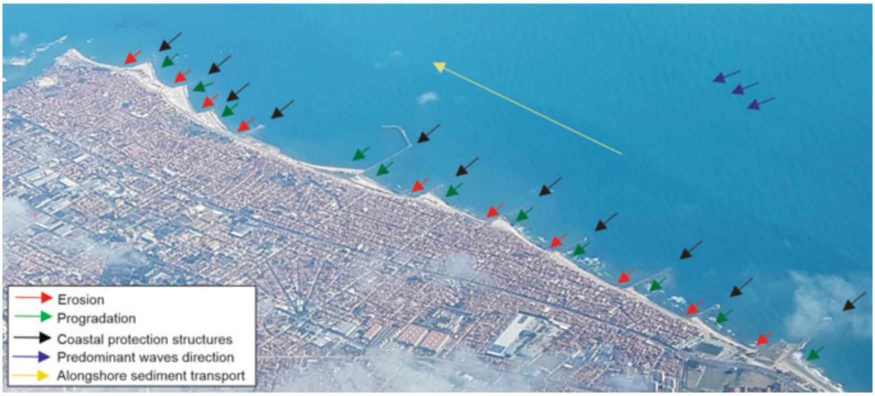


Fig. 7 Area photograph of coastal structures installed on the coastline of the Barra do Ceará and the Moura Brasil neighborhoods (west of Fortaleza. Aerial image courtesy of Everton Marinho)

landscape in the city concerning the presence of these structures, which, in many ways, have dictated the way in which the coastal dynamics occur in the city.

The interference caused by the port structures on the transport of sediments around Fortaleza and the stretch of dunes near the beach led to the need for the installation of structures that are today present along with more than half of the city's coastline (Morais 1980, 1981; Maia et al. 1998; Vasconcelos 2005; Paula 2014, 2015; Ximenes et al. 2018).

Figure 9 illustrates the changes that have taken place on this coastline over the last 144 years (from 1875 to 2019) in the form of intervention through coastal structures. These changes started both in the center of the city and on Iracema beach, after which alterations were made eastward, toward the tip of Mucuripe. However, these alterations triggered erosive processes west of the city.

The manner in which the coast has been used has intensified the modification of the coastal landscape, with the most striking effects occurring as a result of the installation of the port infrastructures and the enhancement of the coastal space. The

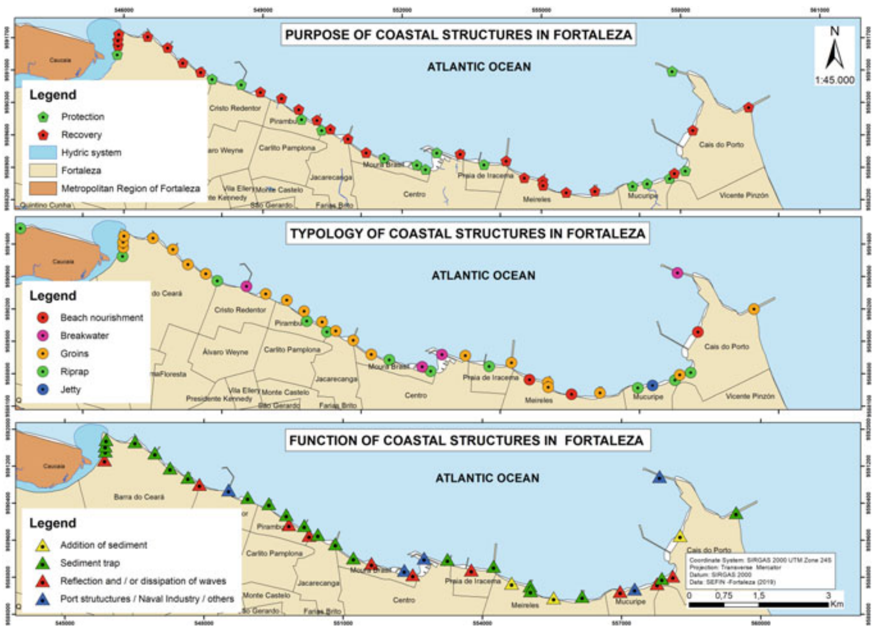


Fig. 8 Arrangement of coastal structures installed on the coast of Fortaleza, with their purposes, typology, and function

verticalization and urbanization of the waterfront began in the late 1970s, bringing new perspectives to the use of these spaces, especially in the stretch that now comprises the most affluent areas of the city (Vasconcelos 2005; Dantas 2009; Paula 2014).

It is noteworthy that this verticalization did not occur equally over the entire coastline of the city and has not occurred in stretches of coastline such as that reaching from the center toward Barra do Ceará, the Cais do Porto region, and Vicente Pinzon, a fact that can be associated with the socioeconomic indicators in these regions and to the historical uses and occupation of the coast.

Another economically important area of the city that was not affected by this process is the stretch that extends from the Titanzinho spike to Sabia-guaba, although in recent years, real estate speculation in the Praia do Futuro area has grown via verticalization. These beaches had become more frequently used since the 1980s when the erosion process became consolidated in the northern part of the city and resulted in a decrease in the range of beaches available for leisure.

When taken together, these aspects help us understand how interventions on the coast take place over time, the effects these structures have on coastal dynamics, the intensification of erosion, and the containment infrastructures installed in the city.

These structures have become fundamental in shaping the current context in which the city of Fortaleza is found, with the search for new space aimed at leisure,

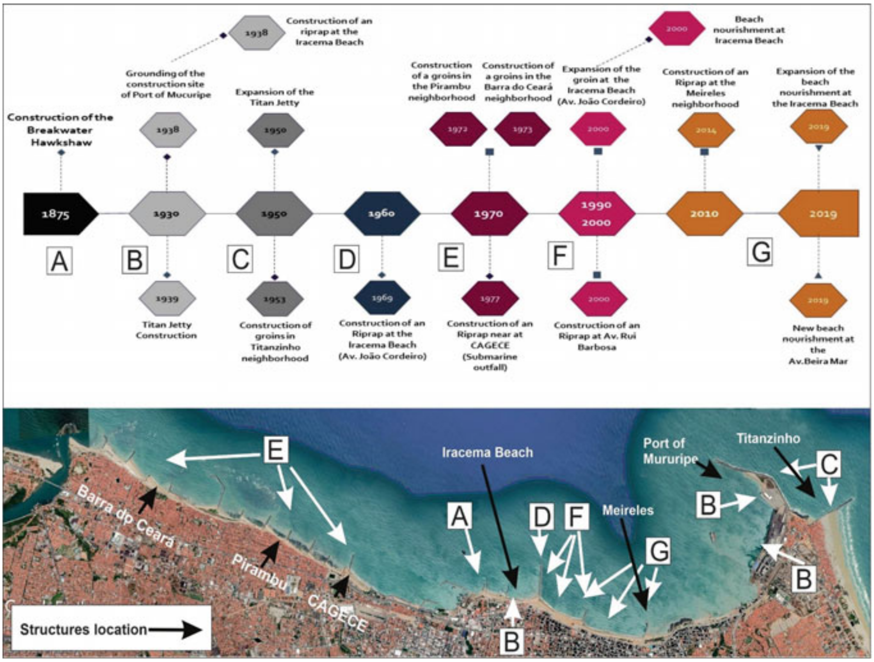


Fig. 9 Timeline showing the construction of the main coastal structures in the coast of Fortaleza between the years 1875 and 2019

sport, and cultural activities, in a city that has for a long time endured with erosion on its shore.

4 Conclusion

Fortaleza has constantly been undergoing restructuring caused by changes to its coastline over its 294 years of history, from the first coastal structure in 1875 to the most recent in 2019. A consequential fact of the growth of the city toward the coast is due to its location, economic, and environmental attraction; this situation is common in several other coastal areas, although it occurs mainly around large metropolitan regions.

Most of the interventions are concentrated in less affluent areas of the city and in neighborhoods with some of the worst human development indexes (HDI), in addition to a high population and demographic density.

The types of structures that are used in these locations are increasingly in disuse as they can have serious impacts on the dynamics of sedimentary transport. One example is the use of sediment traps in the form of spike fields between the neighborhoods of Barra Ceará and Pirambu. These structures were found to directly affect the sedimentary supply in areas further west of the city because they were built in a different time period in which ideas were different than they are at present and the occupations that were there at the time of construction required protection differ from those in the area today.

On the other hand, it was also observed that there is a clear change in the conception of coastal structures installed in the city when we analyze Praia de Iracema and Meireles' neighborhoods with some of the best HDIs in the city.

It is necessary to take into account not only the natural aspects but also those aspects that are linked to the social and economic characteristics of an area, thus minimizing not only the impacts caused by coastal erosion, both natural and anthropic, and including those caused by poorly planned interventions, but also promoting greater equality from the point of view of their economic and social use. This is only possible when carried out jointly with the universities via continuous monitoring over the medium to long term, and with society, with the main premise of the sustainable use of such environments in a participatory way.

Finally, the spatial distribution of coastal protection structures in the Fortaleza city and its typology is associated with the economic and social conditions of the different coastal stretches of the city with the same problem. The light structures with recovery of the beach profile are centered in the prime area, while the heavy structures are located in the economically and socially less prestigious areas. This is a situation that is governed by the state's development policy, giving prestige to tourist areas in keeping with the poorest areas of the city.

References

Albuquerque MG, Calliari LJ, Correa ICS, Pinheiro LS (2009) Morfodinâmica da Praia do Futuro, Fortaleza-CE: uma síntese de dois anos de estudos. Quat Environ Geosci 1:49–57. https://doi.org/10.5380/abequa.v1i2.14092

Alfredini P, Arasaki E (2009) Obras e gestão de portos e costas: a técnica aliada ao enfoque logístico e ambiental. Editora Edgard Blücher, São Paulo

Anfuso G, Pranzini E, Vitale G (2011) An integrated approach to coastal erosion problems in northern Tuscany (Italy): littoral morphological evolution and cell distribution. Geomorphology 129:204–214. https://doi.org/10.1016/j.geomorph.2011.01.023

Anthony EJ, Cohen O, Sabatier F (2011) Chronic offshore loss of nourishment on Nice Beach, French Riviera: a case of over-nourishment of a steep beach? Coast Eng 58:374–383. https://doi.org/10.1016/j.coastaleng.2010.11.001

Bitan M, Zviely D (2020) Sand beach nourishment: experience from the mediterranean coast of Israel. J Marine Sci Eng. https://doi.org/10.3390/jmse8040273

Brazil, Secretaria de Portos da Presidência da República (2015) Plano Mestre Porto do Mucuripe. Universidade Federal de Santa Catarina, Laboratório de Transportes e Logísticas, Santa Catarina

Brazil, Ministério do Meio Ambiente (2018a) Programa Nacional para Conservação da Linha de Costa—PROCOSTA, Brasília. Available in: https://moodle.ifsc.edu.br/pluginfile.php/162252/mod_resource/content/1/procosta.pdf. Accessed on April, 01, Sept 2020

Brazil, Comissão Interministerial para Recursos do Mar (2018b) Guia de Diretrizes de Prevenção e Proteção à Erosão Costeira. Grupo de Integração do Gerenciamento Costeiro, Brasília

Cai F, Dean R, Liu J (2011) Beach nourishment in China: status and prospects. In: Smith JM, Lynett P (eds) Proceedings of 32nd conference on coastal engineering, Shanghai, 2010, management. 31. https://doi.org/10.9753/icce.v32.management.31

Campbell T, Benedet L (2006) Beach nourishment magnitudes and trends in the US. J Coast Res SI 39:57–64 Itajaí, Brasil. ISSN 0749-0208

Carvalho AM, Maia LP, Dominguez JML (2007) A deriva e o transporte litorâneo de sedimentos no trecho entre Cumbuco e Matões-Costa noroeste do estado do Ceará. Arq Cienc Mar 40:43–51. https://doi.org/10.32360/acmar.v40i1.6142

Cooke B, Jones A, Goodwin I, Bishop M (2012) Nourishment practices on Australian sandy beaches: a review. J Environ Manage 113:319–327. https://doi.org/10.1016/j.jenvman.2012.09.025

Corbella S, Stretch DD (2012) Coastal defenses on the KwaZulu-Natal coast of South Africa: a review with particular reference to geotextiles. J S Afr Inst Civ Eng 54:55–64

Coco G, Senechal N, Rejas A, Bryan KR, Capo S, Parisot JP, Brown JA, MacMahan JHM (2014) Beach response to a sequence of extreme storms. Geomorphology 204:493–501. https://doi.org/10.1016/j.geomorph.2013.08.028

Dantas EWC (2009) Maritimidade nos trópicos: por uma geografia do litoral. Edições UFC, Fortaleza, Brasil

Dantas EWC (2011) Mar à vista: estudo da maritimidade em Fortaleza. Edições UFC, Fortaleza, Brasil

De Vriend H, Koningsveld M, Aarninkhof S (2014) 'Building with nature': the new Dutch approach to coastal and river works. ICE Proc Civil Eng 167:18–24. https://doi.org/10.1680/cien.13.00003

Dean RG, Dalrymple AR (2004) Coastal processes with engineering applications. Cambridge University Press, Cambridge

Fletcher CH, Mullane RA, Richmond BM (1997) Beach loss along armored shorelines on Oahu, Hawaiian Islands. J Coast Res 13:209–215

Griggs GB (2005) The impacts of coastal armoring. Shore Beach 73:13–22

Griggs GB (2010) The effects of armoring shorelines: The California experience. In: Shipman H, Dethier MN, Gelfenbaum G, Fresh KL, Dinicola RS (eds) Puget sound shorelines and the impacts of armoring. Proceedings of a state of the science workshop, May 2009: U.S. Geological Survey Scientific Investigations Report 2010-5254, pp 77–84

Guerra RGP (2014) Vulnerabilidade costeira a eventos de alta energia no Litoral de Fortaleza, Ceará. 2014. M.Sc., Dissertation, Federal University of Ceará

Hanson H, Brampton A, Capobianco M, Dette HH, Hamm L, Laustrup C, Lechuga A, Spanhoff R (2002) Beach nourishment projects, practices, and objectives: a European overview. Coast Eng 47:81–111. https://doi.org/10.1016/S0378-3839(02)00122-9

Hartog WM, Benedet L, Walstra DR, Van Koningsveld M, Stive MJF, Finkl CW (2008) Mechanisms that influence the performance of beach nourishment: a case study in Delray Beach, Florida, USA. J Coast Res 24:1304–1319. https://doi.org/10.2112/06-0749.1

Instituto Brasileiro de Geografia e Estatística—IBGE (2020) Censo demográfico 2010: Resultados gerais da amostra Available in: http://www.ibge.gov.br/home/estatistica/populacao/censo2010/resultados_gerais_amostra/resultados_gerais_amostra_tab_uf_microdados.shtm. Accessed on 15 Apr 2020

Instituto de Planejamento de Fortaleza—IPLANFOR (2019) Plataforma de Indicadores Fortaleza 2040. Fortaleza. Available in: https://observatoriodefortaleza.fortaleza.ce.gov.br/. Accessed on 06 Apr 2020

Klein AHF, Diehl, FL, Benedet L (2005) The paradigma between beach protection and beach restoration: Case studies in Santa Catarina state, southeastern Brazil. In: International conference on coastal conservation and management in the Atlantic and Mediterranean, Tavira. Book of abstracts, pp 327–329

Klein AHF, Araujo RS, Polette M, Sperb RM, Freitas D, Sprovieri FC, Pinto FT (2009) Ameliorative strategies at Balneário Piçarras Beach—Brazil. In: Williams AT, Micallef A (org) Beach management guidelines: principles and practice. Earthscan, London, pp 241–255

Köppen W (1948) Climatologia: con un estudio de los climas de la tierra. Fondo de Cultura Econômica, México

Kraus NC, McDougal WG (1996) The effects of seawalls on the beach: an updated literature review. J Coast Res 12:691–701

Lacerda Barros E (2018) Erosão costeira no litoral do município de Icapuí-Ce na última década: causas, consequências e perspectivas futuras. PhD thesis, Federal University of Ceará

Leatherman S (2018) Coastal erosion and the United States national flood insurance program. Ocean Coast Manag 156:35–42. https://doi.org/10.1016/j.ocecoaman.2017.04.004

Lechuga A (2003) Assesment of nourishment project at the Maresme Coast, Barcelona, Spain. Shore Beach 71:3–7

Lins-de-Barros F, Sauzeau T, Guerra J (2019) Historical evolution of seafront occupation in France (Bay of Biscay) and Brazil (Rio de Janeiro) face to coastal erosion vulnerability and risks (19th–21th centuries). Revue franco-brésilienne de géographie. https://doi.org/10.4000/confins.18175

Luijendijk A, Hagenaars G, Ranasinghe R, Baart F, Donchyts G, Aarninkhof S (2018) The state of the world's beaches. Sci Rep. https://doi.org/10.1038/s41598-018-24630-6

Maia LP, Jimenez JA, Morais JO (1998) The coastline of Fortaleza city: a product of environmental impacts caused by the Mucuripe Harbor. Arquivos de Ciências do Mar 31:93–100. https://doi.org/10.32360/acmar.v31i1-2.31378

McFarland S, Whitcombe L, Collins M (1994) Recent shingle beach renourishment schemes in the UK: some preliminary observations. Ocean Coast Manag 25:143–149. https://doi.org/10.1016/0964-5691(94)90044-2

Morais JO, Pinheiro LS, Pessoa PRS, Freire GS, Carvalho AM, Guerra RGP, Barros EL, Moura FJM (2018) Ceará. In: Muehe D (org) Panorama da Erosão Costeira no Brasil, 1st edn. MMA, Brasília, pp 261–288

Morais JO (1980) Aspectos do transporte de sedimentos no litoral do Município de Fortaleza, Estado do Ceará, Brasil. Arquivos de Ciências do Mar 20:71–100. https://doi.org/10.32360/acmar.v20i1-2.31583

Morais JO (1981) Evolução sedimentológica da enseada de Mucuripe (Fortaleza-Ceará-Brasil). Arquivos de Ciências do Mar 21:16–46. https://doi.org/10.32360/acmar.v21i1-2.31547

Morais JO (2000) Compartimentação territorial e evolutiva da zona costeira do Estado do Ceará. In: Lima LC et al (eds) Compartimentação Territorial e Gestão Regional do Ceará, 1st edn. Funece, Fortaleza, pp 106–180

Nordstrom K (2014) Living with shore protection structures: a review. Estuar Coast Shelf Sci 150:11–23. https://doi.org/10.1016/j.ecss.2013.11.003

Paula DP (2012) Análise dos riscos de erosão costeira do litoral de Fortaleza em função da vulnerabilidade aos processos geogênicos e antropogênicos. PhD thesis, University of Algarve

Paula DP (2015) Erosão costeira e estruturas de proteção no litoral da região metropolitana de Fortaleza (Ceará, Brasil): um contributo para artificialização do litoral. Revista Eletrônica do PRODEMA 9:73–86

Paula DP, Dias JA, Souza MAL, Farrapeira Neto CA, Lacerda Barros E (2013) Monitorização de Curto Prazo da Praia do Icaraí (Caucaia, Ceará, Brasil) após Construção de Estrutura Rígida do Tipo Bagwall para Controle da Erosão. In: Proceedings of the VII congress on planning and management of coastal zones in countries of Portuguese expression, Maputo, 24–30 May 2013

Paula DP, Farrapeira Neto CA, Souza MAL, Dias JM (2014) Alterações morfológicas na Praia do Icaraí (Caucaia-Ceará) após a construção de um dissipador de energia para controle da erosão costeira. Revista Geonorte 10:7–11

Pranzini E, Anfuso G, Cinelli I, Piccardi M, Vitale G (2018) Shore protection structures increase and evolution on the Northern Tuscany Coast (Italy): influence of tourism industry. Water 10:1647. https://doi.org/10.3390/w10111647

Pinheiro LS, Morais JO, Maia LP (2016) The beaches of ceará. In: Short AD, Klein AHF (org) Brazilian beach systems. Springer, Florianopolis, pp 175–200

Rangel-Buitrago N, Neal W, Jonge VN (2020) Risk assessment as tool for coastal erosion management. Ocean Coast Manag 186:105099. https://doi.org/10.1016/j.ocecoaman.2020.105099

Sadeghi K, Abdullahi I, Albab H (2018) Classification of seawalls and their failure: an overview. Acad Res Int 9:12–19

Santos M (2004) O espaço dividido: os dois circuitos da economia urbana dos países subdesenvolvidos, 2nd edn. Edusp, São Paulo

Sinitsyn A, Depina I, Bekele Y, Christensen S, Oosterhout D (2020) Development of coastal infrastructure in cold climate: summary guideline. SFI SAMCoT report, p 61

Stive M (2004) How important is global warming for coastal erosion? Clim Change 64:27–39. https://doi.org/10.1023/B:CLIM.0000024785.91858.1d

Stronkhorst J, Huisman B, Giardino A, Santinelli G, Santos F (2017) Sand Nourishment strategies to mitigate coastal erosion and sea level rise at the coasts of Holland (The Netherlands) and Aveiro (Portugal) in the 21st century. Ocean Coast Manag 156:266–276. https://doi.org/10.1016/j.ocecoaman.2017.11.017

USACE, US Army Corps of Engineers (2002) Hydrographic surveying. EM 1110-2-1003. Washington, DC

Vasconcelos FP (2005) Gestão Integrada da Zona Costeira: ocupação antrópica desordenada, erosão, assoreamento e poluição ambiental do litoral. Premius, Fortaleza

Verhagen H (1992) Method for artificial beach nourishment. In: Proceedings of the 23rd international conference on coastal engineering, Venice, Italy

Vousdoukas M, Ranasinghe R, Mentaschi L, Plomaritis T, Athanasiou P, Luijendijk A, Feyen L (2020) Sandy coastlines under threat of erosion. Nat Clim Change 10:260–263. https://doi.org/10.1038/s41558-020-0697-0

Ximenes Neto AR, Morais JO, Pinheiro LS (2018) Modificações na Geomorfologia Marinha a partir de Estruturas Portuárias: o caso do Mucuripe, Fortaleza/CE. Geociências 37:793–805

Zhang K, Douglas BC, Leatherman SP (2004) Global warming and coastal erosion Chang. Clim Change 64:41–58. https://doi.org/10.1023/B:CLIM.0000024690.32682.48

Maia LP, Jimenez JA, Morais JO (1998) The coastline of Fortaleza city: a product of environmental impacts caused by the Mucuripe Harbor. Arquivos deCiências do Mar 31:93–100. https://doi.org/10.32360/acmar.v31i1-2.31378

Eduardo Lacerda Barros He is a bachelor in Geography, graduated in 2012 from the Ceará State University (UECE) where he works as a volunteer researcher in the Coastal and Ocean Systems Research Group (SCO) registered at CNPq through the Laboratory of Coastal and Oceanic Geology and Geomorphology—LGCO / UECE, a group with more than 25 years of experience in works carried out along the coastal area of the state of Ceará. He is a voluntary member of the editorial board of Revista GEOUECE, Geography Magazine of the Postgraduate Program in Geography (PROPGEO) at UECE. He holds a Master's and PhD in Tropical Marine Sciences from the Institute of Marine Sciences—LABOMAR of the Ceará Federal University—UFC where he was a substitute professor of the Environmental Sciences and Oceanography courses between the years 2018 and 2020 where he works as a volunteer researcher at the Laboratory of Geological Oceanography—LOG / LABOMAR. He is a voluntary member of the Northeast Environment Network and the REDE BRASPOR (BRAZIL-PORTUGAL). He is currently a technological innovation scholar—BIT / FUNCAP (Junior Researcher) inserted in the Chief Scientist Environment Program developed at the Ceará State Secretariat for the Environment—SEMA and at the Ceará State Superintendence of the Environment—SEMACE acting as a scientific coordinator of the Coastal and Marine Planning of Ceará under that program. He has an experience in coastal and marine geography, geological oceanography, acting mainly on the following themes: Coastal geomorphology, coastal erosion, coastal management, use and occupation of the coast and sedimentology.

Davis Pereira de Paula did PhD in Marine, Earth, and Environmental Sciences, specializing in Coastal Management at the University of Algarve, Portugal, in 2012, Master's degree from the Postgraduate Program in Geography at Ceará State University (UECE), with an area of concentration in Geoenvironmental Analysis and Territorial Ordering in the Semiarid and Coastal Regions, in 2006, and Bachelor's degree (2003) and a degree (2004) in Geography from the Ceará State University (UECE). Currently, he is an adjunct professor at the Ceará State University, acting as Vice Coordinator of the Postgraduate Program in Geography at UECE. He is an associate professor at the Coastal and Oceanic Geology and Geomorphology Laboratory and a member of the CNPq Coastal and Ocean Systems Research Group. At the same institution, he was also a coordinator of the Geography/CCT courses, between the years 2017 and 2019. He was a professor of the Civil Engineering course at the State University Vale do Acaraú-UVA, between the years 2013 and 2016. He was a permanent professor of the faculty of the Academic Master in Geography—MAG at Vale do Acaraú University (UVA), between the years 2014-2019. He was also the Brazilian coordinator of the Braspor Network, between the years 2015 and 2017; it is an informal network of scientists from Brazil and Portugal who are dedicated to studying coastal environments and their synergies. He works as a researcher in the area of coastal geography with an emphasis on management and coastal impacts, acting mainly on the following themes: environmental history, human-environment interaction, sea surf, management of coastal environments and social and environmental impacts on coastal communities.

Renan Gonçalves Pinheiro Guerra Bachelor and Licensed in Geography from the Ceará State University—UECE. He completed his master's and PhD in Tropical Marine Sciences at the Institute of Marine Sciences (LABOMAR / UFC), where he worked in research related to "coastal vulnerability to storm surges" and "coastal erosion associated with the dynamics of sandy barriers on the semi-arid coastal." He is a member of the Coastal and Oceanic Geology and Geomorphology Laboratory (LGCO / UECE), where he is a member of the Coastal and Oceanic Systems Research Group (CNPq). He is a member of the Chief Scientist Environment Program—Funcap / Sema / Semace as a junior researcher, coordinating the specific project Geographic Information System (GIS) in environment area. He has experience in the areas of geosciences, with an emphasis on the topics of geomorphology, coastal geography, geographic information system, and protected areas.

Jader de Oliveira Santos is a professor of the Department of Geography and Postgraduate Program in Geography and Postgraduate Program in Development and Environment at the Ceará Federal University (UFC), PhD in Geography (Physical Geography) from the University of São Paulo (USP). He was a professor of the Federal Rural of Rio de Janeiro University between the years 2010 and 2013. He is a member at Household Water Insecurity Experiences—HWISE since 2017. He was a tutorial education program tutor—PET Geography at UFC. He received a CAPES scholarship from the CAPES/AULP International Pro-Mobility Program, with an internship developed at the University of Cape Verde—UNICV where he was a collaborating professor of the Postgraduate Program in Development and Environment at the University of Cape Verde—UNICV (2015- 2017). He has experience in the area of environmental planning and spatial planning with the use of geoinformation technologies and water insecurity acting mainly on the following themes: integrated environmental analysis, urban environmental fragility, socio-environmental risks, geoprocessing in geographic analysis, and household water insecurity.

Sustaining Port Activities Through Nature Conservation: The Case of Paraná Coast in Southern Brazil

Eduardo Vedor de Paula, Otacílio Lopes de Souza da Paz, Maíra Oneda Dal Pai, and Marianne de Oliveira

1 Introduction

Coastal regions are known for the significant presence of the sediment deposition process. It is the setting for the end of the process of sedimentary production and transport, where the eroded material from interior regions is brought to the ocean by the river network. In some cases, the principal rivers flow over hundreds of kilometers, collecting sediment from different contexts. However, in the case of the South and Southeastern Coast of Brazil, the situation is different.

On the Southern and Southeastern Coasts of Brazil, we find the Serra do Mar, an orographic chain that extends for 1500 km between the states of Santa Catarina and Rio de Janeiro, reaching altitudes of more than 2300 m. The Serra do Mar is also a water divide, separating the drainage basins of the interior of the continent from those that drain into the Atlantic Ocean.

Because of this characteristic, the river network in this environment is smaller in extension and dimension when compared to other contexts in Brazil. The river network also shows a higher altitude gradient, which results in a high erosive capacity. When added to the intense weather conditions due to the high precipitation averages, we find a realistic scenario of high sediment production.

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

E. V. de Paula (✉) · O. L. de Souza da Paz · M. O. D. Pai · M. de Oliveira
Department of Geography, Federal University of Paraná, Curitiba, Paraná, Brazil
e-mail: edugeo@ufpr.br

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_7

In most cases, in this mountainous region, we find estuaries at this river system's mouths. These become natural deposition environments for the sediments produced in the mountains and transported by the rivers. This characteristic affects port activities, given the concentration of these structures in bay areas. As a result, dredging operations will always be necessary to preserve navigability.

Agricultural activity, associated with poor management, deforestation, poorly built roads, and realignment of river courses can encourage sediment production. However, diminishing sediment production is attractive to port activity, generating an opportunity for mutual benefit. In this chapter, the situation of the coast of Paraná, in the South of Brazil, will be presented. Specifically, how the physical characteristics of the landscape result in high production of sediment and how the land use and forest cover amplify this process shall be addressed. In the end, alternatives to the economic development of the region, taking into account the mitigation of sediment production, will be presented.

2 The Coast of Paraná: A Landscape Marked by the Production of Sediments

The state of Paraná, which is one of 27 federal units located in the South of Brazil, has 105 km of coastline and contains three environmental units: the Serra do Mar (sea ridge), Coastal Lowlands, and estuaries (Fig. 1), which will be shortly described below.

2.1 The Serra do Mar (Sea Ridge)

Present along the entire length of the coastline of Paraná, the Serra do Mar forms an orographic divide between the plateau terrain and the coastal part of the state. Its relief is dissected in the form of escarpments, with altitudes that can reach more than 1800 m above sea level. The mountain range, formed with a rocky and crystalline complex, presents convex ridges, steep slopes, and recessed V-shaped valleys (Maack 1968; MINEROPAR 2006). As a consequence of its physical configuration, pedological formations in the mountains do not usually present good vertical development. It is common to find shallow soil or only incipient development of the regolith in the area (Paula 2010).

The Serra do Mar's climate regime belongs to the Cfb type (oceanic climate) in the Koeppen classification system. Because of the altitude, temperatures are milder than on the rest of the coast, showing yearly averages between 15 and 17 °C. Rains are well distributed throughout the year and directly influenced by the Tropical Atlantic and Polar Atlantic masses' behavior and the orographic barrier of the Serra do Mar (Vanhoni and Mendonça 2008).

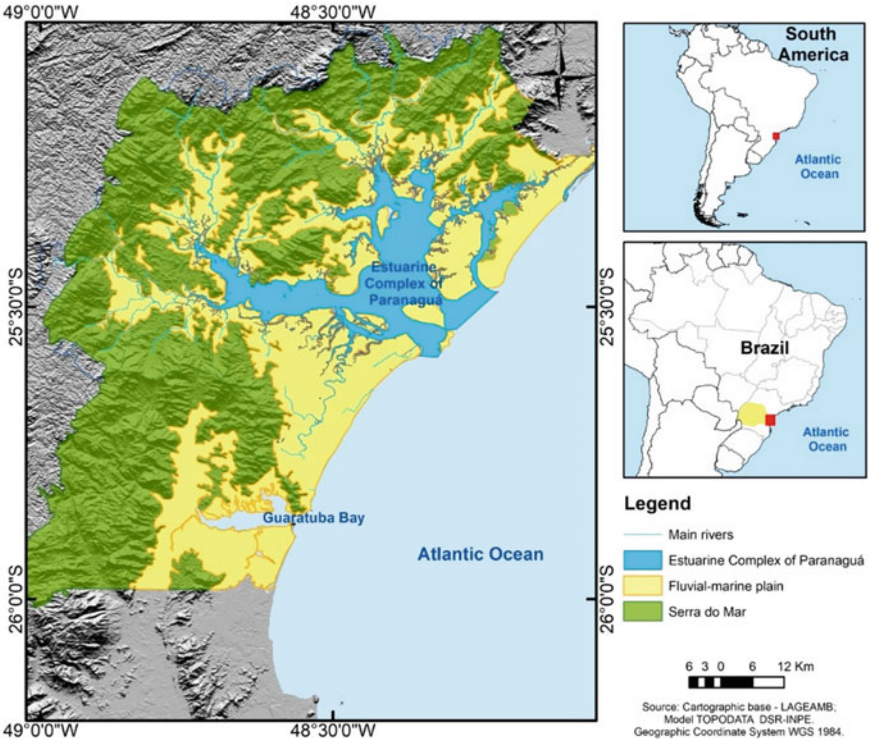


Fig. 1 Environmental units of Paraná's coastline. *Source* The authors, 2020

Associated with the warm and humid climate, we find the montane and upper montane forest formations of the Atlantic Forest (tropical rain forest) covering the Serra do Mar. This forest was declared a biosphere reserve by UNESCO. It is a world biodiversity hotspot and possesses a high capacity for biomass production over short and medium periods of time (Roderjan et al. 2002). Beyond its biological importance, the Atlantic Forest portraits an essential role in the hydrological cycle of the coastline of Paraná, mainly in contributing to the water table and thus springs.

When it comes to sediment, environments like the Serra do Mar are expressive source areas, the sediment release occurs through two main processes: mass movement and hydraulic erosion. Naturally, a combination of factors such as high declivity, underdeveloped soils, and more extensive rainfall events can initiate mass movements (Villaça 2016). Historically, various occurrences of mass movements were registered, associated with extreme rainfalls in the Serra do Mar, involving mud and debris flows, and rotational and translational landslides (Vieira and Gramani 2015).

When it comes to soil degradation caused by water erosion, the disposition of the Atlantic Forest canopy in different strata and tree litter's presence contribute to containing this process. However, even under these conditions, there is still soil loss and thus sediment loss. Averages for soil loss under Atlantic Forest cover are around 0.04–0.08 mg per 10,000 m^2 per year, where the higher values of soil loss are related to steeper slopes (Martins et al. 2010).

2.2 Coastal Plains

Characterized by low dissection, the terrain has a level and gently undulating relief, with altitudes of up to 20 m above sea level. It is formed by the combined actions of marine and fluvial depositional environments, and several types of depositional landforms can be identified, such as foredune ridges, shorelines, foredunes, alluvial fans, river deposits, talus, and colluvium (Angulo 2004).

According to the sediment distribution on the plain, soils tend to display clay grain sizes where they develop on sediment from the Serra do Mar and mainly sand sizes in areas with marine deposits. The combination of the position on the slope plus the grain size characteristics control the distribution of *hydromorphic* soils (which are saturated with water) and well-drained soils (Silva et al. 2013).

Unlike the higher mountainous areas, the plain lies under Cfa (humid subtropical) climate according to the Koeppen classification system, with well-distributed rains and warm summers. The influence of the proximity to the sea is noted as a controlling factor of temperature ranges, the annual temperature averages being between 19 and 21 °C. In addition, there is an influence of the Atlantic Tropical Mass in high precipitation events during the summer (Vanhoni and Mendonça 2008).

The lowland and submontane formations of Atlantic Forest used to occupy the plain naturally and pioneer vegetation formations with marine, fluvial–marine, and fluvial–lacustrine influences could be found in contact with the estuaries and coasts. Due to the intensified process of occupation of the territory in the middle of the nineteenth century, most of the remaining forest formations are secondary growth due to regeneration processes (Roderjan et al. 2002).

The plain is, by definition, an environment of sediment deposition. The rivers that, in the mountains have high energy, lose strength, take on a meandering and braided structure on the coastal plains. A portion of sediment is temporarily stocked in the plain until some disruption in the system alters the balance between the input and output of material and moves what was deposited. These disruptions can be natural or the result of human activity. Tectonic changes at the base level, climate change, extreme rainfall events, and mass movements are examples of natural shifts in the plain's equilibrium (Rocha 2011). The types of land use, management techniques for crop growing, silt removal, and alterations to the course of channels also interfere in deposition dynamics and can remobilize sediment.

2.3 Estuaries

The coast of Paraná possesses two estuarine systems. The first is composed of the bay of Guaratuba, located to the South. The second, in the northern central region, is called the Paranaguá Estuarine Complex (CEP), which includes the bays of Antonina, Paranaguá, Laranjeiras, and Pinheiros.

The formation of the estuarine parts of the coast of Paraná is related to the drowning of fluvial valleys by a rise in sea level. They consist of narrow transitional areas between the land and the sea, in which there is direct contact with the ocean, and thus, they are subject to tide changes (Lessa et al. 1998; Santos et al. 2015). They are characterized by low circulation speeds, which facilitate the deposition of material, and the maintenance of shallow depths. Bottom sediments reflect the source areas' characteristics, the disposition of grains being selected by their transport (Cattani and Lamour 2016).

The mixing of freshwater from water courses with saltwater causes variation in the estuarine environment's salinity. The concentration drops close to the mouths of rivers and rises as it approaches the ocean. This situation favors the retention of nutrients, making the essential estuary environments for various marine species' reproductive cycle.

3 Occupation and Land Use in the Paranaguá Estuarine Complex and Its Drainage Area

The CEP covers an area of 612 km^2 and can be subdivided along two principal axes: (I) an E–W-axis, extending over 56 km, including the bays of Antonina and Paranaguá, and (II) an N–S-axis, extending over 30 km, including the bays of Laranjeiras and Pinheiros (Angulo et al. 2016). The drainage area that contributes to CEP covers an area of 4078 km^2, and it is divided into 43 hydrographic units, as shown in Fig. 2, with the aim of subsidizing the analysis of sediment production in the area.

3.1 Historical Scenario

The oldest evidence of human occupation of the Paraná coastline relates to the various *sambaquis* (shell mounds) found along the coast. Sambaquis are mainly composed of shells, built by prehistoric populations between 7000 and 1000 years BP (Parellada and Neto 1993; Gaspar 1996). At the time of the arrival of Europeans to the area, these populations were no longer present, the territory was occupied by the Carijó people (Bigarella 2009).

The European occupation of Paraná started at the coast. The first economic cycle happened in the sixteenth century as it was based on alluvial gold exploration

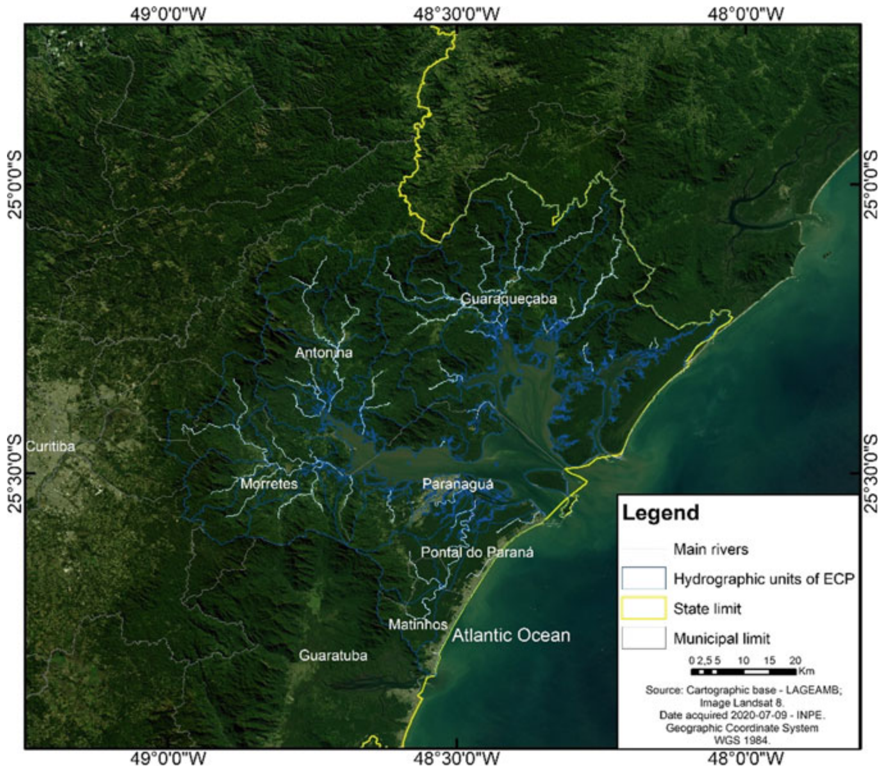


Fig. 2 Location of the Paranaguá Estuarine Complex and its hydrographic units. *Source* The authors, 2020

(Bigarella 2009). The first settlers established themselves in Superagui and on the Cotinga island, while the first real settlement was established by the banks of the River Itiberê and eventually developed into the city of Paranaguá (Pierri et al. 2006).

In the following centuries, the economy of the Paraná coastline was based on agriculture, with several economic cycles: the wood cycle, the coffee cycle, and the erva-mate cycle (Pierri et al. 2006). Tightly bound to the economic cycles, port activity became the main economic driving force behind the cities of Paranaguá and Antonina (Morgenstern 2009).

Currently, (2020) port activities on the coast of Paraná are concentrated in the ports of Antonina and Paranaguá (Fig. 3). In 1920, the port of Antonina was the fourth largest export port in Brazil, due to its proximity and access to the road and rail infrastructure. After the aforementioned economic cycles and changes to the economy post World War II, port activity declined in Antonina (Pierri et al. 2006).

The port of Paranaguá earned importance after the 1970s. With a rise in soybean exports, access to the road network, and deepening of the maritime channel

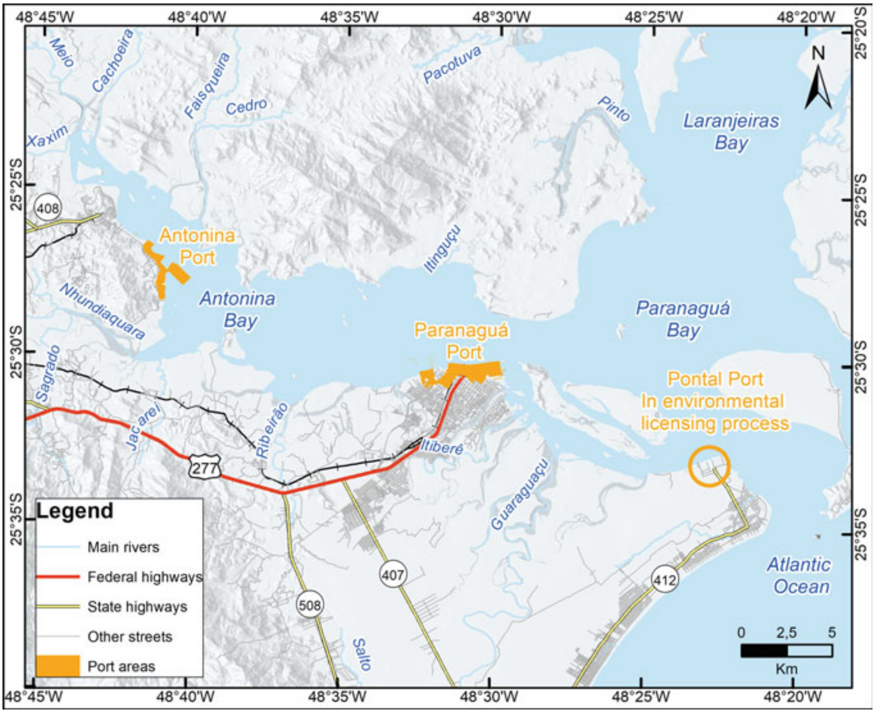


Fig. 3 Port activity in the Paranaguá Estuarine Complex. *Source* The authors, 2020

allowing modern bulker ships to dock, the port became the largest grain exporter in South America (Estades 2003; Pierri et al. 2006).

There is pressure to establish a new port area in the townland of Pontal do Paraná in a location known as Ponta do Poço. The project is hemmed in by environmental concerns, such as the proximity of the port area to mangroves, Restinga (coastal sandy plain vegetation), conservation areas, and also the need to build new access routes, which would require cutting down remaining stands of Atlantic Forest in the area.

Tourism-related economic activity grew more intensely in the 1960s and 70s, with the establishment of seaside resorts on the southern stretch (Pontal do Paraná, Matinhos, and Guaratuba) (Sampaio 2006). After 1970, there was continuous and uncoordinated urban growth on the waterfront, with little consideration given to the fragility of the environment or the availability of public services, causing various problems (Pierri et al. 2006; Sampaio 2006).

3.2 Current Scenario

An estimate published by the Brazilian Institute of Geography and Statistics (IBGE 2020) indicated that 299.824 people inhabit the seven municipalities of the coast of Paraná. As for the usage and land cover (Table 1; Fig. 4), the 2017 mapping for the hydrographic units which drain into the Paranaguá Estuarine Complex (CEP) indicates that 80.65% of the area showed native vegetation, while the anthropized areas (with rural and non-rural activities) occupied 5.7% of the area (Rutyna et al., in press). Other uses are divided among bodies of water and the shoreline.

Paraná's coastal areas' main economic activities are—port use, conservation of ecosystems and biodiversity, fishing, tourism, and farming (Pierri et al. 2006). It is important to add that the latter is the main contributor to sediment production.

The predominant rural anthropic activities are pasture areas, annual agriculture, and perennial agriculture. These activities are concentrated near the fluvial plains and at the mountain foothills. As has already been mentioned, the coast of Paraná has natural conditions for high sediment production rates. Models that correlate the area's natural conditions with poor management demonstrate the potential these activities have in enhancing the sediment production rates (Fig. 5).

Given the land use and cover, the annual sediment production was estimated to be 197,017.23 tons in 2017 (Table 2) (Rutyna et al., in press). The bays of Antonina and Laranjeiras received around 86.48% of this production between them, mainly due to the sea ridge (Serra do Mar) and the concentration of rural activities of the hydrographic units. Due to the estuarine currents and the ebb and flood tide

Table 1 Types of usage and land cover of hydrographic units that drain to the CEP

Types	Area (km^2)	Area (%)
Secondary succession forest	2994.10	63.53
Water body	633.90	13.45
Arboreous pioneer formation	454.60	9.65
Primary succession forest	139.82	2.97
Built area	112.98	2.40
Herb and shrub pioneer formation	101.32	2.15
Upper montane forest	87.00	1.85
Grassland/pasture	73.52	1.56
Agriculture	59.12	1.25
Upper montane grassland	24.33	0.52
Unpaved road	18.23	0.39
Beach	9.30	0.20
Reforestation	2.59	0.05
Exposed soil/mining	2.30	0.05

Source Rutyna et al. (in press)

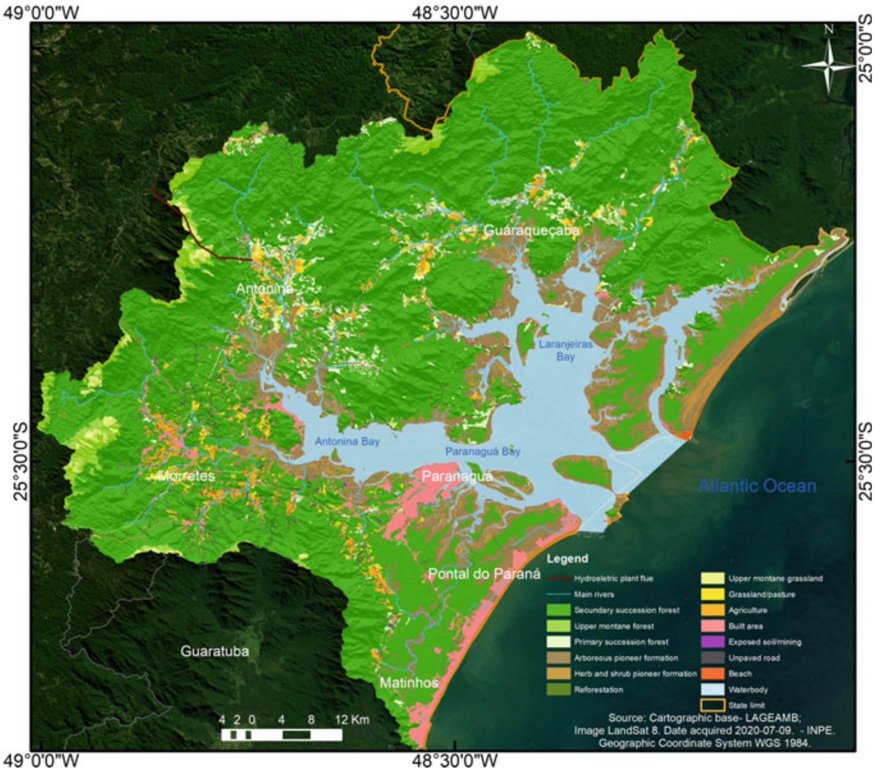


Fig. 4 Usage and land cover of hydrographic units that drain into the CEP. *Source* Rutyna et al., in press

dynamics, the material is transported to and deposited in many parts of the estuary, including Paranaguá Bay.

The rivers are the main agents of sediment delivery to the CEP. Studies indicate that the rivers Nhundiaquara, Sagrado, Cachoeira, Tagaçaba, Serra Negra, Guaraqueçaba, and Jacareí present the highest sedimentation rates in the CEP (Paula 2010). The hydrographic units of the aforementioned rivers have the distinct characteristics of the landscape, which affect the sediment production rates in different ways.

The Cachoeira river basin (UHs 18, 19, and 22; see Fig. 5) has a water increase through a discharge channel built for the operations of the Governador Pedro Viriato Parigot de Souza hydroelectric power plant, which increases its flow and capacity for sediment transportation (Paula 2016). In addition to the presence of cultivation areas next to the river banks, an intense morphological change can be observed in the Cachoeira River (Assis 2011).

The Nhundiaquara river basin (UHs 27, 28, 29, 30, and 31; see Fig. 5) is subject to intense conventional intermittent rural use, with areas of exposed soil in some

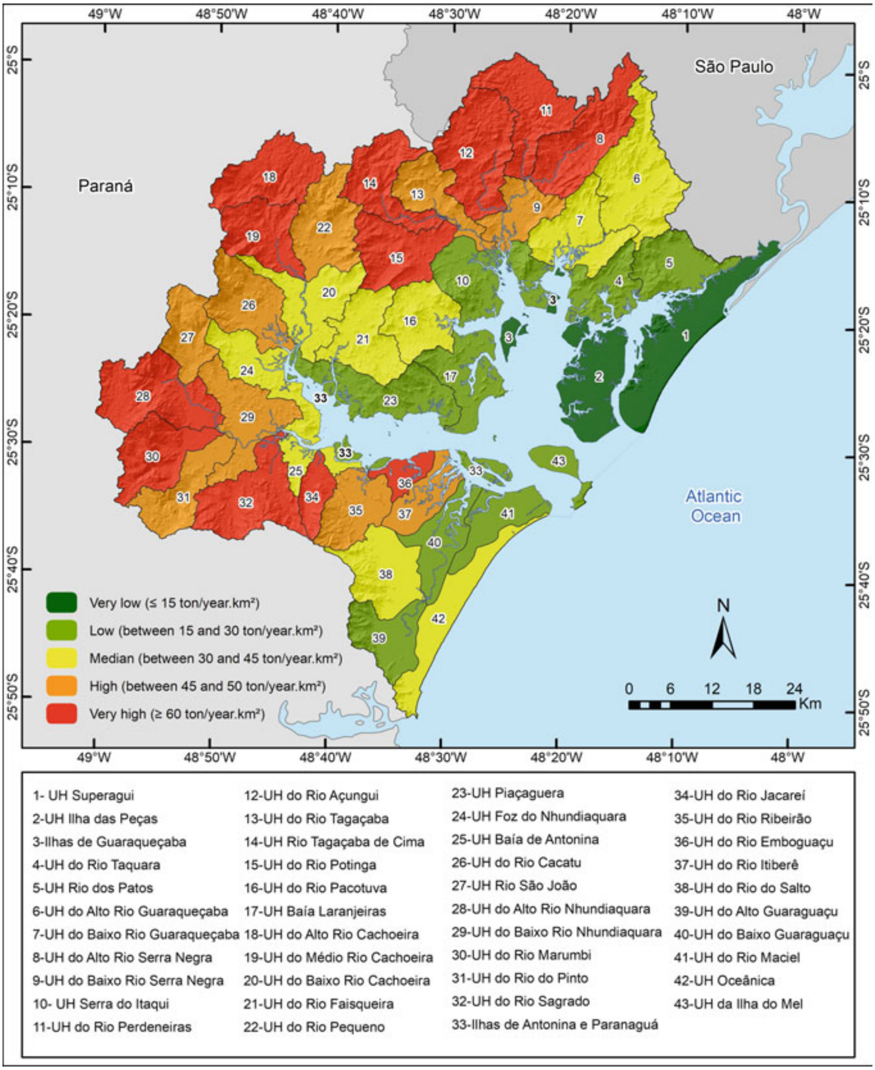


Fig. 5 Estimated sediment production from hydrographic units (UHs) that drain into the Paranaguá Estuarine Complex (CEP). *Source* Rutyna et al., in press

parts of the year, resulting in an increase of sedimentation rates by means of laminar erosion and the formation of erosive grooves. In some places of this basin's hydrographic units, the soil surface horizons are degraded, as the sediments were taken away by laminar erosion.

The Sagrado river basin (UH 32; see Fig. 5) not only is known to have been occupied by areas of agriculture and livestock, but also has a high number of

Table 2 Estimated sediment input for each bay

Bays	Annual production estimate (t. a-1)	Annual production estimate (%)
Antonina Bay	92,153.18	46.77
Laranjeiras Bay	78,223.72	39.70
Paranaguá Bays	18,912.27	9.59
Estuarine Islands/oceanic islands	7,728.06	3.92

Source Rutyna et al. (in press)

non-paved country roads located along the river banks. In rainfall events, these roads work as temporary canals for drainage, contributing to sediment transportation.

The three aforementioned rivers drain into the Antonina Bay. The intense sedimentation of these rivers is demonstrated by changes in the bay's bathymetry and by visual analysis of the landscape, with the formation of sediment banks (Fig. 6a, b). Studies in a stretch of the Antonina Bay using nautical maps have an estimated average growth of 2.6 cm per year (Odreski et al. 2003).

There are many areas destined for pastures that are known for buffalo rearing at the Tagaçaba river basin (UHs 13, 14, and 15; see Fig. 5). This activity results in soil compaction, which favors the formation of erosive grooves (Fig. 7). In rainfall events, these shapes drain the sediments to the fluvial network, explaining the heavy silting of the Tagaçaba River.

In the hydrographic units that make up the rivers Serra Negra (UHs 8, 9, 11, and 12; see Fig. 5) and Guaraqueçaba (UHs 6 and 7; see Fig. 5), there are many extensive areas of monoculture, specially pupunha (palm heart), rice, and banana. Pressure for the increase of production may cause deforestation of surrounding areas with native vegetation, increasing the sediment production rates.

Rainfall events are directly related to the production and transportation of sediment to the CEP. These events remove and mobilize sediments either by the splash effect and laminar erosion in river slopes with exposed soil, or by the concentration of hydraulic flow in erosive grooves increasing it's river flow and enhancing the capacity and efficiency of transportation. These processes occur in a simultaneous and combined way and can be amplified by the region's very characteristic climatic rhythm, the intensification of extreme pluvial events.

Along the coastline of Paraná, these events of extreme and concentrated rainfall take place more frequently in the summer months (December to March) and are classified as equal or superior to 50 mm/24 h (Goudard and Paula 2016). Contributing to erosion and sediment transportation and increasing the rates of sediment production, these events can also trigger natural disasters such as mass movement and floods.

Landslide events on Paraná's coast were already registered at the basins of the rivers Marumbi, Sagrado, and Cubatãozinho (Cunico 2007; Silveira and Oka-Fiori 2007; Mikosik et al. 2009), but none with the intensity and extent of what happened in 11/03/2011 in the Jacareí river basin (UH 34; see Fig. 5). After a pluviometric

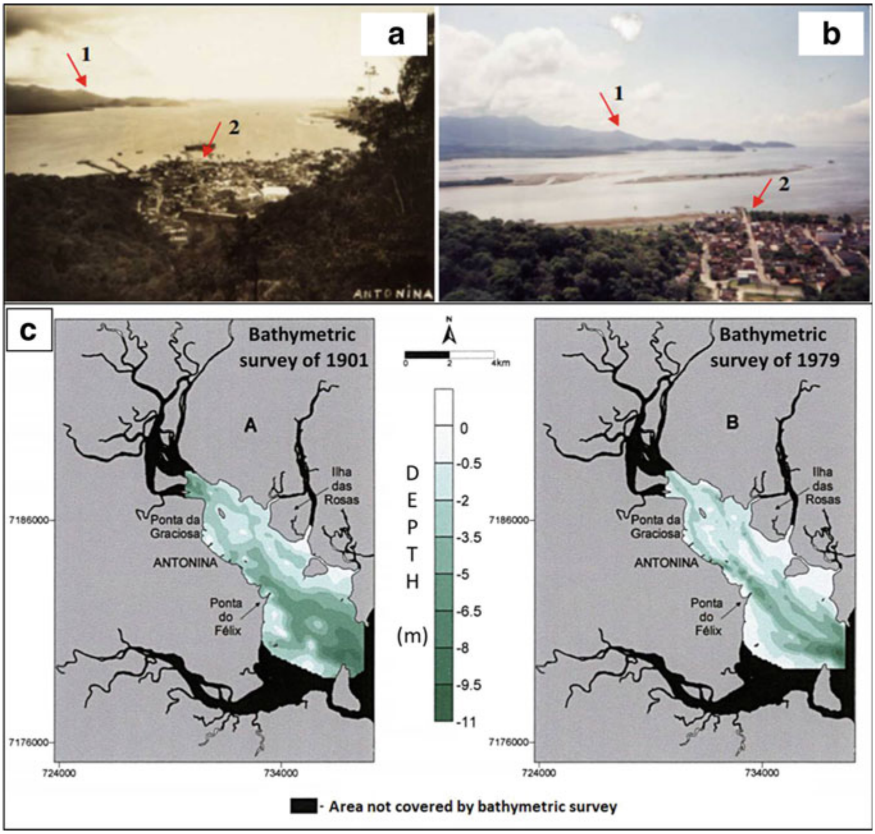


Fig. 6 Photographs taken in 1930 (**a**) and 2002 (**b**) evidencing of the filling of Antonina Bay with the emergence of sediment banks. Point 1: Ridge of the Faisqueira Mountain range. Point 2: Pier At Feira Mar municipal seat of Antonina. **c** Comparison of the bathymetric survey of part of the Antonina Bay between 1901 and 1979. *Source* Ademadan, 2010 and Odreski et al. (2003)

accumulation of 321 mm in 24 h, many translational landslides were registered at river slopes in the Serra da Prata mountain range, leading to mud and debris flows (Silveira et al. 2014) (Fig. 8). The plains close to mountain areas were strongly affected, resulting in material accumulation, floods, accelerated erosion, economic losses, and loss of life.

The BR 277 highway dammed the flows of mud and debris in the Jacareí river basin. After the bridge was broken, a part of the material was drained into the CEP, and another part was retained at the alluvial plain of the Jacareí River. Thus, this area is a great stock of sediment in the Paraná coastline. Expedition campaigns indicate that the plain had a vertical growth between 0.4 and 1 m.

In this scenario of intense sedimentation in the CEP, which is the result of the combination of use and land cover and the environment's natural processes, the topic of silting in Antonina and Paranaguá bays is very present in discussions about

Fig. 7 Erosive grooves at pasture areas in the basin of the Tagaçaba River. *Source* Carlos Wroblewski (2016)

environmental planning and territory management. Dredging works for upkeep and to deepen the Galheta canal are frequent, as this is where the ports of the region are accessed.

Studies show that between 1999 and 2018, the total of reallocated sediments in navigation channels in the CEP was 42,517,662.79 m^3, aggregating a little over 4000.000 m^3 per year (Rutyna et al., in press). Dredging works have a high impact on aquatic fauna as they affect the estuarine sediment dynamic and, if the dredged material is inadequately discharged in shallow areas, this can affect the morphology of the coastline.

In the context of this situation of sedimentation in CEP, it is observed that the permanent occurrence of dredging in navigation channels becomes a vicious circle. The production of sediment is constant and intrinsic to Paraná's coastline landscape, and the improper handling of the soil magnifies it. Even though extreme events are common in this landscape, its frequency can increase due to climate change (Goudard and Paula 2016).

Fig. 8 Results of the extreme rainfall event of 11/03/2011. **a** Translational landslide in the mountains. **b** Floods and buryings at the alluvial plain of the Jacareí River. **c** Breaking of the bridge at the BR 277 highway, draining a part of the material to Antonina Bay. **d** Discharge of the material at Antonina Bay. *Source* a—Oscar Salazar Junior, 2011; b—Rogério Machado/SECJ, 2011; c—Orlando Kissner/Agência Estadual de Noticias, 2011; Estate News Agency, 2011 and d—Ecovia, 2011)

Therefore, alternatives for territory use and occupation which respect this landscape's fragility are necessary. Along with this issue, the hydrographic units that drain into the CEP are mostly covered by Southern Brazil's Atlantic Forest's last remnants. Of the 44 conservation units on the coast of Paraná, 41 are located totally or partially in the CEP's drainage area, occupying 76.51% of the area (3214.49 km^2). Furthermore, protected areas were not yet completely mapped/studied, such as permanent preservation areas (APP) of headwaters, rivers, mangroves, restingas, high declivity, mountain tops, archaeological sites such as sambaquis (shell mounds), among others.

For this purpose, the recovery of degraded areas becomes crucial to minimize the production of sediments. There are many interesting alternatives taking place in some parts of the coast of Paraná attached to this question, which may point to solutions for economic development, which respect the frailty of the environment, focusing the generation of income on the landscape's potential.

4 The Coast of Paraná: A Landscape Marked by the Production of Sediments

Although there is the environmental issue described in the studied area, promising practices to solve the sediment production are taking place. Among these, there is the proposal of the recovery of degraded areas inside the conservation units at the hydrographic basins, which drain to the port, to mitigate sediment production.

Identifying priority areas for recovery was the first step of the Recovery Program of Degraded Areas (PRAD). The program was established by the Brazilian board responsible for the management of Federal Conservation Units (ICMBio—Chico Mendes Institute for Biodiversity Conservation) with the aim of tackling the environmental licensing process to drain and deepen the Galheta channel. This project is being managed by the Administration of Paranaguá and Antonina Ports (APPA).

This study was realized with the help of the Geographic Information System (GIS) and integrated information of susceptibility to sediment production, vegetation cover and land use, permanent preservation areas (APP), and hydromorphic environments (APPA 2018). The project is at the moment in tender and aims to involve 100 local rural properties and to convert 40 ha of degraded areas into agroforestry systems (SAFs) associated with the recovery of the native vegetation.

SAFs are production models based on trees and bushes' association with cultivation, pastures, or animals, which allows the ecological interaction between species (Young 1997). Several authors point out that the SAF is an efficient alternative to environment conservation and production (Young 1997; Kay et al. 2019; Udawatta et al. 2019).

A successful example of this practice is found at the José Lutzenberger Agroforestry Settlement, located in Antonina (Vaneski Filho and Torres 2019). The settlement area was a buffalo pasture. Images obtained/collected from the Google Earth Library show the vegetation's steady increase between 2002 and 2020, especially along the Pequeno River (UH 22; see Fig. 5), without the pressure of its previous usage back to a meandering pattern (Fig. 9).

The importance of vegetation for reducing sediment production is evidenced in studies in Sagrado and Tagaçaba hydrographic units. The land cover in 2005 (mainly rural roads and agricultural activities) was responsible for a 46.24% increase in annual sediment production in the Sagrado hydrographic units (Almeida and Paula 2016; Paula 2016). A study at the Tagaçaba river basin showed that the vegetation recovery in APP would represent a decrease of sediment production of 76.6% (Paz et al. 2016).

In addition to the examples aforementioned, there are several environmental services associated with the recovery of native vegetation. Aiming to encourage such actions, policies such as the Payment for Environmental Services (PSA) can be implemented. The PSAs are voluntary transactions that are acquired by a buyer from a seller who guarantees the provision of a given environmental service (Wunder 2005).

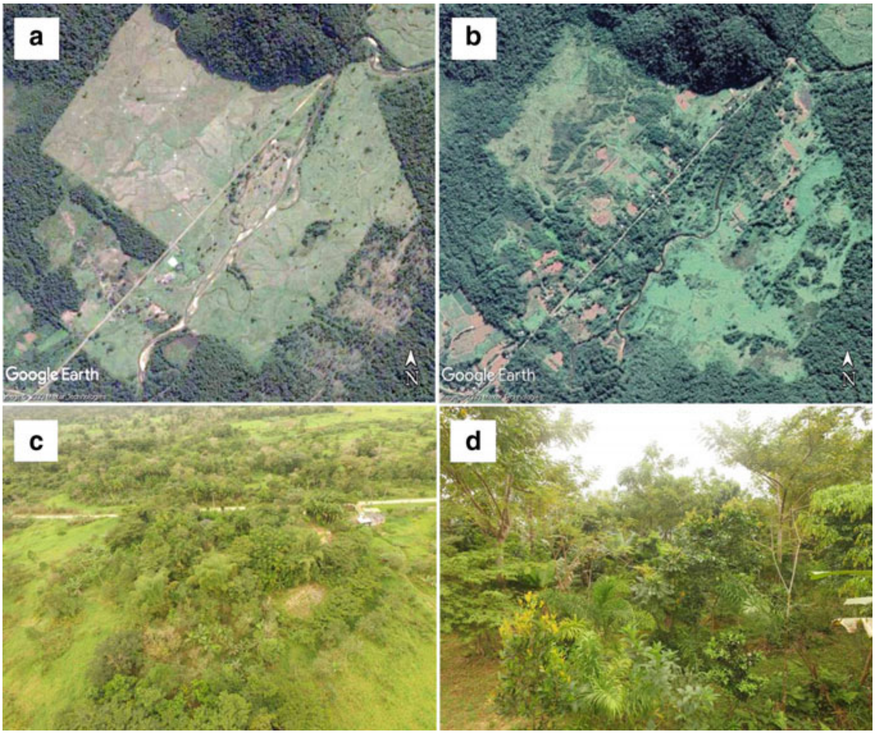


Fig. 9 José Lutzenberger Agroforestry Settlement, in **a** 2002 and **b** 2020. The **c** oblique and **d** horizontal view of SAF. *Source* a and b—Google Earth Library; c and d—Otacílio Paz, 2018)

In a landscape where the PSA would be financially more interesting than the yearly agricultural production, the landowners could be paid to plant native vegetation or adapt their conventional production to a SAF. As a result, a decrease in sediment production is hoped for. This reduction will result in a smaller demand for silting works in the local rivers, as well as port dredging. The port activity, being the largest beneficiary in this process, has the potential to finance future PSA projects on the coast of Paraná. For further development, it is necessary to do in-depth studies of sediment input monitoring in the main rivers that drain into the CEP and studies that estimate the avoided sediment's economic value.

Along with the recovery of native vegetation as observed in the José Lutzenberger Agroforestry Settlement, the coastline plains' fluvial channels, which were straightened, can now return to their meandric pattern. The channels of the rivers Sagrado and Jacareí are examples of basins that stand out due to their estimated sediment production volumes.

Rectified rivers in the coastal plain have a greater flow speed and, as a result, higher efficiency and capacity to transport sediment. In addition, as a direct result of engineering works, the channel deepens, leading to the widening of the plain base level. Consequently, the drainage network's erosive power is enhanced, transporting more sediment to the CEP.

Vegetation recovery can be associated with the recovery of the fluvial channel's meandering patterns. This recovery results in a decrease in sediment production in at least two situations. Firstly, the fluvial bends decrease the flow speed, reducing the erosive power and promoting sediment deposition on the plain. Secondly, periodic floods that are characteristic of coastal plain rivers cause sediment deposition on the plain. Properties close to the rivers can become "sediment farms."

Lastly, in the context of the high rates of sediment production observed, especially in estuarine springs in the CEP (Antonina Bay), and the high costs of dredging work in this region, it is believed that the Antonina bay port should have adequate cabotage activities, shipyard, and tourism, in other words, activities that do not rely on drafts deeper than 5 m.

5 Final Considerations

The case study on sediment production in the drainage area of the Paranaguá Estuarine Complex illustrates a recurring issue in all of the South–Southeast of Brazil, where the country's main ports are located. These ports receive growing sediment input from hydrographic basins which spring from the sea ridge (Serra do Mar). The future outlook is disquieting as a result of the combination of three aspects:

- the inadequate use of land in the region;
- the intensification of extreme climatic events;
- recent Brazilian environmental policies that reduce the protection of preserved areas.

In this context, the experience described in the PRAD area, which is going through a tendering process at the Paraná ports, proves to be an innovative and very promising strategy where degraded areas previously mapped as sources of sediments will be converted to SAFs, or if they show a low agricultural potential they will be restored with native vegetation.

Recently in 2019, the Paraná coastline's sustainable development plan (PDSL 2019) was published. This plan is the most complete and extensive ever written for this region and praises the great opportunity of implementing a PSA as an economic tool to enable the recovery of degraded areas, focusing on increasing port activity and from what we call refrained sediment mechanisms.

References

Almeida AM, Paula EV (2016) Avaliação do Potencial de Produção de Sedimentos nas Áreas de Preservação Permanente da Bacia do Rio Sagrado (Morretes/PR). Paper presented at the 11st Brazilian National Symposium of Geomorphology (SINAGEO) (2016) State University of Maringá, Maringá, 15–21 Sept 2016

Angulo RJ (2004) Mapa do Cenozóico do litoral do Estado do Paraná. Boletim Paranaense de Geociências 55:25–42

Angulo RJ, Borzone CA, Noernberg MA (2016) The state of Paraná Beaches. In: Short AD, Klein AH da F (eds) Brazilian beach systems. Springer International Publishing, Cham, pp 419–464

Administração dos Portos de Paranaguá e Antonina – APPA (2018) Programa de Recuperação de APPs Degradadas para a APA de Guaraqueçaba. Projeto Técnico Compensatório da Dragagem de Aprofundamento dos Portos do Paraná previsto na ALA nº 10/2012 do ICMBio. Paranaguá, 197p

Assis AQS (2011) Análise da dinâmica fluvial do rio Cachoeira (Antonina/PR), entre os anos de 1954 e 2005. Geografia (Londrina) 21(2):85–111

Bigarella JJ (2009) Matinhos: homem e terra - reminiscências. Fundação Municipal de Curitiba, Curitiba

Cattani PE, Lamour MR (2016) Compartimentação Geomorfológica da Baía de Antonina pela Integração e Análise Espacial de Dados: Abordagem Sedimentológica. Paper presented at the 11st Brazilian National Symposium of Geomorphology (SINAGEO). State University of Maringá, Maringá, 15–21 Sept 2016

Cunico C (2007) Zoneamento ambiental da bacia hidrográfica do Rio Marumbi - PR: perspectivas para a análise e avaliação das condições socio-ambientais. Dissertation, Federal University of Paraná

Estades NP (2003) O litoral do Paraná: entre a riqueza natural e a pobreza social. Desenvolvimento e meio ambiente 8:25–41

Gaspar MD (1996) Análise das datações radiocarbônicas dos sítios de pescadores, coletores e caçadores. Boletim do Museu Paranaense Emílio Goeldi 8:81–91

Goudard G, Paula EV (2016) O Clima do Litoral Paranaense: Variabilidades, Mudanças Climáticas, Tendências e Desafios. In: Boldrini EB, Paes LSOP, Pinheiro F (eds) Clima: Boas práticas de adaptação. ADEMADAN, Antonina, pp 13–27

Instituto Brasileiro de Geografia e Estatística - IBGE (2020) População Estimada. https://cidades.ibge.gov.br/brasil/pr/panorama. Accessed 6 Oct 2020

Kay S, Graves A, Palma JHN, Moreno G, Roces-Díaz JV, Aviron S, Chouvardas D, Crous-Duran J, Ferreiro-Domínguez N, Jalón SG, Măcicăşan V, Mosquera-Losada MR, Pantera A, Santiago-Freijanes JJ, Szerencsits E, Torralba M, Burgess PJ, Herzog F (2019) Agroforestry is paying off—economic evaluation of ecosystem services in European landscapes with and without agroforestry systems. Ecosyst Serv 36: https://doi.org/10.1016/j.ecoser.2019.100896

Lessa GC, Meyers SR, Marone E (1998) Holocene Stratigraphy in the Paranaguá Bay Estuary, Southern Brazil. J Sediment Res 68(6):1060–1076

Maack R (1968) Geografia Física do Paraná. Editora UEPG, Ponta Grossa

Martins SG, Silva MLN, Avanzi JC, Curi N, Fonseca S (2010) Fator cobertura e manejo do solo e perdas de solo e água em cultivo de eucalipto e em Mata Atlântica nos Tabuleiros Costeiros do estado do Espírito Santo. Scientia Florestalis 38(87):517–526

Mikosik APM, Paula EV, Mesquita C, Santos LJC (2009) Caracterização das Cicatrizes de Movimentos de Massa na Bacia Hidrográfica do Rio Sagrado (Morretes/PR). In: Boldrini EB, Paula EV (eds) Gestão Ambiental Portuária: Subsídios para o licenciamento das Dragagens. ADEMADAN, Curitiba, pp 179–189

Minerios do Paraná - MINEROPAR (2006) Atlas Geomorfológico do Paraná - Escala Base 1:250.000, Modelos Reduzidos 50.000. Minerais do Paraná e Universidade Federal do Paraná, Curitiba

Morgenstern A (2009) Porto de Paranaguá, volume I: contribuição à história, período de 1648/1935. Coração Brasil Editora, Curitiba
Odreski LLR, Soares CR, Angulo RJ, Zem RC (2003) Taxas de assoreamento e a influência antrópica no controle da sedimentação da Baía de Antonina-Paraná. Boletim Paranaense de Geociências 53(1):07–12
Parellada CI, Neto AG (1993) Inventário de sambaquis do litoral do Paraná. Arquivos do Museu Paranaense 7:1–42
Paula EV (2010) Análise da produção de sedimentos na área de drenagem da Baía de Antonina/PR: uma abordagem geopedológica. Federal University of Paraná, Thesis
Paula EV (2016) Análise da Produção de Sedimentos na Área de Drenagem da Baía de Antonina, Paraná: Contribuições ao planejamento do território. In: Reis RA, Abrahão CM de S, Tiepolo LM, Chemin M (eds) Litoral do Paraná: Território e Perspectivas. Brazil Publishing, Curitiba, pp 11–35
Paz OLS, Hung M, Wroblewski CA, Paula EV (2016) Estimativa da produção de sedimentos nas áreas de preservação permanentes (apps) da bacia hidrográfica do rio Tagaçaba (Guaraqueçaba/PR) em três cenários distintos. Paper presented at the 11st Brazilian national symposium of geomorphology (SINAGEO). State University of Maringá, Maringá, 15–21 Sept 2016
Plano para o Desenvolvimento Sustentável do Litoral do Paraná (PDSL) (2019) Governo do Estado do Paraná. Secretaria de Estado de Planejamento e Projetos Estruturantes, Curitiba
Pierri N, Angulo RJ, SOUZA MC, Kim MK (2006) A Ocupação e o Uso do Solo no Litoral Paranaense: Condicionantes, Conflitos e Tendências. Desenvolvimento e Meio Ambiente 13:137–167
Rocha PC (2011) Sistemas Rio-Planície de Inundação: Geomorfologia e Conectividade Hidrodinâmica. Caderno Prudentino de Geografia 33(1):50–67
Roderjan CV, Galvão F, Yoshiko SK, Hatschbach GG (2002) As Unidades Fitogeográficas do Estado do Paraná. Ciência & Ambiente 13(24):75–92
Rutyna BB, Soares CR, Wroblewski CA, Paula EV Assoreamento nas baías de Antonina e de Paranaguá – PR: análise integrada das áreas fontes de sedimentação e obras de dragagem. Revista Brasileira de Geografia Física (in press)
Sampaio R (2006) Uso Balneário, Apropriação do Espaço e Meio Ambiente em Pontal do Paraná, Litoral Paranaense. Thesis, Federal University of Paraná
Santos LJC, Paula EV, Soares CR (2015) Antonina Bay and Superagui Island: a mosaic of mountains, coastal plain, and Atlantic Forest. In: Vieira BC, Salgado AAR, Santos LJ (eds) Landscapes and landforms of Brazil. Springer, Dordrecht, pp 103–113
Silva V, Fagundes MCV, Lima MR, Lima VC, Tavarez AK (2013) Conhecendo os Principais Solos do Litoral do Paraná: Abordagem para educadores do ensino fundamental e médio. Sociedade Brasileira de Ciência do Solo, Matinhos
Silveira CT, Oka-Fiori C (2007) Análise empírica da fragilidade potencial e emergente da bacia do rio Cubatãozinho. Estado do Paraná. Caminhos da Geografia 8(22):1–17
Silveira CT, Fiori AP, Schilipack P, Dias SM (2014) Mapeamento preliminar da suscetibilidade natural a movimentos de massa da Serra do Mar Paranaense apoiado na análise digital do relevo. Revista Brasileira de Geomorfologia 15(01):03–22
Udawatta RP, Rankoth L, Jose S (2019) Agroforestry and biodiversity. Sustainability 11(10):0–22
Vaneski Filho E, Torres KI (2019) Estado de Injustiça e Conflito Socioambiental: O Caso do Acampamento José Lutzemberg. Raega - O Espaço Geográfico em Análise 46(2):88–100
Vanhoni M, Mendonça F (2008) O Clima do Estado do Paraná. Revista Brasileira de Climatologia 3:49–63

Vieira BC, Gramani MF (2015) Serra do Mar: the most "Tormented" relief in Brazil. In: Vieira BC, Salgado AAR, Santos LJ (eds) Landscapes and landforms of Brazil. Springer, Dordrecht, pp 285–297

Villaça MCG (2016) Corridas de Detritos e as Taxas de Denudação a Longo-Termo da Serra do Mar/SP. University of São Paulo, Thesis

Wunder S (2005) Payments for environmental services: some nuts and bolts. Cent Int Forestry Res 42:1–23

Young A (1997) Agroforestry for soil management. CAB International, Wallingford

Eduardo Vedor de Paula is Professor in the Department of Geography in the Federal University of Paraná (UFPR), Brazil. He obtained bachelor, master, and PhD in geography from UFPR. He developed postdoctoral research in territorial planning at UNCuyo (Mendoza/Argentina). He has experience in teaching in higher education and the development of technical and academic projects in the area of geoprocessing applied to environmental studies and of planning and environmental management of the territory.

Otacílio Lopes de Souza da Paz is currently a PhD student in geography at the Federal University of Paraná. Also, he has master's, bachelor and licentiate degree in geography at the same university. He has done researches mainly in fluvial geomorphology, geotechnology, environmental analysis, and geography teaching.

Maíra Oneda Dal Pai is Geographer graduated from the Federal University of Paraná and presently a master's student in geography at the same university. Her main focuses are geomorphology and pedology, but also she has experience in environmental analysis and geography teaching.

Marianne de Oliveira is Geographer at the State University of Ponta Grossa and at present is a PhD student in geography at the Federal University of Paraná. She has experience in researching in the areas of geomorphology, remote sensing, and Geographic Information System (GIS).

Urban Environmental Changes in South America: A Study on Air Pollution and Urban Heat Island over Rio de Janeiro

Heitor Soares de Farias, Andrews José de Lucena, and Vitor Fonseca Vieira Vasconcelos de Miranda

1 Introduction: The City and the Urban Climate

Urbanization is a pattern related to the twenty-first-century landscape. Natural or rural spaces are removed continuously and are replaced by urban and human-made features, which is a consequence of urban growth and development.[1] This trend

[1]The usage of the concept "development" can be erroneous to describe the transformations of old natural features to urban spaces, since it has not been criteria to the boundaries of the growth in underdevelopment countries, such as the ones from South America, Africa or Asia. In those countries, urbanization can be considered unfinished or late, which demands more challenges. So it is more convenient to explore the concept of "growth," where there is no determination for the transformations of old natural spaces to urban space.

H. S. de Farias (✉) · A. J. de Lucena
Integrated Laboratory of Applied Physical Geography (LIGA), Federal Rural University of Rio de Janeiro (UFRRJ), Rio de Janeiro, Brazil

V. F. V. V. de Miranda
Laboratory of Environmental Satellites Applications (LASA), Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_8

generates new processes, dynamics, and products, which affect the natural or environmental[2] system by setting new standards in the pedosphere, lithosphere, hydrosphere, biosphere, and atmosphere (Oke et al. 2017).

Cities are the main sites of environmental issues due to changes in the geographic landscape, resulted from the fast unequal populational growth[3] and the new usage and function that classify it.[4] The expansion of the cities creates more dense and problematic urban spaces, such as metropolises, which also enhance environmental issues.

South American cities are great examples of late or unfinished urbanization,[5] which creates a space changed by severe environmental impacts that conflict and affect the population's quality of life. Cities like Caracas and Maracaibo (Venezuela); Bogotá and Medelín (Colômbia); Quito and Guayaquil (Equador); Lima (Peru); Santa Cruz de la Sierra (Bolívia); Santiago (Chile); Buenos Aires (Argentina); Montevidéu (Uruguai); and São Paulo, Rio de Janeiro, Brasília, Salvador, Fortaleza, and Belo Horizonte (Brasil) are all an example of cities with more than 2 million habitants and have the same history of underdeveloped spatial urban organization. Rio de Janeiro, Bogotá, Lima, and São Paulo[6] are the cities with the highest population among those cities, reaching numbers above 6 million people.

The urban climate is a complex system, singular to the city. It is a place with a profound change in atmospheric parameters, such as circulation, turbulence, air quality, heat storage, evapotranspiration, and others (Taha 1997; Arnfield 2003; Kanda 2006). According to Monteiro (2003), the urban climate can be characterized by three different forms or groups: the physicochemical, the thermodynamical, and the hydrometeorological, which are represented by the atmospheric pollution (affecting air quality), the urban heat island (thermal comfort), and the severe thunderstorms (urban flooding, respectively). In a recent publication, Henríquez and Romero (2019) review a series of papers about the urban climate in several cities over South America, based on the Monteiro (2003) approach.

Atmospheric pollution is not only a matter related to the cities; somewhat, it is enhanced by urbanization due to the higher density of sources and emissions.

---

[2]The concept of "natural" and "environmental" is far from being equal or even the same; by the way, they need to be distinguished. Nature or natural is a concept supported by the idea of the absence of direct human influence over space. Environment/environmental is a harmonic or symbiotic relationship between human and fauna, flora, or other elements of physical geographical space.

[3]The unequal populational growth is related to the irregular disposition of housing sets by square meters or the lack of control in health, education, security, leisure or even the neglect of preserving green places in the city.

[4]The usage is related to the removal of vegetation cover by human-made materials, or automobiles as the main mean of displacement through roads, or at last the availability of natural resources, such as air and water to ensure the habitants' needs.

[5]It is unfinished because many places in those cities, especially in the low urban areas, have scarcity of essential and basic services such as health, transport, water supply, sewer, and others.

[6]São Paulo has an estimated population around 12 million of habitants, nowadays.

Different papers show that particulate matter (PM) has a considerable influence on morbidity and mortality on the local population, even when the average concentrations are within the international thresholds of air quality (Daumas et al. 2004). The most affected are children and the old population, which has been verified for the countries in Europe (Clancy et al. 2002; Gervois et al. 1977), North America (Dockery and Pope 1994; Jacobson 1984; Levy et al. 1977; Mazumdar and Sussman 1983; Schimmel and Murawski 1976), South America (Borja-Aburto et al. 1997; Ostro et al. 1996; Cifuentes et al. 2000), and particularly Brazil (Braga et al. 1999; Freitas et al. 2004; Gouveia and Fletcher 2000a, b; Gouveia et al. 2006; Saldiva et al. 1995).

For a long time, air pollution in the cities was attributed to industrial emissions; currently, the governments tried to modernize the industries, applying an environmental licensing mandatory, which has managed to decrease industrial atmospheric emissions. In contrast, the rapid development of the vehicle fleet has increased the pollutant emission significantly, being the primary source of air quality degradation.

Urban heat island (UHI) is the main product of the urban climate and one of the biggest environmental problems of the twenty-first century (Rizwan et al. 2008). The UHI is related to the cities' heat storage compared to its surroundings (non-urbanized) and generally cooler surfaces. UHI is also related to air or surface temperature increases, where UHI is defined by three main aspects: shape, intensity, and localization toward a hotter nucleus. Those aspects are different for each city, related to its seasonality, climate characteristics, geographical morphology, and the thermal properties related to the materials that are used in the urban surface. The UHI's leading causes are related to anthropogenic factors and atmospheric factors, such as wind, cloud cover, and moisture (Voogt 2002).

There are many effects of the UHI; most of them are negative, implying thermal comfort and human health (Voogt and Oke 2003). UHI can also favor the increase of energy consumption toward refrigeration (Konopacki and Akbari 2002), an increase of the tropospheric ozone level, mortality (Changnon et al. 1996), and high ecological prejudice (Santamouris et al. 2007). Brazil is a continental country, with more than 200 million habitants, extended between the tropical and intertropical South American areas, with important biomes (Amazon and Atlantic Forest, Cerrado, Caatinga, Pantanal) and a vast maritime coast, where its cities are of great representativeness for the urban climate and air quality.

In this context of urban climate and South American cities, we intend to identify areas with higher potential to concentrate pollutants and relate it to the UHI for the Metropolitan Area of Rio de Janeiro (MARJ) in this decade (2011–2020). This work is divided into four sessions: study area, methodology, results, and conclusions.

2 Study Area: The Metropolitan Area of Rio de Janeiro (MARJ)

The MARJ is composed of 21 cities (Fig. 1), with a total of above 11.5 million people, where 80% of the entire state of Rio de Janeiro resides in it. Because of its geographic, historical, economic, and political positions, it possesses the second-highest demographic concentration pole and economic activity center of Brazil. A large volume of activities and supply of specialized services lead to exacerbating a high rate of urbanization.

The physical landscape of MARJ shows lowlands, hills, bays, and lagoons. In the coastal plain, there are three major hills—Tijuca, Gericinó–Mendanha, and Pedra Branca. There are two bays—Guanabara and Sepetiba; in the background, there are the Serra do Mar hills, with an average altitude of 900 m (Fig. 2). MARJ presents peculiar characteristics, capable of generating local effects that change the atmospheric flow regime (Oliveira-Júnior et al. 2017). Topography imposes resistance to the atmospheric flows, decreasing the wind speed, preventing the sea breeze from reaching the neighborhoods and municipalities, which concentrate pollutants in specific areas, defined as air basins (Farias 2013).

MARJ is the area with an intense land occupation, resulted from its essential economic and logistical role due to its diversified industrial area. In the first years of the actual century, a new economic world scenario and the rise of a new political project of development in Brazil enhanced Brazil's economic and social changes (Oliveira and Oliveira 2020 p. 43).

The population's demographic evolution (rural and urban) exhibits two tendencies: the ascension from the 1940s and the stabilization in the 1990s. In 1990, the urban population stabilized between 9 and 10 million. Between 1960 and 1970, the rural population has an abrupt decrease, reaching a little bit less than 50,000 habitants, settling in isolated spaces in MARJ. The urban population concentrates in the metropolitan nucleus, in the suburbs, and in the space attract by the metropolitan self-segregation. In contrast, the rural population occupies the surrounding rural–urban areas, localized in the extremes east and west of MARJ.

The public and private investments in MARJ, with the perspective to restructure the production and to recover the economy in a short period, include the construction of the Petrochemical Complex of Rio de Janeiro (COMPERJ), located in the city of Itaborai in the extreme east; the construction of the Thyssenkrupp steelmaker company (TKCSA) in the industrial district of Santa Cruz in the city of Rio de Janeiro, supported by the highway BR-493 called Metropolitan-Arc[7]; and the Itaguai Harbor in the extreme west, essential to the international trade of Brazil (Gusmão 2010). The land use has a highlighted combination of natural and

[7]The name is related to the coverage area, which goes around MARJ, crossing its suburb, from east to west, also related to the expansion of the metropolis, to areas with social and infrastructure needs. Between 1990 and 2010, the Metropolitan Arc was the main area of land incorporation, with high rates of populational growth.

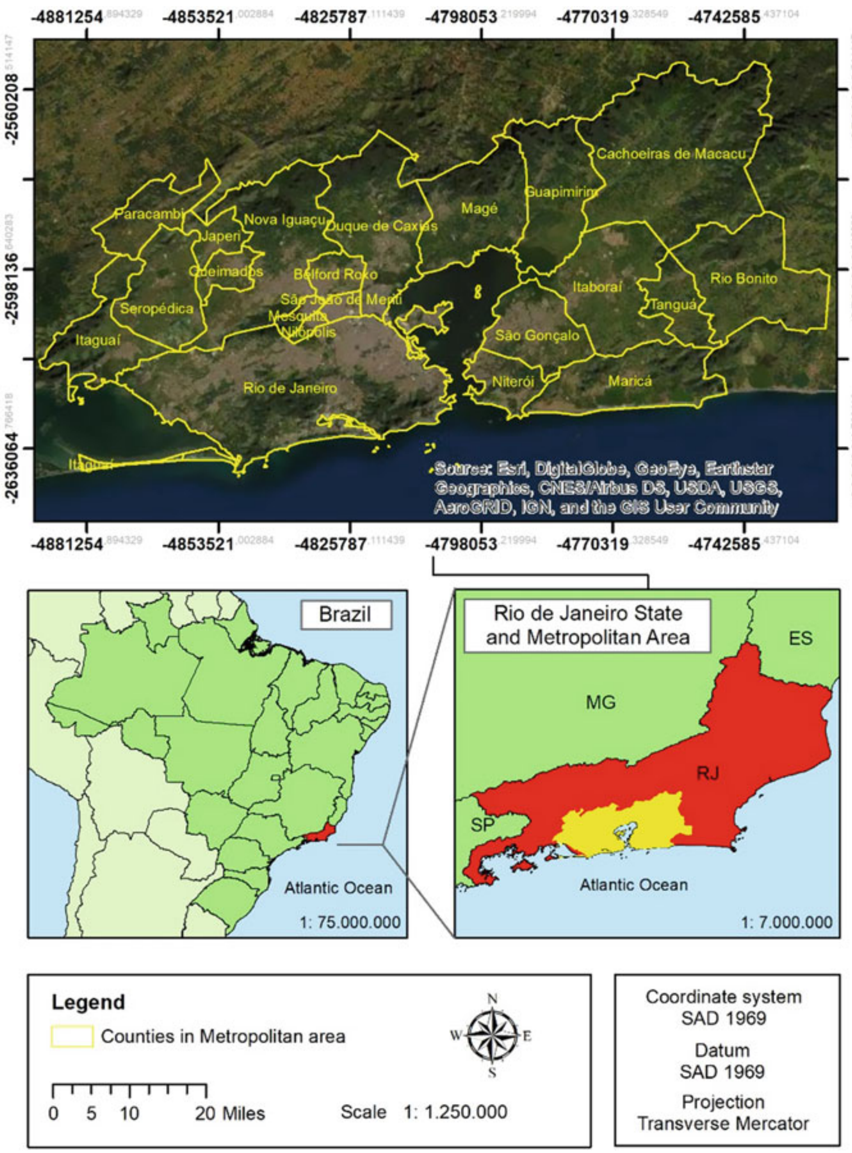


Fig. 1 Metropolitan Area of Rio de Janeiro. *Source* CEPERJ/Government of the State of Rio de Janeiro

human-made materials. To Souza (2000), MARJ is an example of polishing and environmental degradation in large cities on the capitalist suburbs. Throughout its history, massive interventions resulted in undermining natural beauty and attractiveness (p. 118, 119). MARJ combines many elements that can aggravate

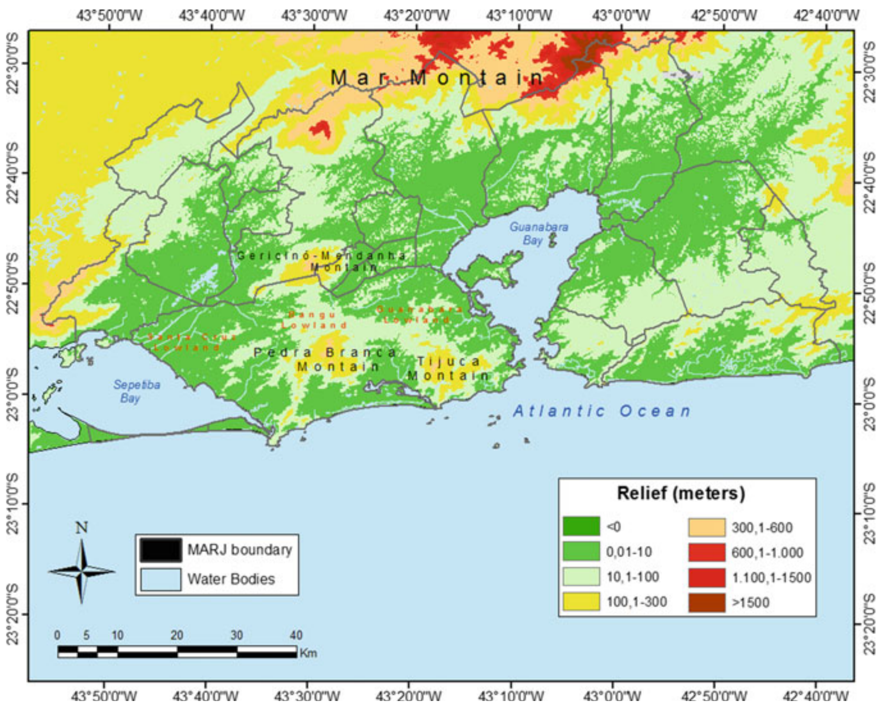


Fig. 2 MARJ landscape. *Source* CEPERJ/Government of the State of Rio de Janeiro

environmental issues. It is the second-largest metropolitan area of Brazil, concentrating people and industries, and also the second in quantity of source of pollutants.

MARJ landscape has a crucial role in the process of concentrating/dispersing pollutants, where the hills act as physical barriers to the prevailing winds, disturbing the direction of the winds on the surface, changing the atmospheric flow, and creating specific patterns of dispersion (Farias 2013).

At last, MARJ's geographical transformations occurred throughout history, results in a series of modifications in the environment, changing water resources, geomorphological systems, biogeographical systems, and the atmosphere. The local atmosphere has been suffered from changes, mainly related to air quality (high influence related to the emissions) and the surface energy balance (high influence related to the diurnal and nocturnal heat and temperature).

3 Materials and Methods

This methodology section is split up into two sections: The first is related to the mapping of pollutants in relation to the air basins; the second is related to the UHI and the mapping of the heat spaces based on the land surface temperature (LST), normalized difference vegetation index (NDVI), and the index-based built-up index (IBI).

3.1 Mapping of the Areas that Concentrate More PM10: 2010–2020

We have searched the literature before mapping the areas that concentrate more particulate matter in 10 μm or less (PM10) in the decade of 2010–2020. There are ample references that highlight land use, highways, industries, landscape, and air basins which are the parameters capable of influencing air quality (Chiesa et al. 2008; Farias 2013; Gregório 2011; Souza and Sant'anna Neto 2009). Percentage of influence has been defined for each of the parameters, and weights have been assigned to the specificities of the parameters, as can be observed in Table 1, using the tool weighted overlay in ArcGIS software.

The land use is attributed to the highest weight (30) for defining the areas of the city where particulate material is most produced in anthropic activities. Places with higher populational density also have a higher concentration of vehicles that is why it is attributed to the highest weight. There is a reduction in vehicular circulation in medium and low population density areas, and the weight has decreased proportionally. The areas that are not inhabited—rock, tree vegetation, and field—have received minimum weight.

For the industries, it is attributed to a lower percentage of influence on the production of particulate material (20%), as they are responsible for less air pollution than vehicles, respectively, 23 and 77%, according to the State Air Quality Report of Rio de Janeiro (INEA 2014). The areas close to the industries are more exposed to pollution, having considered the radius of 1 km to define the surroundings of the same ones that received the maximum weight for the particulate material concentration. The distant areas, 5 km or more, receive minimum weight because the increasing distance from the industry makes the pollutants disperse. The types of industry are also considered. The maximum weight has been given to the most polluting industrial activity, e.g., power generation industries (thermoelectric plants) and petrochemicals, according to INEA (2014).

Highways are attributed to the same percentage of influence from industries (20%), despite the fact that most of the pollution is produced by vehicles, as previously mentioned. When considering the roads that cross urban areas (where the vehicle flow is more intense) and an interference area of 200 m on each margin, the weight given to the parameter land use is accumulated since it is considered as an area with high emission. In contrast, when passing through a non-urban area where the flow is less, the weight accumulated is smaller. For this analysis, we have considered the main circulation routes of MARJ. The distance of 200 m has been used in several international studies, such as the case of research that relates the continued exposure to air polluted by particulate matter and the increased incidence of dementia in humans living in areas close to highways (Chen et al. 2017).

The parameters of landscape and air basin have received lower percentages of influence (15%) however them being important for the pollutants concentration or dispersion . From the part of the landscape parameters, the lowlands and slopes with up to 100 m have received the higher weights (i.e., a higher tendency of pollutant

Table 1 Parameters and percentages of influence on air quality

Parameter	Potential for pollutant concentration	Weight	Influence (%)
Soil use	Rock	1	30
	Tree vegetation	1	
	Fields	1	
	Lower population density	4	
	Medium population density	6	
	Higher population density	9	
Industries	Areas up to 1 km	9	20
	Areas more than 5 km	1	
Highways	Areas up to 200 m	9	20
	Areas more than 200 m	1	
Relief	Areas up to 200 m of altitude	9	15
	Areas above 200 m of altitude	1	
Air basins	Air Basin 1	9	15
	Air Basin 2	1	
	Air Basin 3	6	
	Air Basin 4	2	

Source Weight determined by the authors

concentration). Above 100 m of altitude, the minimum weight has been attributed (at this point, the pollutants tend to disperse). This is a consequence of the wind circulation in the air basins that were classified based on the analysis of the results of the wind circulation model (Farias 2013), as shown by the air circulation for 10/12/2010 (Fig. 3).

Figure 3 shows the height of the landscape with the color-indexing. A detailed interpretation may be given as:

- On the Serra do Mar hills, the value reaches close to 1600 m (shown as red), and the arrows represent the wind direction and intensity. It has been observed that in the west of MARJ (Air Basin 1), there is difficulty in dispersing pollutants, as the winds are blocked by the coastal massifs (shown as blue). It causes to assign greater weight in this parameter.
- The central area (Air Basin 3) also receives a slightly lower weight considering that it ranks as the second in terms of the difficulty in dispersing pollutants.
- The east of MARJ (Air Basin 4) and the coastal area (Air Basin 2) receive considerably lower weights because they do not impose difficulties in dispersing pollutants.

For this analysis, the predominant type of weather over the state of Rio de Janeiro has been considered on the day and time of atmospheric flow data collection, which was in conditions of atmospheric stability. Afterward, the same data related to the air circulation on 12-10-2010 has been used to simulate the dispersion of particulate matter in five different specific spots.

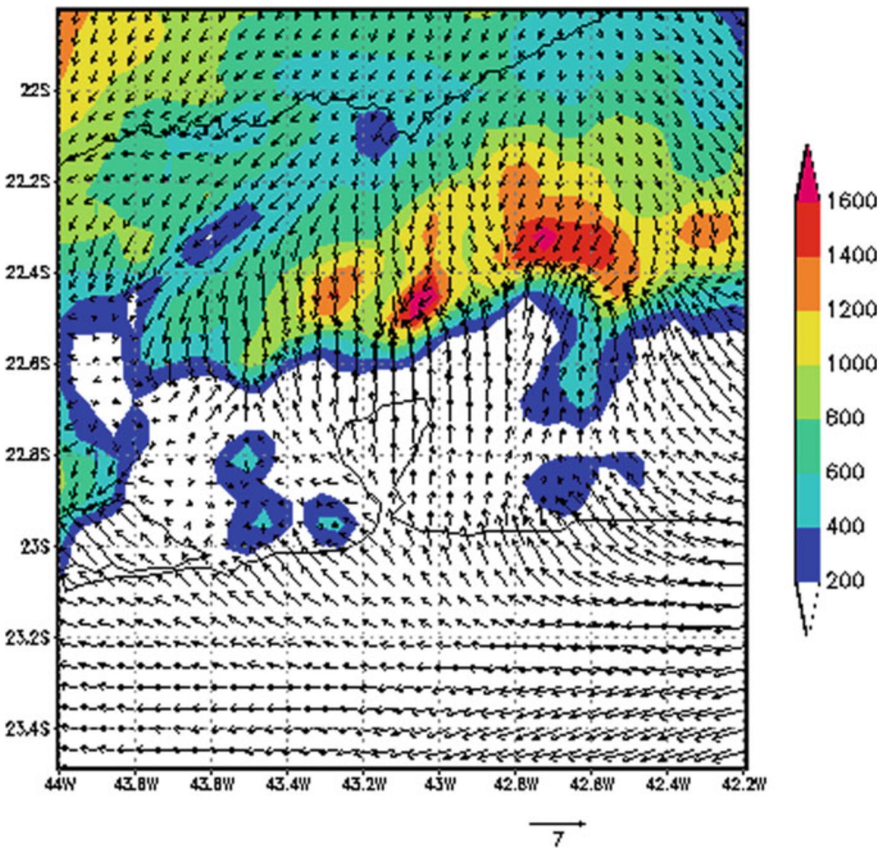


Fig. 3 Atmospheric flow pattern for the day 12/01/2010, at 09:00 a.m., local hour. *Source* Authors

- Spots 1 and 2 for Air Basin 1;
- Spots 3 and 4 for Air Basin 3 and
- Spot 5 for Air basin 4 (Fig. 4).

The colors in Fig. 4 represent the height of the trajectories at which the pollutant can reach. It is clear that spots 1 and 2 exhibit more difficulties for the pollutant to reach higher altitudes and distances.

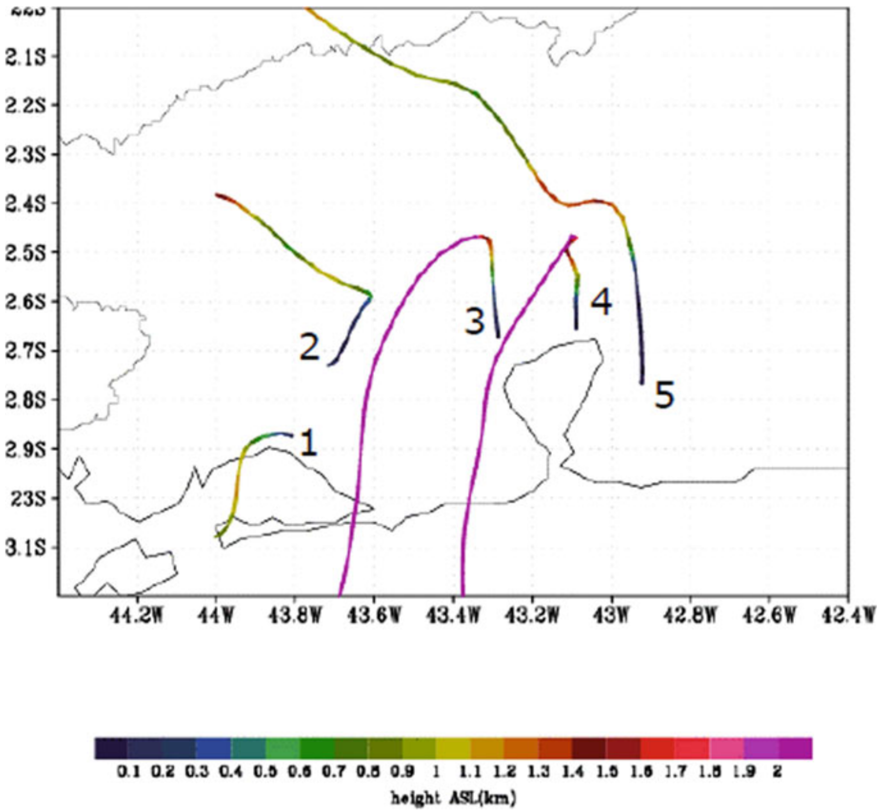


Fig. 4 Simulated trajectories for the day 12-01-2010, 09:00 a.m., local hour. *Source* Authors

3.2 Mapping of Land Surface Temperature (LST)

We have used here 142 satellite images[8] between the years 1984 and 2019 that cover MARJ.[9] The images are obtained from the Landsat platform with different sensors, i.e., Thematic Mapper (TM) for series 5 (1984–2011), Enhanced Thematic Mapper Plus (ETM+) for series 7 (2001–2003; 2012), Operational Land Imager (OLI), and Thermal Infra-Red Scanner (TIRS) for series 8 (2013–2019). The time series is extensive. In the case of MARJ, since 1984, the thermal band with a spatial

---

[8]Landsat accomplishes its path, crossing the same area within 16 days. Because of this, many months has gaps or only one image to represent it, depending on the radiometric and cloud cover conditions. In this work, the criteria for selecting images were the absence of clouds that covers MARJ.

[9]Because of Landsat scene, two cities were excluded from the political division, which are: Cachoeiras de Macacu and Rio Bonito. Those cities are split in the path/row 217/76, which covers all the other cities.

resolution of 120 m for TM and ETM+ and 100 m for TIRS allows a better analysis of the region with rich landscape details. Even with different sensors, the Landsat series has similar spectral resolutions within the reflectance and thermal bands, allowing the usage of all the images as one unique time series. The data is provided free by the United States Geological Survey (USGS).[10] Landsat is one of the pioneer tools for urban climate investigations, offering a better spatial mapping of LST and UHI (Lougeay et al. 1996; Voogt and Oke 2003; Amanollahi et al. 2016).

Despite USGS already providing georeferenced images, some had residual errors, demanding a second geometric correction, which has been made using Spring 4.3 software. Radiometric calibration has also been made to ensure converting the digital numbers to radiance values, using the constants from Chander (Chander et al. 2009) as part of the preprocessing procedure. Three cloud cover masking techniques have been used: (a) technique of the threshold on the red band, (b) technique of threshold for the brightness temperature band, and (c) technique for the Q ratio between red and infrared bands (Franca and Cracknell 1995), all also described at Peres et al. (2018).

Some of the urban climate papers using the thermal infrared remote sensing data have used the brightness temperature associated with the radiance in the top of the atmosphere as a proxy for the LST (Souza and Silva 2005). We emphasize here the need to make an emissivity and atmospheric correction that can generate the real LST, reducing the noise.

LST has been retrieved using the thermal band of Landsat, based on different parametrizations (Qin et al. 2001; Souza and Silva 2005). The atmospheric correction has been made using data from surface weather meteorological stations distributed over MARJ. The retrieved LST is the result of a combination between the atmosphere and the surface emissivity. Surface emissivity was retrieved based on the NDVI (Van de Griend and Owe 1993). The demonstration of the algorithms and equations could be found in Lucena et al. (2013) and Peres et al. (2018).

Two indexes have been used here to help the analysis of the LST and UHI: the normalized difference vegetation index (NDVI) and the index-based built-up index (IBI). NDVI is based on the difference between the maximum absorption of radiation in the red region, the presence of clorofila pigments, and the maximum reflectance of radiation in the infrared region (Huete et al. 2002). The values of NDVI vary between −1.0 and +1.0, where a positive value represents an area with high non-stressed vegetation, and a negative value of NDVI represents stressed or non-vegetation areas. A value close to 0 (e.g., 0.1 or 0.2) represents the urban region (Rouse et al. 1974).

IBI (Xu 2008) is an urban index that distinguishes itself from the others because it uses a composition of other indexes, such as NDVI, modified normalized difference water index (MNDWI), and the normalized difference built-up index (NDBI). It can be divided into three components: (1) water, (2) vegetation, and (3) built-up areas. High positive IBI value, i.e., close to 1.5, represents built-up

[10]Visit http://earthexplorer.usgs.gov/.

areas. A low negative value, i.e., close to −1.5, represents vegetated areas, and a value close to 0 is more likely to represent the exposed soil. The equations and the thematic indexes' compositions could be found in Lucena et al. (2013).

All 142 images for the period of 1984–2019 have been combined in a single composition, reproducing three maps (TSC, NDVI, and IBI), considering a medium value composition for each pixel. The other 6 maps are generated—2 for each parameter, representing two periods of the actual decade: 2011–2015 and 2016–2019. For the first period (2011–2015), 33 images and the second (2016–2019) 25 images have been used.

4 Results

4.1 Land Use and Pollutant Map

In the land use mapping,[11] the urban areas' high population density has been represented with red. This zone corresponds mainly to the Rio de Janeiro city. Furthermore, it has extended to the other municipalities of the Fluminense Lowlands[12]—São João de Meriti, Nilópolis, Mesquita, Belford Roxo, Nova Iguaçu, Duque de Caxias, and also Niterói, which extends to the neighboring municipality of São Gonçalo (Fig. 5). From each high population density area, the medium and low populational area is settled, as we can see in the west zone in Rio de Janeiro. The green areas are non-urbanized places.

Figure 6 represents the industrial areas, which are in red, the ones with the higher potential polluting area for particulate matter—the zone of energy, petrochemical, and steelmaker industries. Those industries are located mainly in the suburbs, at far from Rio de Janeiro, in metropolitan west (Seropédica) and the east (COMPERJ, Itaboraí), but also the industrial parks of Belford Roxo, São João de Meriti, Duque de Caxias, and Niterói.

As the distance increases from the areas with high potential to produce particulate matter, the colors tend to be more reddish. In green, there are the areas free of industries' influence. For the highways mapping, only the main circulation routes are shown in red (Fig. 7) because they are the significant areas of particulate matter emission. In addition to the highways, an influence area of 200 m off its borders is also considered. The city with the highest highway density is the state capital, Rio de Janeiro. In the past, Rio de Janeiro was also the capital of the country, since it ceased to be, there has been no project of real integration with neighboring municipalities.

[11]The land use map was prepared based on information from the State Environment Institute (INEA) of Rio de Janeiro, in 2007, which is the most updated.

[12]It is a set of cities with similar historical and social characteristics in the MARJ, which are Duque de Caxias, Nova Iguaçu, Nilópolis, São João de Meriti, Mesquita, Queimados, Japeri, and Seropédica.

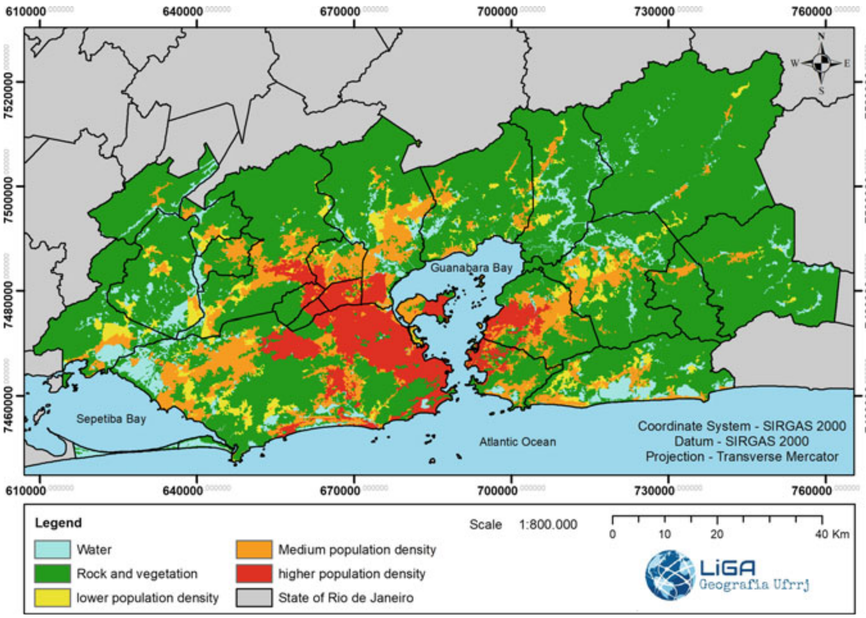


Fig. 5 Areas that liberate atmospheric pollutants—soil use. *Source* Authors

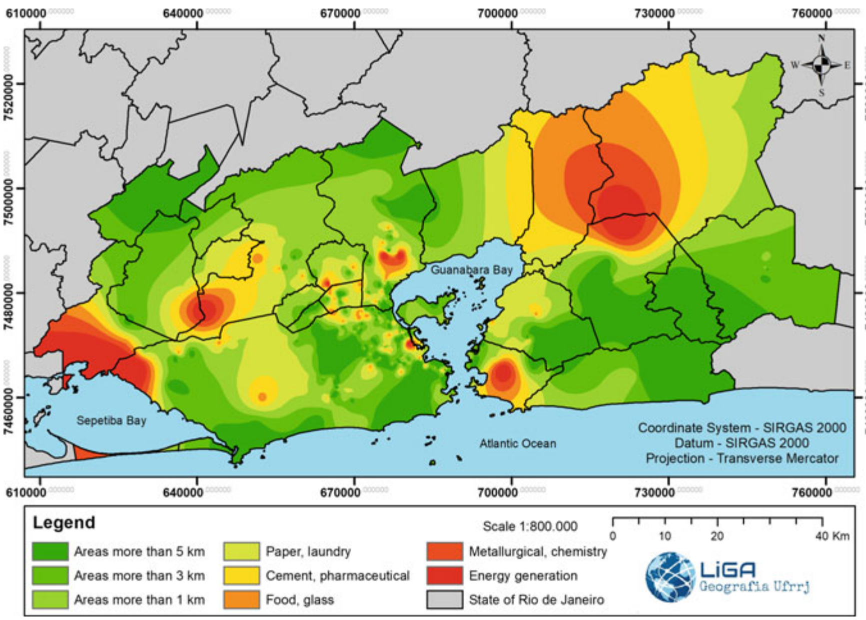


Fig. 6 Areas that liberate atmospheric pollutants—industries. *Source* Authors

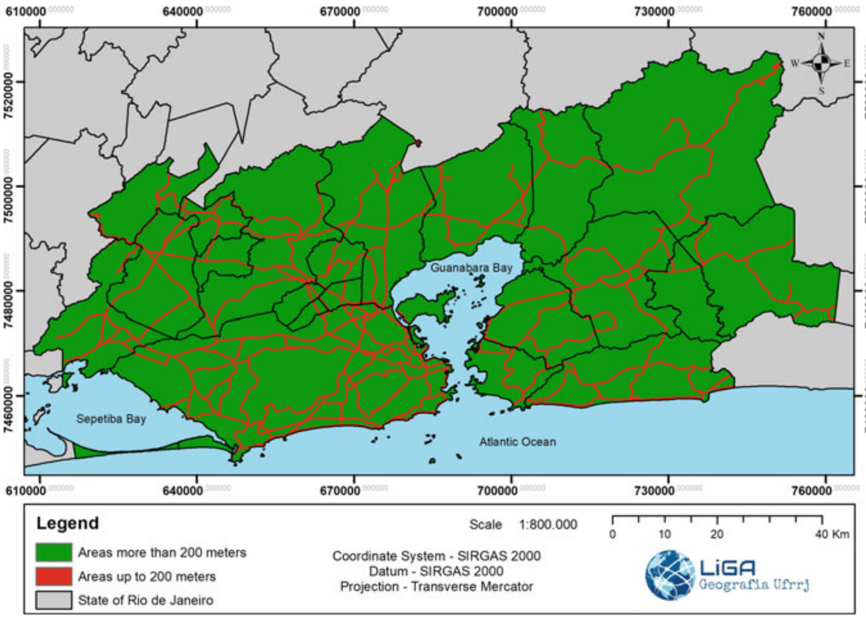


Fig. 7 Areas that liberate atmospheric pollutants—highways. *Source* Authors

In general, all municipalities in MARJ are crossed by at least two major traffic routes. The municipalities with the least roads are furthest from the capital, such as Paracambi, Japeri, Queimados, Guapimirim, and Tanguá. Areas that have no important circulation routes are not considered to emit atmospheric pollutants from vehicles and are represented in green.

For the landscape mapping, lowland areas and hillsides up to 200 m are represented in red to show high potential into concentrated atmospheric pollutants, being places more harmful to populations' health (Fig. 8). Areas above 200 m are represented in green, where pollutant disperse is possible.

For the air basin mapping, the local wind circulation has been considered the main factor in pollutant concentration (Fig. 9). The Air Basin 1 shows more incredible difficulty dispersing the pollutants (red). With less difficulty, but also with problems, there is the Air Basin 3 (orange). The Air Basins 2 and 4 show less difficulty to disperse pollutants (yellow). In green, we have the areas outside the air basins.

The overlay of the five maps (Figs. 5, 6, 7, 8, and 9) could identify the areas with the potential to concentrate pollutants in MARJ (Fig. 10). In the map, it is possible to observe the areas with very high potential to concentrate pollutants (red), which correspond to the routes with greater population density and constructions and in areas with lower population density near to industries in lowland areas. Those areas are mainly located in the north region of Rio de Janeiro, extending through the Brasil Avenue (BR 101) to the west region and the Highway Presidente Dutra (BR

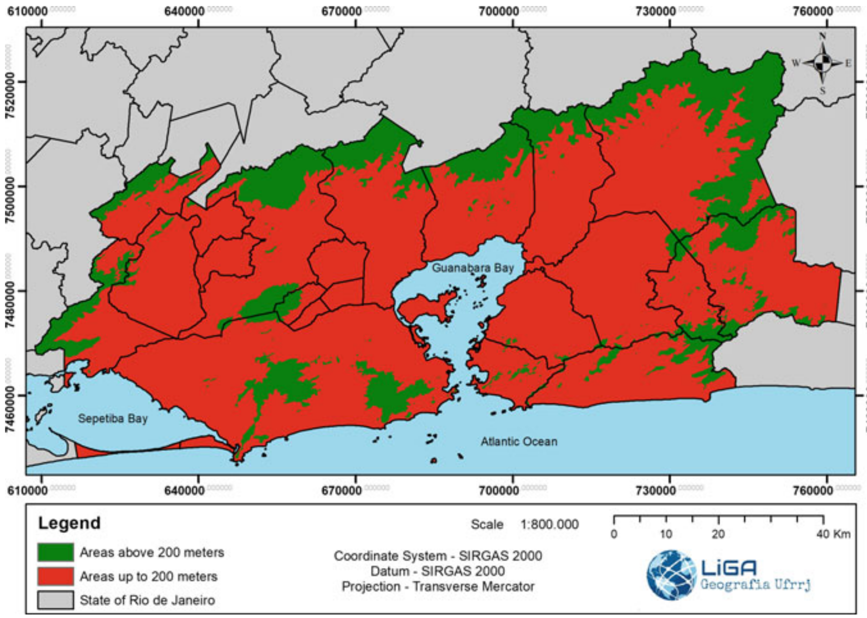


Fig. 8 Areas that accumulate atmospheric pollutants—landscape. *Source* Authors

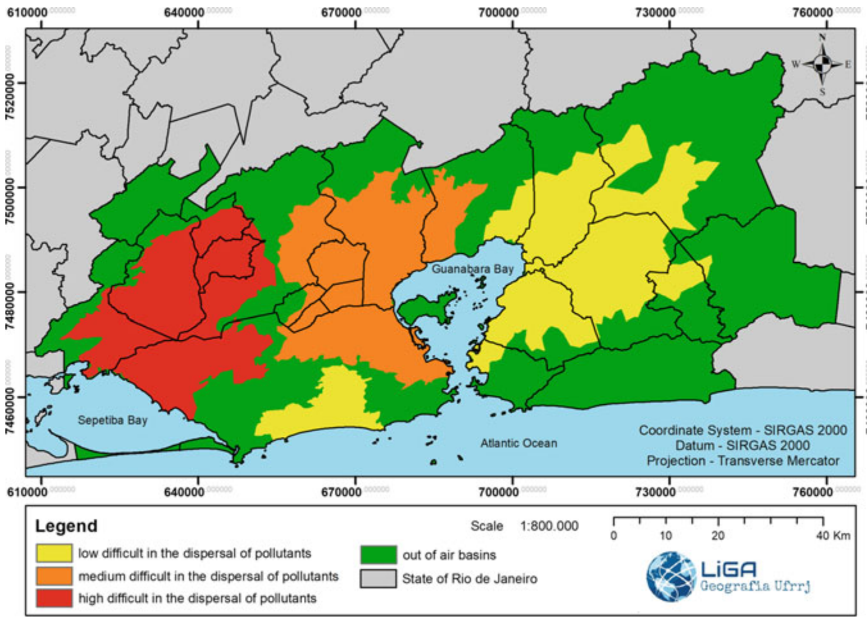


Fig. 9 Areas that accumulate atmospheric pollutants—air basins. *Source* Authors

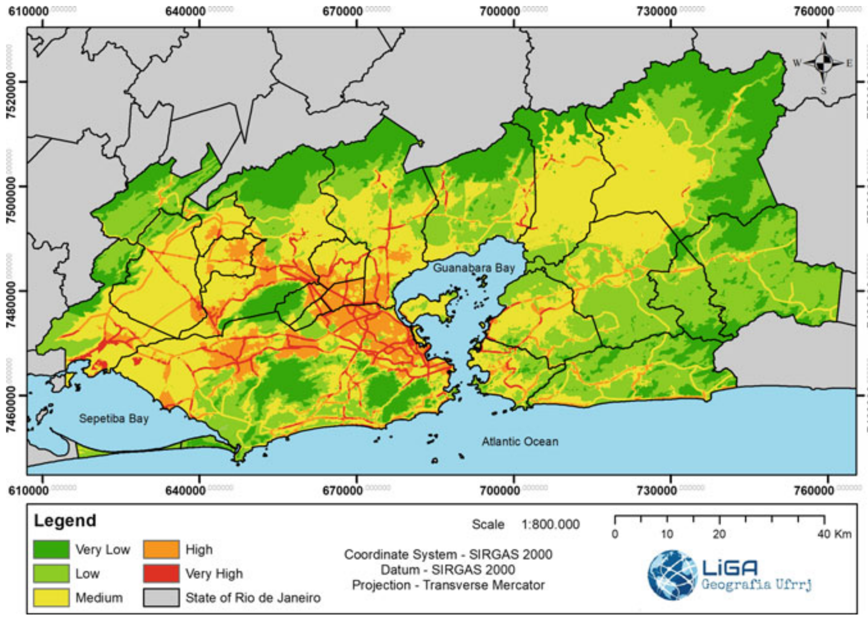


Fig. 10 Areas that liberate and accumulate atmospheric pollutants. *Source* Authors

116) to the Fluminense Lowlands—Duque de Caxias, Belford Roxo, São João de Meriti, Mesquita, Nova Iguaçu, to Itaguaí, where there is a convergence of all highways and flows, to the harbor.

It is observed that there is a high potential to accumulate pollutants in urban areas with a high population density, adjacent to the mentioned highways, and as well on the highways themselves when they cross less dense urban areas of the metropolis. These areas are Seropédica, Queimados, Japeri, Nilópolis, Magé, Guapimirim, São Gonçalo, and Niterói. In the metropolitan west, only in Paracambi, there are no areas with very high potential to concentrate pollutants. In the metropolitan east, Maricá, Tanguá, and Rio Bonito are the ones with a low probability of concentration. That behavior of low concentration can also be observed in municipalities with less vegetated areas, high values related to the landscape, and without the presence of industries.

4.2 LST Mapping

Considering the LST map for the years 1984–2019 (Fig. 11), the higher heat spaces are focused in the central metropolitan portion (colors: red and orange) at Guanabara Bay's east and west borders. Those heat spaces can be considered as primary, with temperatures around 32–41 °C or above, and are the hot spot of the

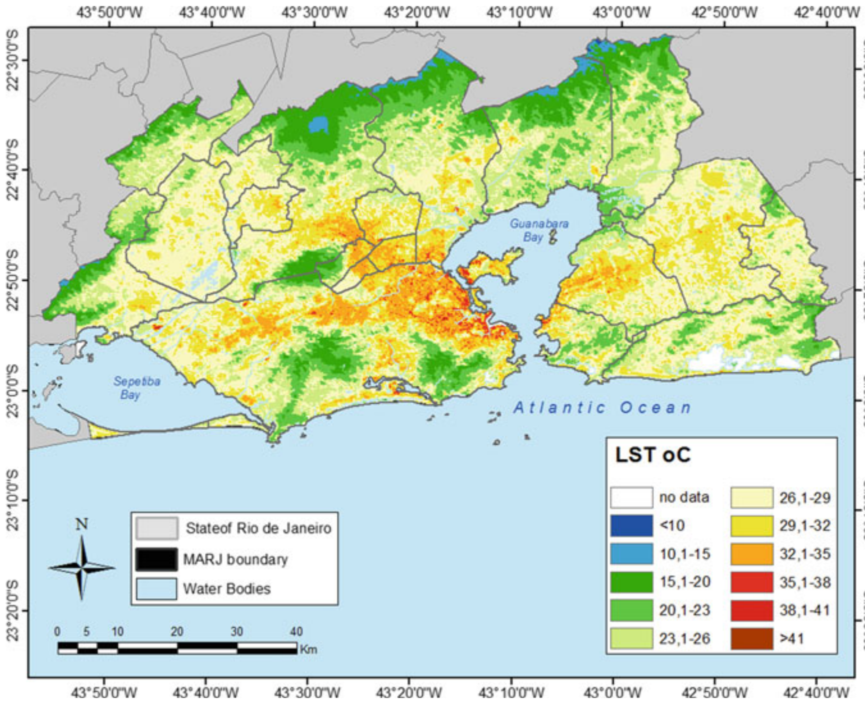


Fig. 11 LST map by MARJ (1984–2019). *Source* Authors

UHI over MARJ. The cities that are this area of influence are Rio de Janeiro, São João de Meriti, Nova Iguaçu, Duque de Caxias, Mesquita, Nilópolis (in the central west), and Niterói and São Gonçalo (east).

In Rio de Janeiro, those primary heat spaces are located in Guanabara Lowland. It includes the northern region neighborhoods, a very well-urbanized area, with a horizontal nature and suburban characteristic, covering many slums.[13] The Guanabara Bay is responsible for the urban expansion in the city of Rio de Janeiro, which follows in direction to the surrounding cities, like São João de Meriti, Nova Iguaçu, Duque de Caxias, Mesquita, and Nilópolis, which also correspond to the Fluminense Lowlands. The primary heat spaces are also observed toward west, near the lowlands of Jacarepaguá and Bangu, constrained by the Tijuca and Pedra Branca Massifs, and Pedra Branca and Mendanha Massifs, respectively, representing a recent occupational area in the city of Rio de Janeiro. It integrates with the cities of Seropédica, Itaguai, and Nova Iguaçu, called "the metropolitan west."

[13]Slums are a habitation space very popular, especially in the suburbs of the Latin American cities. They can be defined as areas with inefficient infrastructure in pavement and basic sanitation, with low educational levels, precarious health conditions, and high rates of crime and social marginalization.

Tijuca Massif reaches the central area, the south and north zones of the city of Rio de Janeiro, and the massifs of Pedra Branca and Mendanha placed in the west zone. The three massifs act like a barrier to urban expansion and organization, also disposing of the urbanization of other cities, contiguous to the urban city of Rio de Janeiro.

Secondary spaces are shown in yellow color, with LST around 26–32 °C, which covers the entire east, west, and north of MARJ. Those secondary spaces can be classified as a second hot spot of the UHI. Those areas merge the classical urban usage with rural or natural spaces.

Lastly, the third group of the heat spaces in MARJ is represented by the values lower than 26 °C, shown with green and blue color sheds. This zone covers the naturals or low urban density areas of MARJ. The third zone has appeared in the three coastal massifs (Tijuca, Pedra Branca, and Mendanha), the Serra dos Órgãos hills (Mar Mountains), and the small hill's vegetation and parks or conservation units. Those areas work as an excellent freshness passage in MARJ, softening the urban spaces' high temperatures. This third zone can be termed as urban cool island (UCI).

The maps display the actual situation for the periods 2011–2015 (Fig. 12) and 2016–2019 (Fig. 13). They replicate LST's spatial pattern for the entire period; however, LST's spatial pattern is amplified in the primary spaces of heat island and reduced for the second and third.

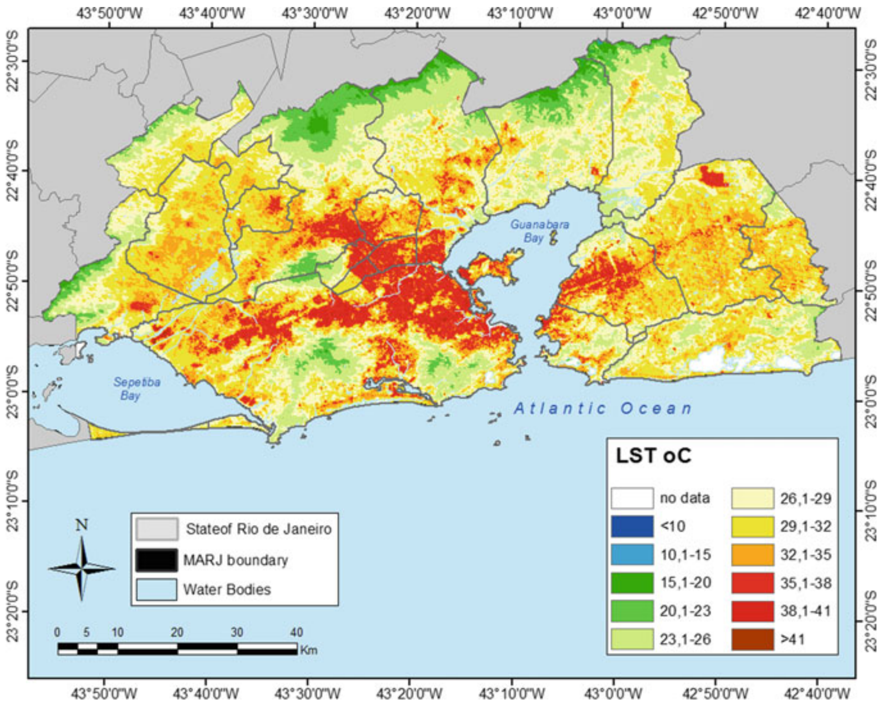


Fig. 12 LST map of MARJ (2011–2015). *Source* Authors

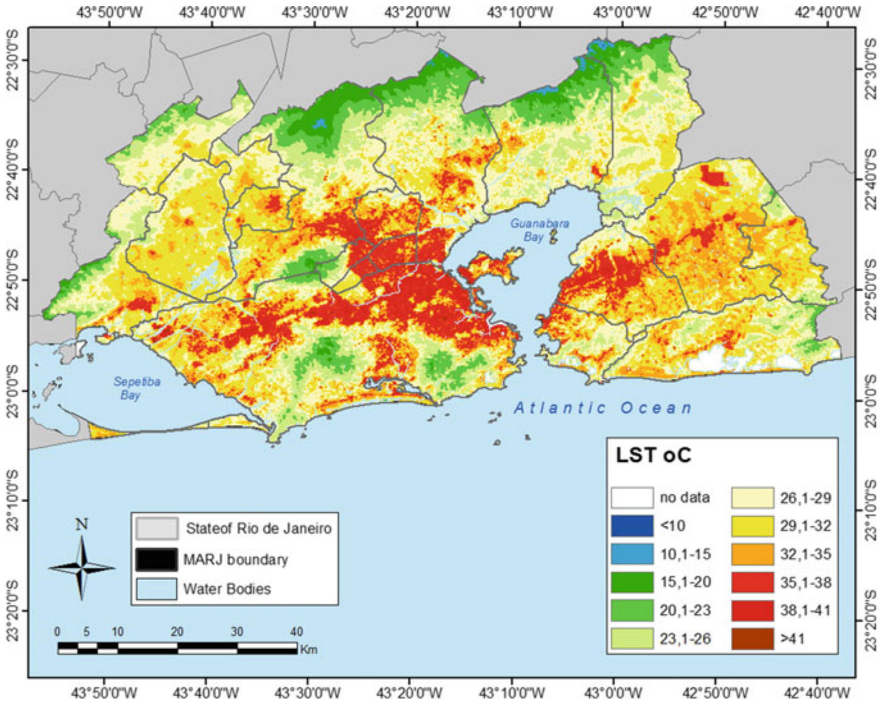


Fig. 13 LST map of MARJ (2016–2019). *Source* Authors

The first spaces of heat island evolve toward east, west, and north embracing the west zone, the Fluminense Lowlands and the east portion (Niterói and São Gonçalo) Maricá and Tanguá, now experience a rise in the heat group. It is essential to mention the role of the highways and the new industrial enterprises[14] from the actual century, related to the classification of these new spaces of heat. On the other hand, it is also essential to highlight the role of the natural places such as the coastal massifs (Tijuca, Pedra Branca, and Mendanha), Serra do Mar hills, parks, and conservation units that soften the advance of the heat spaces and restrict the thermal stress. The difference between the primary heat spaces and UCI spaces can reach almost 20 °C.

[14]Highways like BR-101, BR-116, BR-040, and BR-493 and enterprises like Itaguaí Harbor and COMPERJ, in Itaboraí.

4.3 NDVI and IBI Mapping

The IBI maps (Figs. 14, 15, and 16) show that the spatial condition is directly proportional to LST, while NDVI maps (Figs. 17, 18, and 19) show an opposite spatial condition to IBI and LST. Higher values of IBI above zero correlate with the elevated values of LST; the higher values of NDVI correspond to the lower values of IBI and LST.

High values of IBI above zero (red or orange) represent either the highly urbanized spaces or the exposure of soils and outcrops, which elevates the LST. The higher values of NDVI, above 0,50(green), represent more natural spaces, distant of the urban impact.

The three NDVI maps exhibit a very similar spatial pattern, keeping small differences between them. Thus, the NDVI map shows lower values between 0 and 0,30 (red and orange) in the most urbanized metropolitan core. The highest values of NDVI are above 0,50 (green), which is found concentrated in the UCI regions.

The three IBI maps present relatively higher values above zero for large areas, especially during 2011–2015 (Fig. 15). In addition to the metropolitan core, the urbanized and large suburban areas in the far west, east, and north are also stained with IBI values above zero. This fact can be explained by the composition of the

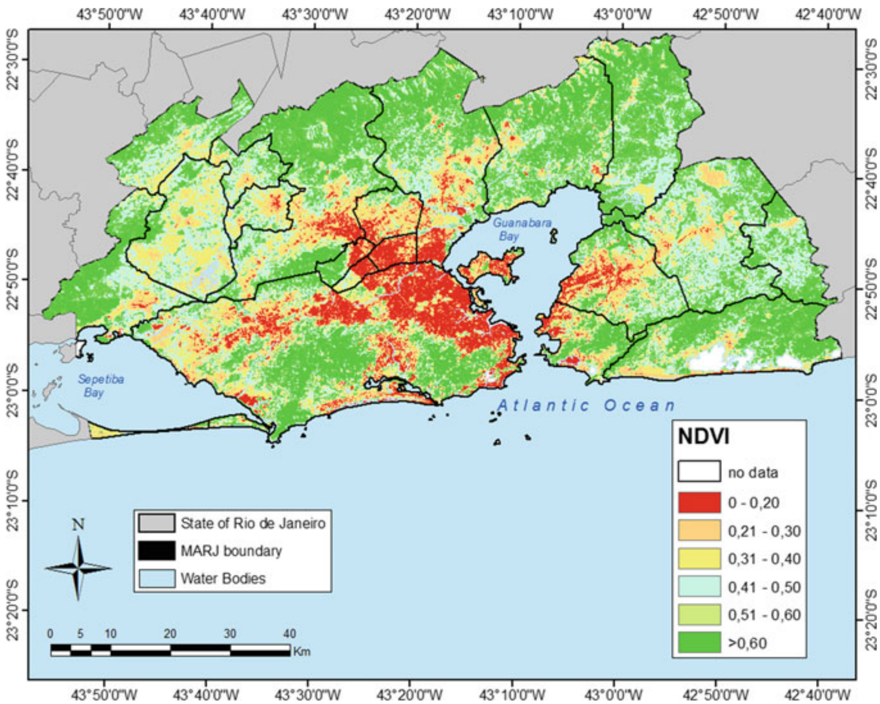


Fig. 14 IBI map of MARJ (1984–2019). *Source* Authors

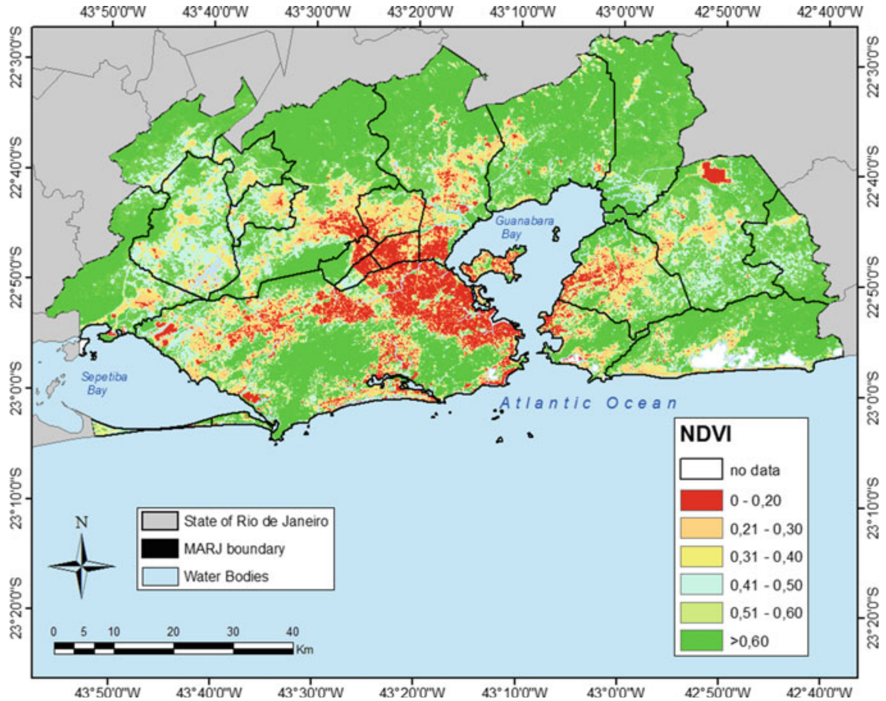


Fig. 15 IBI map of MARJ (2011–2015). *Source* Authors

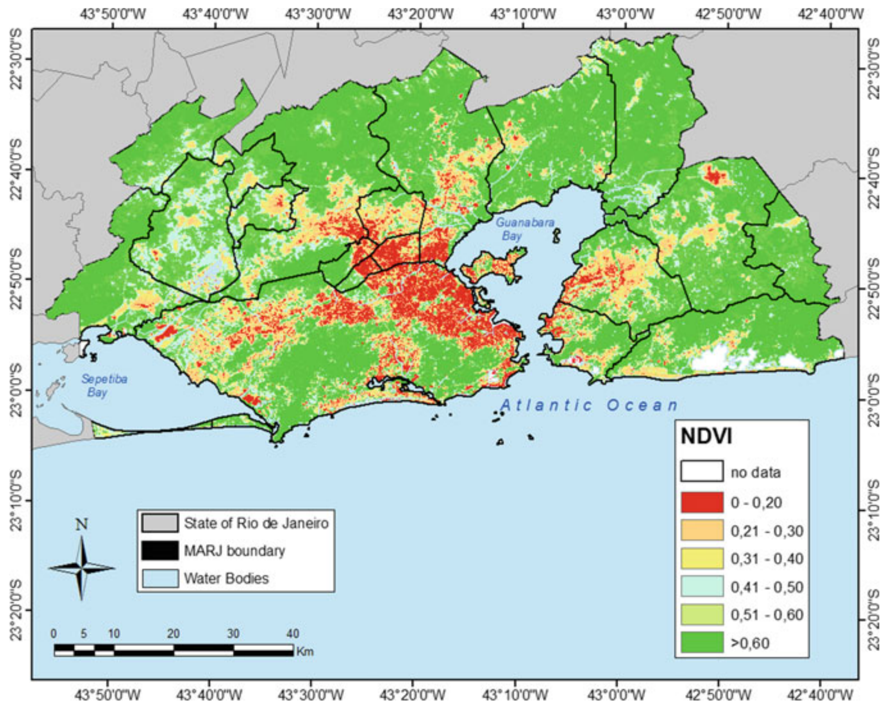


Fig. 16 IBI map of MARJ (2016–2019). *Source* Authors

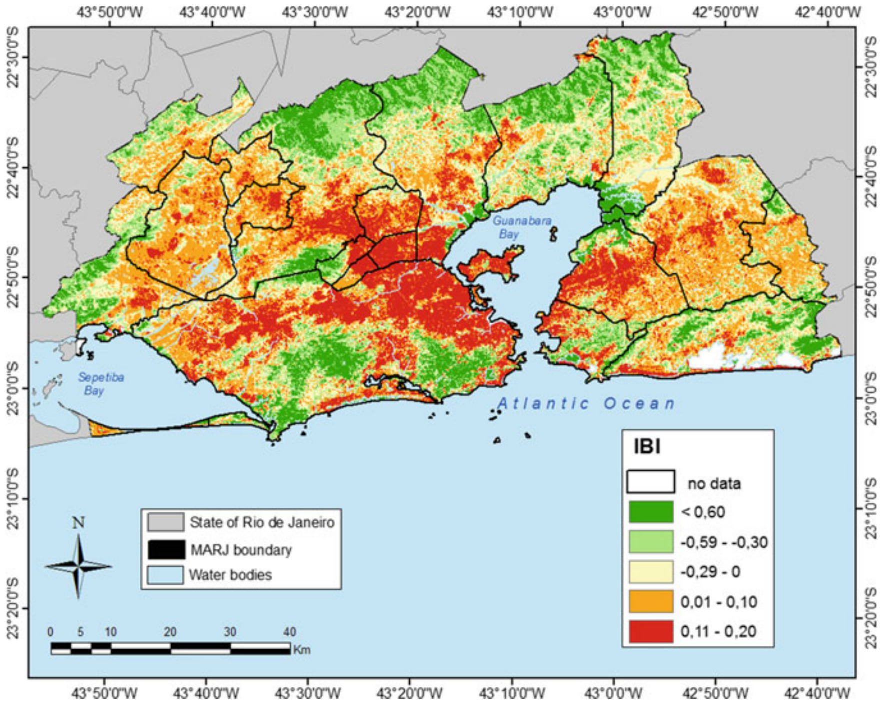


Fig. 17 NDVI map of MARJ (1984–2019). *Source* Authors

index equation. It takes into account not only the construction area (the NDBI) but the vegetation and urban water (NDVI and MNDWI, respectively). Thus, the negative values of IBI are restricted to large vegetated areas of the mountains, protected areas, and urban parks.

5 Conclusions

MARJ is a favorable space to several environmental problems and conflicts, among which air pollution and the urban heat island are at the forefront. The consolidated urban areas of MARJ are the "eye" of air pollution and UHI. MARJ is a complex physical and social metropolitan area and portrays the situation of other metropolitan areas of the world, especially in the southern hemisphere, such as Latin America and Africa.

In this work, areas with a high potential to concentrate pollutants correspond to roads with a high flow of vehicles, located in urban areas or close to very polluting industries and lowland areas. On the other hand, in areas with a higher incidence of

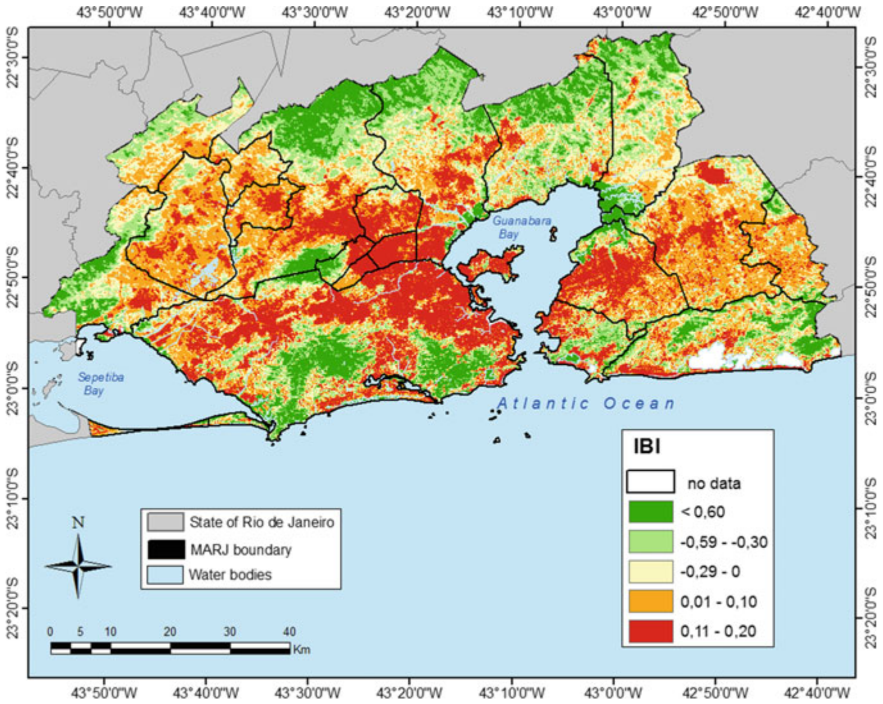


Fig. 18 NDVI map of MARJ (2011–2015). *Source* Authors

vegetated areas, with the rugged landscape, and without the presence of heavy industries, there is a low potential for concentrating pollutants.

Urban areas with high population density and built area are the warmest and converge to the urban heat island, with high LST values. The NDVI and IBI indexes support this scenario since high IBI and low NDVI values corroborate with high LST values. In contrast, low IBI values and high NDVI values agree with low LST values, which converge to the urban cool island. We also observe that the spaces with difficulties in dispersing pollutants are more significant indications of urban heat island (low NDVI, high IBI, high TSC, and denser road network), which corresponds to the Air Basins 1 and 3. Although the Air Basin 4 region also has a high IBI to the east of Guanabara Bay (in the city of São Gonçalo), there is a high presence of vegetation, which mitigates the effects of UHI.

The urban heat island in the suburbs or semi-suburbs, as is the case of MARJ in Brazil, presents a spatial pattern where the core of the urban heat island is not exclusive to its central area and does not decrease toward the suburb as is the classic cases in North American and European cities. Urban or semi-urban uses in developing countries are mixed and undefined, making it challenging to classify land use itself, and determine a polynucleated spread of hot spots, as identified in this work for MARJ. This is a characteristic of the southern hemisphere countries,

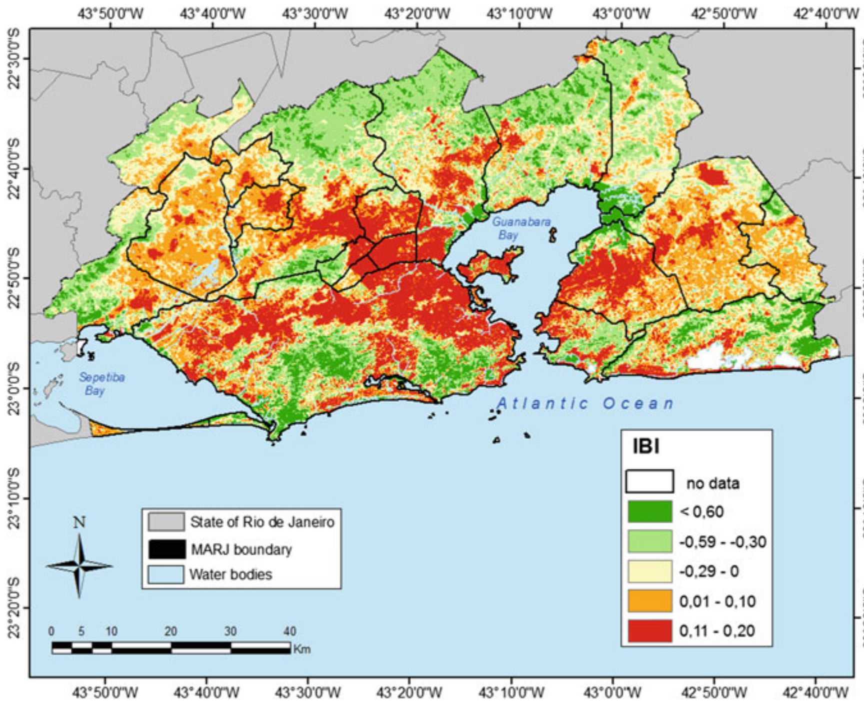


Fig. 19 NDVI map of MARJ (2016–2019). *Source* Authors

which, in their majority, carry particularities in the genesis, organization, and disposition of cities, attributing other conclusions to these regions. Given the scope and spatial complexity of these countries, such as Brazil, with metropolitan areas like the size of Rio de Janeiro, there is an urgent need for a redefinition more appropriate for the phenomenon of the urban heat island to its socio-environmental reality, then named as metropolitan heat island (MHI) (Lucena 2013).

With the advance of the focuses on atmospheric pollution and the metropolitan heat island to other areas of the MARJ, development policies should focus on the metropolitan west, the Fluminense Lowlands, and the far east, which are the areas of current urban expansion, and these are the targeted areas of the new fronts of space interventions, whether industrial, logistics, or related to real estate. It is recommended to remodel the urban development of MARJ with sustainable policies that ensure the control of atmospheric pollution and the metropolitan heat island. Some actions, such as installing green spaces and the rational use of collective transport, are mitigation measures capable of controlling the adverse effects of air pollution and the metropolitan heat island over MARJ.

References

Amanollahi J, Tzanis C, Ramli Mf et al (2016) Urban heat evolution in a tropical area utilizing Landsat imagery. Atmos Res 167:175–182

Arnfield AJ (2003) Two decades of urban climate research: a review of turbulence, exchanges of energy and water and the urban heat island. Int J Climatol 23:1–26

Borja-Aburto VH, Loomis DP, Bangdiwala SL et al (1997) Ozone, suspended particulates, and daily mortality in Mexico City. Am J Epidemiol 145:258–268

Braga AL, Conceição GM, Pereira LA et al (1999) Air pollution and pediatric respiratory hospital admissions in São Paulo, Brazil. J Environ Med 1:95–102

Chander G, Bl Markham, Dl Helder (2009) Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. Remote Sens Environ 113:893–903

Changnon SA, Kunkel KE, Reinke BC (1996) Impacts and responses to the 1995 heat wave: a call to action. Bull Am Meteor Soc 77:1497–1505

Chen H, Kwong JC, Copes R et al (2017) Exposure to ambient air pollution and the incidence of dementia: Apopulation-based cohort study. Environ Int 108:271–277

Chiesa A, Westphal M, Akerman M (2008) Doenças respiratórias agudas: um estudo das desigualdades em saúde. Cad. Saúde Pública, Rio de Janeiro, vol 24(1), pp 55–69 (in Portuguese)

Cifuentes LA, Veja J, Kopfer K et al (2000) Effect of the fine fraction of particulate matter versus the coarse mass and other pollutants on daily mortality in Santiago, Chile. J Air Waste Manag Assoc 50:1287–1298

Clancy L, Goodman P, Sinclair H et al (2002) Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. Lancet 360(9341):1210–1214 (Oxford)

Daumas RP, Mendonça GAS, Leon AP (2004) Poluição do ar e mortalidade em idosos no município do Rio de Janeiro: análise de série temporal. Cadernos de Saúde Pública, Rio de Janeiro, vol 20, pp 311–319 (in Portuguese)

Dockery DW, Pope CA III (1994) Acute respiratory effects of particulate air pollution. Rev Public Health 15:107–132

Farias HS (2013) Bacias aéreas: uma proposta metodológica para o estudo da qualidade do ar em áreas influenciadas pelo relevo. Revista Brasileira de Climatologia, vol 12(9), pp 48–60 (in Portuguese)

Franca GB, Cracknell AP (1995) A simple cloud masking approach using NOAA AVHRR daytime data for tropical areas. Int J Remote Sens 16:1697–1705

Freitas C, Bremner SA, Gouveia N et al (2004) Internações e óbitos e sua relação com a poluição atmosférica em São Paulo, 1993 a 1997. Revista de Saúde Pública, São Paulo 38(6):751–757 (in Portuguese)

Gervois M, Dubois G, Gervois S et al (1977) Pollution atmosphérique deniveau modéré et affections respiratoires d'origine banale. Enquête de Demain - Quiévrechain (Nord.). Revue d'Epidemiologie et de Santé Publique 25:195–207 (in French)

Gouveia N, Fletcher T (2000a) Respiratory diseases in children and outdoor air pollution in Sao Paulo, Brazil: a time series analysis. Occup Environ Med 57:477–483

Gouveia N, Fletcher T (2000b) Time series analysis of air pollution and mortality: effects by cause, age and socioeconomic status. J Epidemiol Community Health 54:750–755

Gouveia N, Freitas CU, Martins LC et al (2006) Hospitalizações por causas respiratórias e cardiovasculares associadas à contaminação atmosférica no Município de São Paulo, Brasil. Cadernos de Saúde Pública, Rio de Janeiro 22(12):2669–2677 (in Portuguese)

Gregório LS (2011) Risco ambiental à saúde humana: um estudo aplicado aos efeitos da poluição atmosférica no Estado do Rio de Janeiro. Dissertação, Universidade Federal do Rio de Janeiro, Rio de Janeiro (in Portuguese)

Gusmão PP (2010) Vulnerabilidade das Megacidades Brasileiras às Mudanças Climáticas: Região Metropolitana do Rio de Janeiro. In: Nobre, C. and Hogan, D.J., Eds., Projeto Megacidades, Vulnerabilidade e Mudanças Climáticas. INPE/UNICAMP/UFRJ (in Portuguese)

Huete A, Didan K, Miura T et al (2002) Overview of the radiometric and biophysical performance of the MODIS vegetation indices. Remote Sens Environ 83:195–213

Inea – Instituto Estadual do Ambiente (2014) Relatório Anual de Qualidade do Ar do Estado do Rio de Janeiro. Rio de Janeiro: INEA, 108p (in Portuguese)

Jacobson BS (1984) The role of air pollution and other factors in local variations in general mortality and cancer mortality. Arch Environ Health 3:306–313

Kanda M (2006) Progress in the scale modeling of urban climate: review. Theor Appl Climatol 84:23–33

Konopacki S, Akbari H (2002) Energy savings for heat island reduction strategies in Chicago and Houston (including updates for Baton Rouge, Sacramento, and Salt Lake City). Draft Final Report, LBNL-49638, University of California, Berkeley

Levy D, Gent M, Newhouse MT (1977) Relationship between acute respiratory illness air pollution levels in an industrial city. Am Rev Respiratory Dis 116:167–173

Lougeay R, Brazel A, Hubble M (1996) Monitoring intra-urban temperature patterns and associated land cover in Phoenix, Arizona using Landsat thermal data. Geocarto Int 11:79–89

Lucena AJ (2013) A ilha de calor na região metropolitana do Rio de Janeiro. Thesis, Universidade Federal do Rio de Janeiro (in Portuguese)

Lucena AJ, Rotunno Filho OC, Peres LF et al (2013) Algorithms implementation for land surface temperature estimation based on Landsat data as an indicator of urban heat island. In: Joint urban remote sensing event (JURSE). IEEE, pp 262–266

Mazumdar S, Sussman N (1983) Relationships of air pollution to health: results from the Pittsburgh study. Arch Environ Health 38:17–24

Monteiro CAF (2003) Teoria e Clima Urbano. In: MONTEIRO, Carlos Augusto Figueiredo; MENDONÇA, Francisco. Clima Urbano. São Paulo: Contexto, pp 9–67 (in Portuguese)

Oke TR, Mills G, Christen A et al (2017) Urban climates. Cambridge University Press, London

Oliveira FJG, Oliveira LD (2020) Espaço metropolitano, regionalização da economia e reestruturação produtiva no estado do Rio de Janeiro, Brasil. Cuyonomics. Investigaciones en Economía Regional 3(5) (in Spanish)

Oliveira-Júnior JF, Terassi PMB, Gois G (2017) Estudo da circulação dos ventos na Baía de Guanabara/RJ, entre 2003 e 2013. Revista Brasileira de Climatologia 21(13):59–80 (in Portuguese)

Ostro B, Sanchez JM, Aranda C et al (1996) Air pollution and mortality: results from a study of Santiago, Chile. J Expo Anal Environ Epidemiol 6:97–114

Peres LF, Lucena AJ, Rotunno Filho OC et al (2018) The urban heat island in Rio de Janeiro, Brazil, in the last 30 years using remote sensing data. Int J Appl Earth Obs Geoinf 64:104–116

Qin Z, Karnieli A, Berliner P (2001) A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. Int J Remote Sens 22(18):3719–3746

Rizwan AM, Dennis YC, Leung LC et al (2008) A review on the generation, determination and mitigation of Urban Heat Island. J Environ Sci 20:120–128

Rouse JWJR, Haas RH, Deering DW et al (1974) Monitoring the Vernal Advancement and retrogradation (Green Wave Effect) of Natural vegetation. NASA/GSFC. Type III Final Report, Greenbelt, MD

Saldiva PH, Pope CA, Schwartz J et al (1995) Air pollution and mortality in elderly people: a time-series study in Sao Paulo, Brazil. Arch Environ Health 50:159–163

Santamouris M, Paraponiaris K, Mihalakakou G (2007) Estimating the ecological footprint of the heat island effect over Athens, Greece. Clim Change 80:265–276

Schimmel H, Murawski TJ (1976) The relation of air pollution to mortality. J Occup Med 18:316–333

Souza GM, Sant'anna Neto JL (2009) Geografia da saúde climatologia médica: ensaios sobre a relação clima e vulnerabilidade. Revista Brasileira de Geografia Médica e da Saúde, Uberlândia, Hygeia (in Portuguese)
Souza JD, Silva BB (2005) Correção atmosférica para temperatura da superfície obtida com imagem TM: Landsat 5. Revista Brasileira de Geofísica 23(4):349–358
Souza ML (2000) O desafio metropolitano: um estudo sobre a problemática sócio-espacial nas metrópoles brasileiras. Bertrand Brasil, Rio de Janeiro (in Portuguese)
Taha H (1997) Urban climates and heat islands: albedo, evapotranspiration, and anthropogenic heat. Energy Build 25:99–103
Van De Griend AA, Owe M (1993) On the relationship between thermal emissivity and the normalized difference vegetation index for natural surfaces. Int J Remote Sens 14:1119–1131
Voogt JA (2002) Urban Heat Island, Causes and consequences of global environmental change. Encycl Global Environ Change 3:660–666
Voogt JA, Oke TR (2003) Thermal remote sensing of urban climates. Remote Sens Environ 86:370–384
Xu H (2008) A new index for delineating built-up land features in satellite imagery. Int J Remote Sens 29(14):4269–4276

Heitor Soares de Farias is graduated in geography from the Federal University of Rio de Janeiro, UFRJ (2004), master in geography from the UFRJ (2007) and PhD in geography from the Federal Fluminense University (2012). Since 2013, he teaches in higher education and is currently Adjunct Professor in geography at undergraduate and graduate courses in at the Federal Rural University of Rio de Janeiro (UFRRJ). He works with environmental planning based on geographical climatology, researching the health risk associated with climatic phenomena, such as islands of heat, rains, and air pollution, mainly. He coordinates the Integrated Laboratory of Applied Physical Geography (LIGA)/UFRRJ, ORCID: https://orcid.org/0000-0003-3585-5028.

Dr. Andrews José de Lucena is Adjunct Professor, Federal Rural University of Rio de Janeiro, Brazil. He has completed his master in geography from the State University of Rio de Janeiro and holds a PhD in atmospheric sciences from the Alberto Luiz Coimbra Postgraduate Institute and Engineering Research (COPPE/UFRJ). His research interest is chiefly concerned with the urban climate and its research methods, climate change, and environment. He participated and integrated research projects with several professionals and institutions in the areas of climatology and urban meteorology, atmospheric hydrological modeling, remote sensing in urban areas, and urban development in the Metropolitan Region of Rio de Janeiro. He coordinates the Integrated Laboratory of Applied Physical Geography (LIGA/UFRRJ) and integrates the Environmental Satellite Applications Laboratory of the Meteorology Department (LASA/UFRJ). He manages the Web site www.climatologia.com.br with information about land surface temperature (LST) of the Metropolitan Area of Rio de Janeiro from 1984 to the present.

Vitor Fonseca Vieira Vasconcelos de Miranda is graduated in mathematics and earth sciences with the specialization in remote sensing and geoprocessing (2017) and master in meteorology (2020), both from Federal University of Rio de Janeiro (UFRJ). Since 2014, he works with remote sensing of the land and the atmosphere, where he has major interests in biosphere–atmosphere interactions, with emphasis to land surface models (LSMs), radiative transfer models (RTMs), environmental changes in natural surfaces (urban heat island effect), and extreme events (such as droughts and heat waves).

Assessment of Climatic Guidelines and Urban Planning in North-Eastern Coast of Brazil

Max Anjos, António Lopes, Elis Alves, Ezequiel Correia, and Francisco Mendonça

1 Introduction

The climate services approach provides an important perspective to debate the climate applicability into the planning process and healthy growth of cities. The climate services are defined as:

> The transformation of climate-related data – together with other relevant information – into customized products such as projections, forecasts, information, trends, economic analyses, assessments (including technology assessments), counseling on best practices, development, and evaluation of solutions, and any other service in relation to climate that may be of use for the society at large (European Commission: Directorate-General for Research and Innovation 2015).

As such, the climate information must be accessible and easily understandable by non-specialists (Street 2016). Planners and policymakers have considered the

---

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the publisher or author concerning the legal status of any country, area or territory or of its authorities or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents and databases in this chapter are not warranted to be error free, nor do they necessarily imply official endorsement or acceptance by the publisher or author.

M. Anjos (✉) · F. Mendonça
Laboratory of Climatology (LABOCLIMA), Federal University of Paraná (UFPR), Curitiba, Brazil
e-mail: maxanjos@campus.ul.pt

A. Lopes · E. Correia
Centre of Geographical Studies, Institute of Geography and Spatial Planning (IGOT), Universidade de Lisboa, Lisbon, Portugal

E. Alves
Instituto Federal de Educação, Ciência E Tecnologia Goiano, Ceres, Brazil

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_9

impact of the urbanization on the local climate conditions sduring the planning process. There are some successful climate-planned projects (Bitan 1992; Monteiro and Mendonça 2005; Alcoforado and Andrade 2005; Ng 2009) showing the important role played by the climate to get liveable and sustainable cities.

Cities are warmer than surrounding rural areas due to the Urban Heat Island (UHI) phenomenon (Oke et al. 2017). The UHI effects on human comfort and health are amplified under severe weather conditions (e.g. heatwave), a certain type of climates (e.g. hot and humid) and global warming scenarios. In this view, integrating the UHI effect into the town planning and design could be advantageous to identify the key climatic areas more susceptible to heat stress and helps to preserve ecosystem benefits associated with the local climate. However, the scientific knowledge of the climate, such as the UHI effect, is still insufficiently incorporated into the planning process of south-american cities. There are few climate services related with UHI knowledge, i.e. its translation and tools into the planner's language and needs. Oke (1984) and Monteiro et al. (2015) argued that the planner might consider the work of the urban climatologist irrelevant if he does not understand the nature of the problem and, consequently, has no affinity with it. Instead, the climatologist can even ignore the planning process. On the other hand, if the climate information is relevant, but the planner finds it incomprehensible, it implies that he may have a little scientific-climate background. And finally, if the planner recognizes the relevance of climate information to a specific problem but considers it inapplicable, this suggests a lack of communication between the planner and the climatologist (Oke 1984; Monteiro 1976). In an interesting study, Eliasson (2000) evaluated how climate knowledge could be integrated into the urban planning process in three Swedish cities. The study showed that urban planners were interested in climate aspects, but the use of climate information was unsystematic and had a low impact on the planning process due to several constraints related to five explanatory variables: concept and knowledge-based, technical, policy, organizational and the market.

In fact, the planner needs geographical and cartographic information. This suggests a need to transfer the local knowledge of the urban climate into accessible and easily mapping tools that are useful to planners and stakeholders to make the right decision in the planning process. The Urban Climatic Maps (UCMaps) raise as a potential mapping tool with spatially characteristic of the urban climate (e.g. UHI behaviour, ventilation patterns and air quality conditions (Ren et al. 2011; Ng and Chao 2015). UCMaps are divided into two types: assessment or climate functions and climatic guidelines. The former shows areas of "special local climates" or "potential climatic response" that are influenced by urban morphology, land use and ventilation conditions, commonly referred to as climatopes (VDI 1988; Scherer et al. 1999). Alcoforado et al. (2005) define climatopes as physically homogeneous areas in terms of urban morphology and topographic position that interact in a particular way with the urban boundary and canopy layer. Therefore, each climatope will have specific local climatic conditions that require specific measures to reduce the negative impacts of climate and take advantage of the positive characteristics from it. After the assessment of the climatopes, they are reorganized as

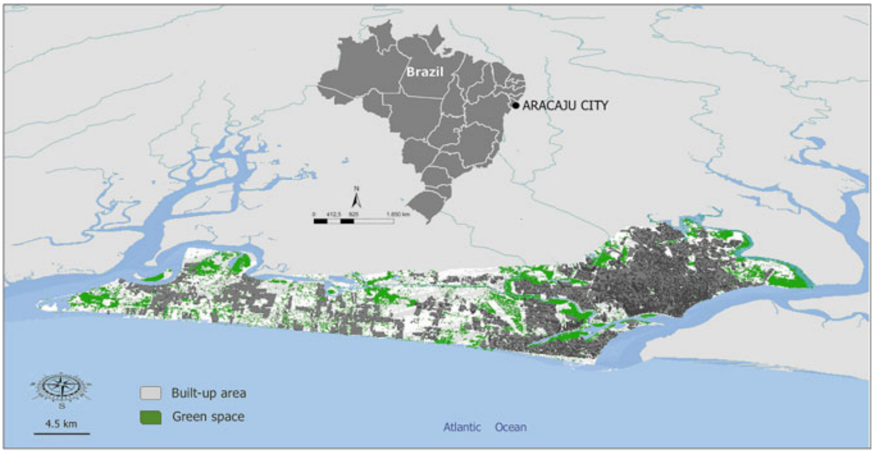


Fig. 1 Geographic location of Aracaju in Brazil. *Source* By the authors, 2020

coherent planning units, which can be a departure point to conceive climatic guidelines and measures to combat the UHI and improve human comfort and air quality in the city.

The development of UCMaps has been conducted in cities located in different latitudes such as in the tropical zone: Salvador, Brazil and Hong Kong, China; at middle latitudes: Berlin, German, Birmingham, UK and Lisbon, Portugal; and at high latitudes: Gothenburg, Sweden and Arnhem, Holland (Ng and Chao 2015).

In coastal cities of north-eastern Brazil (up to 15° latitude south), which includes hot summers and cool winters with an annual mean temperature around 27.0 °C, the UHI has great relevance to human activities as, when exposed to high temperatures increases the heat stress. Moreover, most Brazilian cities experienced rapid urbanization and population growth that is accompanied by several environmental problems, which becomes UHI effects an important challenge (Mendonça 2015).

This chapter is a local climate action-planning proposal based on UCMap. It presents a set of climatic guidelines to combat UHI effects in Aracaju, a city localized in Sergipe, on the northeast coast of Brazil (10° 51’–11° 07’S, 37°02’–37° 09’W) (Fig. 1), were the UHI intensities can reach up to 7.0 ºC in the compact high-rise built-up areas (Anjos et al. 2017, 2020a; Anjos and Lopes 2017).

2 Elaboration of the UCMaps

The UCMap is developed from the intersection of different information levels related to local geography by using the Geographic Information System (GIS) (Ng and Chao 2015). Such information includes different land use and covers, density and geometry of buildings, previous surface, water bodies, topographic situation, and ventilation patterns. UCMaps theoretically result of the influence that these parameters have on the variation of air temperature, relative humidity, local wind patterns, and air quality.

Figure 2 shows UCMap elaboration and its application to urban planning. Using GIS toolbox ESRI ARCGIS™ 10.6, several urban forms and land cover types are converted into layers with a resolution pixel of 100 × 100 m, and the classification is based on the magnitude of the effects of these physical parameters on the air temperature. For example, a class of positive signal indicates a positive magnitude effect on the air temperature and vice versa. Such magnitudes are based on studies derived from extensive researches carried out on the local climate in the study area. Thus, the UCMap of Aracaju is composed of two main layers, urban morphology and ventilation classes, besides additional information.

2.1 Base Cartographic (Layers)

Urban morphology layer identifies potential areas of high air temperature in the city related to urban surface properties, such as vegetation, impervious surfaces, density building, volume building, height-to-width ratio—H/W (Oke et al. 2017). The urban morphology map is based on two sub-layers: sky view factor and green spaces. The green spaces sublayer shows air temperature reduction areas

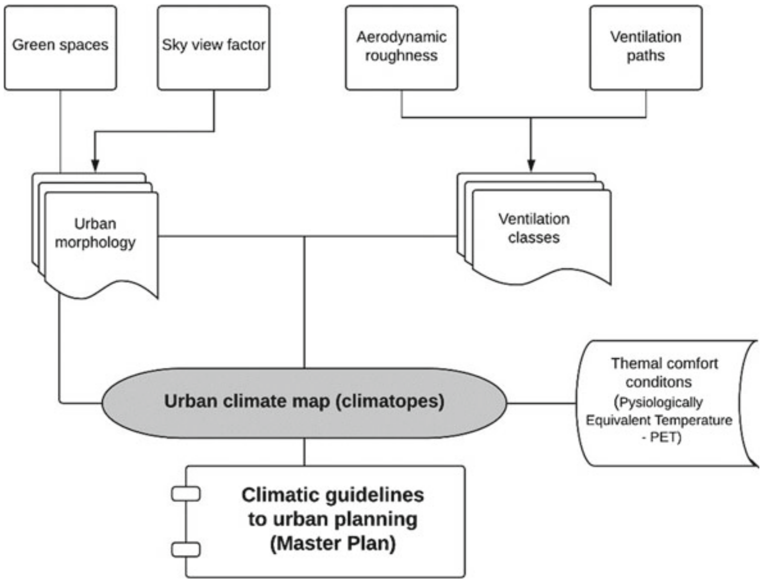


Fig. 2 Methodology for UCMap elaboration in Aracaju. *Source* Adapted from Anjos (2017)

due to the cooling effect as trees alter the energy and hydric balances through the evapotranspiration process and produce changes in the surface solar radiation by shared areas. The cooling tree effect is commonly named as urban cool island (UCI) phenomenon. Anjos and Lopes (2017) reported UCI with an average intensity of −2.0 °C during the day in Aracaju. According to tree canopy density, we mapped the green spaces into three land use and cover classes: dense tree, shrub/grass and no vegetation (Fig. 3a).

Sky view factor (SVF) is defined as the proportion of sky view from a specific point surface and varies from 0 (low) to 1 (high). SVF shows how urban geometry or building density affects the air temperature across the city, so that low SVF is usually associated with large UHI intensity (Chen et al. 2012). The SVF of Aracaju was calculated with the SVF mapping tool that uses 3D building data (Gál and Unger 2014). Anjos (2017) reported that a decrease of 0.5 in the SVF could affect positively thermal anomaly with 1.2 °C during the afternoon in Aracaju. We classifed the SVF values into three classes (Fig. 3b), according to its effect in the air temperature, as follows:

- Low SVF (0–5.0) is associated with the effect of 2.0 °C in the air temperature;
- Medium SVF (>5.0–0.70) with effect of 1.0 °C;
- High SVF (>0.70–1.0) no effect on air temperature.

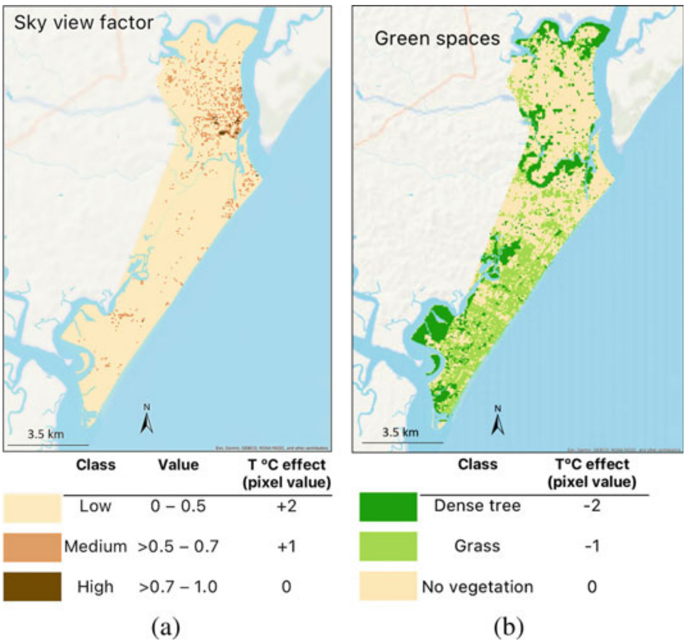


Fig. 3 **a** Green spaces and **b** SFV maps of Aracaju. *Source* Adapted from Anjos (2017)

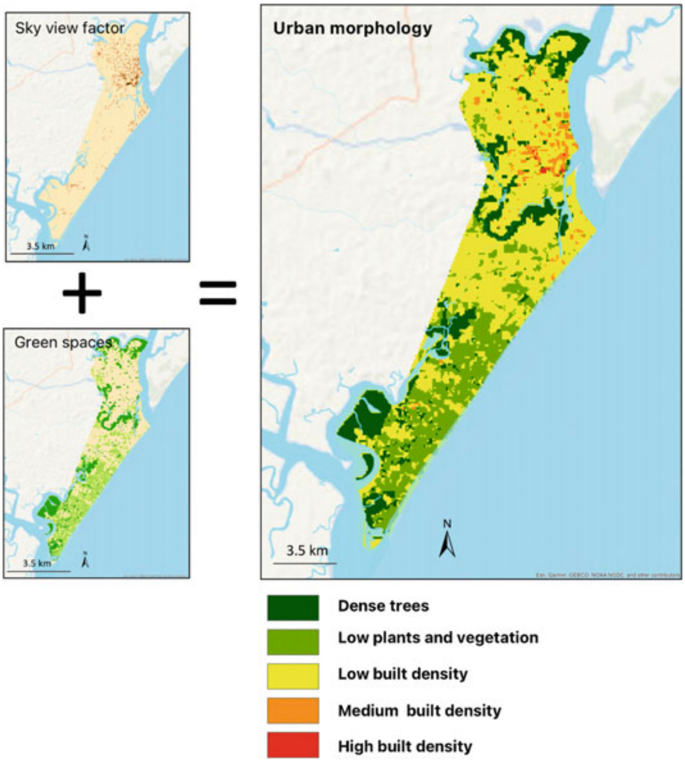


Fig. 4 SFV and green spaces resulting in the map of urban morphology for Aracaju. *Source* By the authors, 2020

Thus, the urban morphology map of Aracaju matched SVF and green space sublayers (Fig. 4).

Ventilation classes layer shows homogeneous areas in terms of air mass exchange, either potential air paths and breezeways or deficient ventilation mechanism. This map combines two sub-layers: aerodynamic surface roughness and ventilation paths. The former refers to the building (and tree) arrangement effect on the reduction of wind velocity at a low level. Aerodynamic roughness length (z_0), zero-plane displacement length (z_d) and mean height of the roughness elements (z_H) are the main parameters used to measure the surface roughness in the unit of metres. The Aracaju roughness information was calculated from 2.5 (LOD 1) building data using roughness mapping tool (Gál and Unger 2009) (Fig. 5a).

The ventilation path sub-layer describes areas perpendicular to the dominant wind direction with a relatively great probability of free-airflow patterns (Fig. 5b). Ventilation paths help mitigate UHI (Wong et al. 2010) and improve air quality by dispersing atmospheric pollutants. Aracaju's wind pattern is characterized by the tropical Atlantic trade winds, which blow predominantly from the east (Anjos and

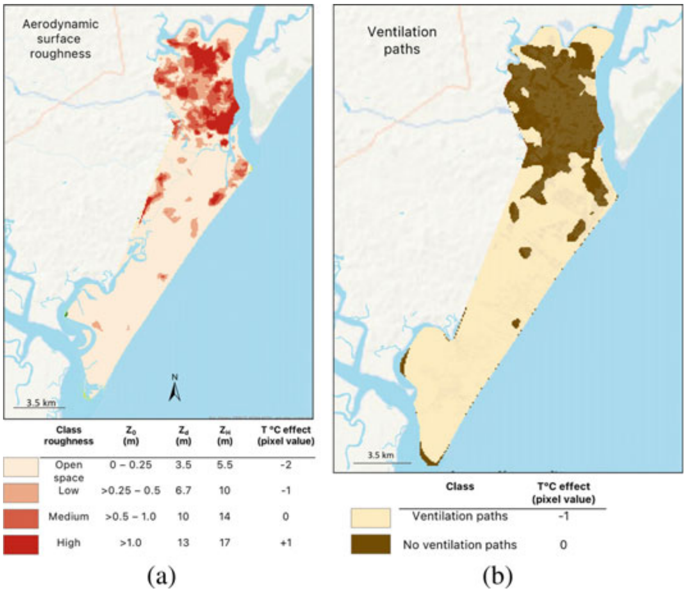


Fig. 5 **a** Aerodynamic surface roughness and **b** ventilation paths maps of Aracaju. *Source* Adapted from Anjos (2017)

Lopes 2019). The main criteria used to define the ventilation paths of Aracaju are as follows (Matzarakis and Mayer 1992; Gál and Unger 2009):

- The value of z_0 should be less than 0.5 m;
- The value of z_d is negligible if less than 3.0 m;
- To select polygon area with a sufficiently large length of 1 × 1 km;
- To select the polygon area with the largest length of 50 × 50 m to the east direction.

The urban ventilation classes map of Aracaju was created overlaying the ventilation paths and aerodynamic surface roughness layers (Fig. 6).

Thermal comfort conditions (additional information) were integrated into the UCMap framework to complete the bioclimatic assessment. For such, we quantified the thermal biometeorological conditions by using the physiologically equivalent temperature (PET). PET expresses the air temperature at which the energy balance of the human body for a typical indoor condition is balanced by the skin temperature, core temperature and sweat rate as equal to the actual outdoor conditions (Höppe 1999). The PET calculation considers in situ microclimatic measurements of the physical environment and human factors (e.g. heat production, clothing, age, activity). Anjos (2017) evaluated the thermal physiological conditions in Aracaju by assessing the PET and applying the multiple regression techniques and grid-based mapping approach. He performed the spatial distribution of PET values and showed that the PET values reached up to 37.5 °C during daytime (Fig. 7). We

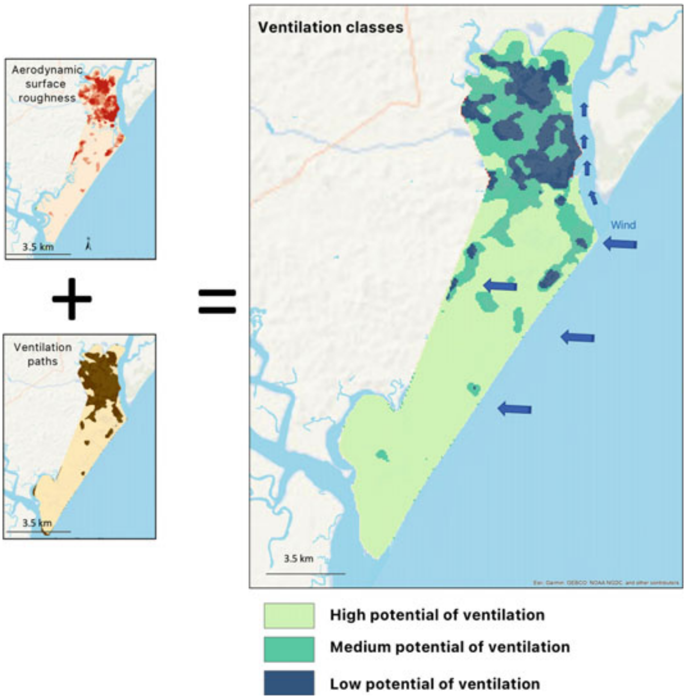


Fig. 6 Aerodynamic surface roughness and ventilation paths resulting in the map of ventilation classes for Aracaju. *Source* By the authors, 2020

extracted the PET >34.0 °C values from the PET map in Fig. 7 to include the thermal heat stress areas in the UCMap. The PET values (>34.0 °C) indicate very hot thermal perceptions with a physiological grade to strong heat stress, proposed by Souza (2010) to a specific group of people in open urban spaces in Salvador, a coastal city of north-eastern Brazil with similar hot and humid conditions to the study area.

Finally, the UCMap of Aracaju was generated combining the urban morphology, ventilation classes, and excess heat areas maps. It consists of a set of climatic units or climatopes in which the planners should pay attention regarding local climate effects, as shown in Fig. 8.

3 Characterization of the Climatopes

Aracaju has a diverse land cover and uses with six different climatopes, as follows:

- **Climatope 1** is characterized by *high-density built-up areas with reduced ventilation potential*, where the heat stress conditions (PET >34.0 °C) and the

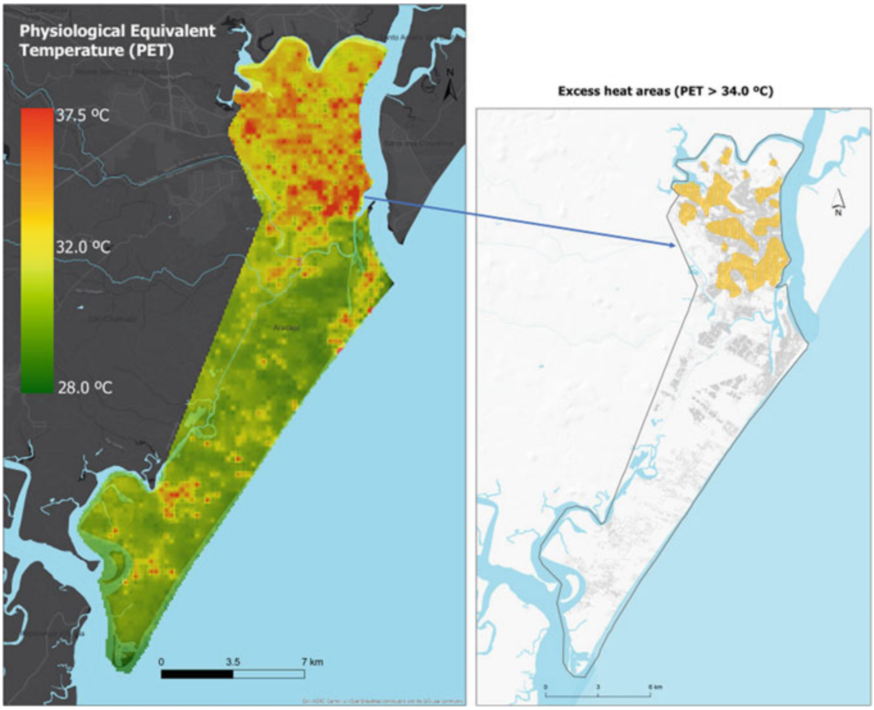


Fig. 7 PET map of Aracaju. *Source* Adapted from Anjos (2017)

reduction in the wind speed are found. The hallmark of climatope 1 includes a great percentage of area covered by impervious surfaces and low vegetation and water bodies. Due to the intense human activities, elevated air pollutant concentration is expected (Anjos et al. 2019).

- **Climatope 2** featured *medium-density built-up areas with moderate ventilation potential*, where are often the situation with heat stress. The reduction in wind speed can occur at certain streets, as well as air pollutant concentration.
- **Climatope 3** describes *low-density built-up areas with moderate and elevated ventilation potential*. Thermal discomfort conditions can occur in open spaces caused by large solar incoming during the daytime, and the high UHI can be found in the large compact low-rise building areas. The presence of the ventilation paths can contribute to relatively low heat stress in some areas along the river. Air pollution production can also be considered on streets with heavy traffic (Anjos et al. 2019).
- **Climatope 4** corresponds to *beach areas with low plants and elevated ventilation potential*. The free-wind pathways can have a certain control over air temperature regimes and ensure pleasant thermal conditions. The artificial heat and air pollutants production are unlikely in climatope 4, thought eventual human activities (e.g, tourism) could produce considerable air pollutants.

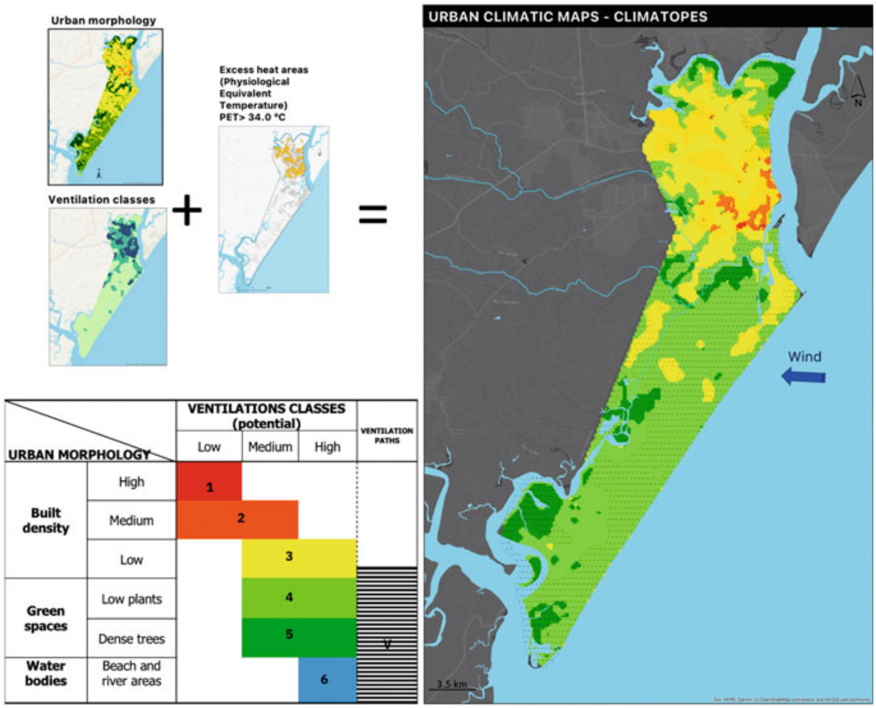


Fig. 8 UCMap and climatopes of Aracaju. *Source* By the authors, 2020

- **Climatope 5** describes *green areas with dense trees*. By the evapotranspiration process and shadowing, the tree plays an important role in reducing air temperatures, so that the thermal comfort sensation experienced by people is expected. Climatope 5 also consists of mangrove ecosystems along the rivers, locally so-called *mangue*, and some patches of Atlantic forest in the urban parks. Other aspects of vegetation, such as improved air quality by filtration of atmospheric pollutants, also mediate the climatic role of this climatope.
- **Climatope 6** describes *water bodies*. They facilitate the transport of cool air from the ocean to the city, reducing the UHI intensity. Moreover, it plays an important role in the protection of several coastal marine ecosystems, such as mangroves.

4 Implications of UCMap for Urban Planning in Tropical Coastal Cities

With the UCMap, urban policymakers have various urbanistic interventions, measures, and strategies available to combat the adverse effects of the UHI and preserve the climate-related ecosystem services, such as mangroves. Each coloured climatope consists of general and specialized guidelines with the potential to be integrated to urban development.

4.1 General Climatic Guidelines: Lessons Learned

The general guidelines to counteract UHI's adverse effects in tropical coastal cities must be based on the urban green spaces, the protection against excessive mean radiative temperature, the improvement of natural ventilation, and the adequate building density.

Green spaces are the most important ecological infrastructure that can reduce air temperature (Reis and Lopes 2019) and include multiple benefits to improve human health and environmental quality (Nowak and Crane 2002). The tree shades and protects against intense solar radiation so that a simple tree can provide thermal comfort conditions in its surroundings in a tropical city (de Abreu-Harbich et al. 2015). A network of green corridors is highly recommended to reduce high UHI intensity. In densely constructed areas, like urban centres with a large proportion of impervious surfaces, planting trees can be a challenge due to the potential disruption of infrastructure, sidewalks and roads (Mills et al. 2015). Note that planners should consider the urban green infrastructure—the type of species, right place, benefits and drawbacks during its implementation. For example, Lopes et al. (2009) demonstrated that trees could fall, putting people and their goods at risk during windstorms. They suggest that the tree species must be carefully chosen, and the planners must take into account their resistance, the capacity to absorbed pollutants and carbon dioxide. Anjos and Lopes (2017) reported that situations of thermal discomfort could occur in open areas found inside the urban park of Aracaju due to high exposure to solar radiation. Vos et al. (2013) showed that roadside urban vegetation can leads to increased pollutant concentrations at least locally due to the trees and other types of vegetation reduce the ventilation. Therefore, considering the benefits and drawbacks of trees in constructing and revitalizing urban spaces during the planning process is desirable. In this view, new actions can be implemented through innovative urban design, in which trees form a part of existing urban elements. For example, instead of permanently placing trees inside a street, they can be placed and replaced using large "green planting boxes" (Mills et al. 2015). Planting tree boxes allow rapid implementation of new urban forest resources and create "mobile" shade areas, improving the local thermal conditions in the surrounded areas. But care must be taken to avoid dense parks in ventilation paths.

An important measure to create and plan thermally pleasing outdoor urban spaces is protection against short- and longwave radiative fluxes, both direct and reflected, to which the human body is exposed (Lin et al. 2011; Abreu et al. 2012). The sum of all these radiative fluxes is named as mean radiant temperature (T_{mrt}). The T_{mrt} effects on heat stress are particularly critical to plan according to the climate of districts. The example in Fig. 9 illustrates a situation in which the T_{mrt} variable is not adequately incorporated into in urban planning. Note that high T_{mrt} not only increases thermal discomfort but also it heats surfaces that may lead to the uselessness of the public structure (e.g. seating) by pedestrians during the most intense sunshine hours. In such cases, shadowing on pedestrian areas is highly recommended, preferably using green structures.

Natural ventilation is a key point to reduce UHI intensities through the advection and transportation of cool air (Berkeley et al. 2001; Ng 2009; Rajagopalan et al. 2014). Thus, the promotion of ventilation paths should be addressed for a good air circulation in the city and preferably accompanied by shade area provided by trees. In waterfront areas, new buildings' distance from each other must be observed to ensure that sea breezes can go inland and positively affect the urban environment. However, a caution word is that the sea breeze of Aracaju develops as a line of clouds parallel to the shoreline called sea breeze front (SBF).

Recently, Anjos et al. (2020a, p. 10) showed that the SBF potentializes heat stress of people of Aracaju during daytime, after being exposed to higher solar radiation and air temperatures. According the authors, this was attributed to "changes in the nebulosity pattern caused by inland penetration of SBF, which created a clear sky region behind the head of the front and a cloudy one ahead of it. These clear sky conditions facilitated the penetration of direct shortwave radiation

Fig. 9 Public seating exposed to multiple daytime radiative fluxes in a district of Aracaju. *Source* Anjos (2017)

onto the urban and rural surfaces". This means that the SBF produces warmer days than the non-SBF days in Aracaju.

Aracaju has different designs and arrangements for buildings and streets. Among many building and design parameters, the height-to-width ratio (H/W) is commonly used to describe the relationship between air temperature and urban canyons. High H/W >1 decreases radiative loss rate in a canyon street, increasing the nocturnal air temperature. Abreu-Harbich et al. (2014) evaluated the relationship between 3D street canyon and thermal comfort conditions in Campinas, Brazil, and showed that the H/W ratio less than 0.5 can reduce daytime PET values. Besides that, they recommend adequate inclusion of trees to promote shade on pedestrian areas and on façades to achieve pleasant thermal conditions. This suggests that H/W ratio ≤ 1 and mainly ≤ 0.5 is recommended to improve the bioclimatic thermal stress of the city dwellers.

4.2 Specialized Climatic Guidelines

Table 1 shows a set of specialized guidelines addressed to each climatope of the UCMap in Fig. 8 in order to improve the bioclimatic thermal conditions of the pedestrian in the outdoor urban spaces.

4.3 UCMaps and Master Plan

This section shows how the specialized climatic guidelines can be used in the Urban Development Master Plan for Aracaju. Master Plan is a dynamic long-term document that includes analysis, recommendations and legislation for various urban development sectors (Amirtahmasebi et al. 2016). For the land use and cover sector, the relationship between UHI and Master Plan has already been addressed in some Brazilian cities as a way to integrate climate knowledge into urban planning, such as Londrina (Anjos et al. 2020b) and São Paulo (Prefeitura de São Paulo 2014).

Aracaju's Master Plan of 2015 defines four urban macro-zones that have similar characteristics in terms of infrastructure, environmental conditions and morphology (Aracaju 2015). The four urban macro-zones are the following: basic settlement zone (BSZ), priority settlement zone (PSZ), controlled settlement zone (CSZ), and restricted settlement zone (RSZ). The climatic guidelines in Table 1 were matched with each macro-zone to evaluate climatic key areas that should be targeted to combat the UHI effects.

Although potential areas for urban development, the BSZ has a deficit in the infrastructure, road system, transportation, commerce and services (Fig. 10). Based on the bioclimatic assessment of the UCMap in Fig. 8, BSZ presents excess of heat areas indicated by the climatope 3 in the northern districts, where it is recommended the use of climatic guidelines **3.1** and **3.2** (Table 1). Grageru and Luzia districts,

Table 1 Details of specialized climatic guidelines that can be used in the planning process for Aracaju

Type of climatopes		Climatic guidelines to improve outdoor thermal conditions
1	High-density built-up areas with reduced ventilation potential	1.1 To avoid compact high-rise built-up area, guaranteeing H/W ratio <1 and high SVF >0.70 (see Fig. 3b) 1.2 To avoid obstacles perpendicular to the predominant east or southeast trend winds 1.3 To promote light colours and low conductive construction material (high albedo), when renovating the urban structure (building, public seating, etc.) 1.4 To maximize green infrastructure, such as cool pavements, cool and green roofs and suitable planting tree. Type of species, density of leaf area, and right place should be considered in the promotion of shade areas
2	Medium-density built-up areas with moderate ventilation potential	2.1 To ensure that guidelines **1.1, 1.2,** and **1.3** are kept 2.2 To preserve the guideline **1.4**, considering the existence of open spaces 2.3 To promote ventilation paths from east to west and alongside river
3	Low-density built-up areas with moderate and elevated ventilation potential	3.1 To ensure that guidelines **1.1, 1.2** and **1.3** are kept, regarding new verticalized building development 3.2 To promote the guideline **1.4**
4	Beach areas with low plants and elevated ventilation potential	4.1 To avoid further high and medium-rise compact built-up areas alongside the beach, regarding new urban development 4.2 To design freeways alignments of building to the east or southeast windsin new neighbourhood 4.3 To create urban parks considering the guideline **1.4**
5	Green areas with dense trees	5.1 To preserve the existing green areas, including mangroves (*mangue*) 5.2 To cool urban spaces with shading and evapotranspiration 5.3 To promote connections between green spaces and ventilations paths. Attention should be paid to the effect of the high tree density on the reduction of wind speed 5.4 To promote biodiversity 5.5 To avoid open spaces inside urban parks due to the intense solar radiation 5.6 To ensure that guidelines **1.1** is kept
6	Water bodies	6.1 To avoid channelling water bodies to reduce urban flooding 6.2 To preserve the guideline **5.1**

(continued)

Table 1 (continued)

Type of climatopes		Climatic guidelines to improve outdoor thermal conditions
		6.3 To avoid new high-rise compact built-up areas alongside river to preserve good ventilation
V	Ventilation paths	**V.1** To preserver guidelines **1.2** and maintain low z_0 **V.2** To ensure that the guideline **5.3** is kept

Source The authors 2020

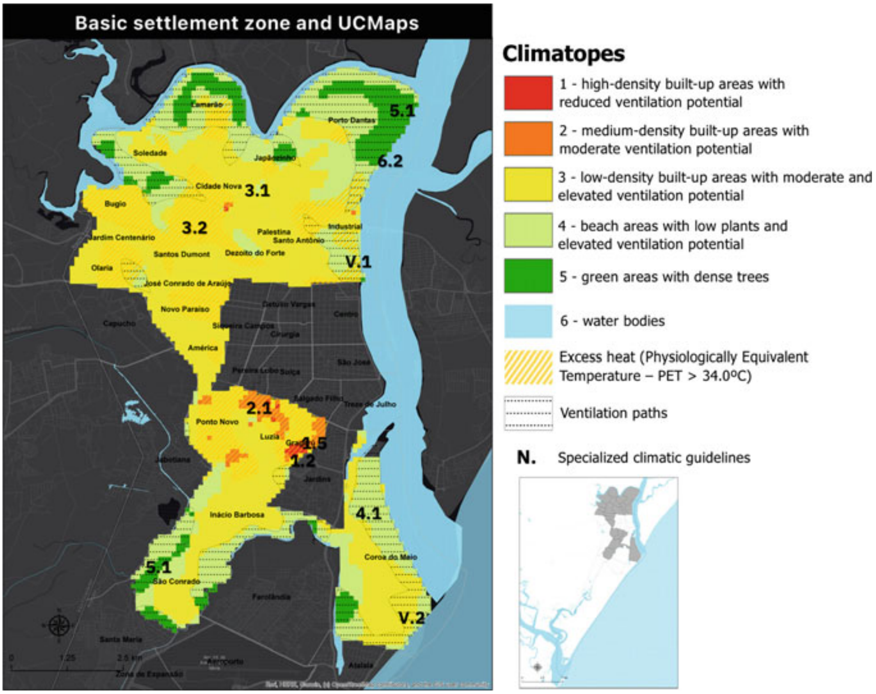


Fig. 10 Basic settlement zone and UCMap in Aracaju. *Source* By the authors, 2020

located on the south of BSZ, the climatope 1 and 2 indicate high UHI intensity, so that the guidelines **1.3**, **2.1** and **2.2** are suggested. In the seashore areas, the BSZ induces urban densification that could create further high UHI intensities since UCMap shows climate 3 for these areas. It is suggested the guidelines **3.3** control the UHI effects and the guidelines **V.1** and **V.2** (ventilation paths) ensure that the east or southeast trend winds penetrate the urban structures. The extreme north and south of the BSZ have significant patches of climatopes 4, 5 and 6, suggesting the implementation of guideline **4.1**, **5.1** allied to **6.1** and **6.2** to preserve the existing green areas and the fluvial-mangrove ecosystem.

For the north-eastern part of the PSZ, UCMap indicates excess heat areas with low ventilation potential due to climatopes 1, 2 and 3 (Fig. 11). We highlighted that guideline **1.4** for the maximization of green spaces is consistent with that proposed by the Master Plan for Aracaju, art. 20 item IV: to intensify the increase of green areas and afforestation system, improving the environmental quality at street level. Climatopes 4 and 5, and the ventilation paths cover the south part of the PSZ, in which it is recommended to preserve mainly the measures **4.1** for the heights and spacing of buildings and **V.1** and **V.2** for maintenance of natural ventilation, avoiding a climate compromise in the future. Moreover, the natural ventilation and controlled building volume are very important to improve bioclimate thermal conditions for the areas around river and sea. For example, the verticalized buildings in the PSZ can compromise the good circulation in the inner city and peripheral neighbourhoods by blocking the prevailing winds from the east.

The CSZ set up a controlled land use occupation because of the large deficit in the urban infrastructure and services (Fig. 12). The northern part of CSZ presents a recent urban growth due to the investment in respect of housing and gated communities. For these areas, the UCMap is classified as climatope 3, and attention

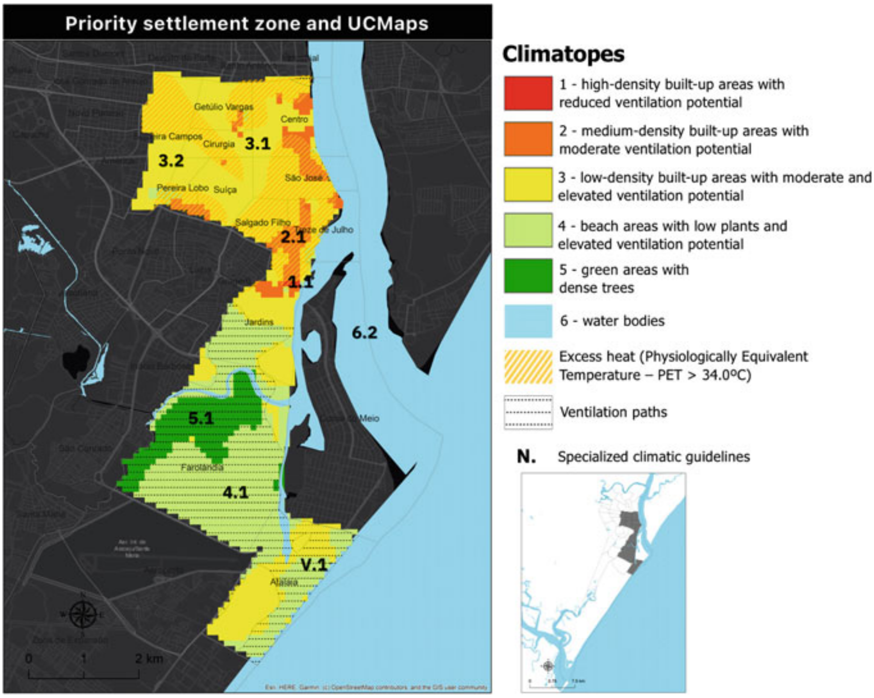


Fig. 11 Priority settlement zone and UCMap in Aracaju. *Source* By the authors, 2020

should be paid to avoid moderate thermal excess and wind reduction. Moreover, the environmental fragility of the CSZ is linked with mangrove devastation, and the mapped climatopes 5 and 6 can offer the associated guidelines **5.1** and **6.1** to preserve this ecosystem. The southern part of CSZ covers part of the Expansion Zone of the city characterized by intense growth of low-density housing due to rapid urban sprawl that may further increase the temperature in CSZ. In addition, the existence of unoccupied areas or open spaces, classified as climatope 4 and ventilation paths, should be targeted with the long alignments of building to the east or southeast winds (**4.2**) and adequate inclusion of green spaces (**1.4**) to guarantee low UHI intensity in the new neighbourhood.

The RSZ covers the whole Expansion Zone of the city that includes disperse and discontinuous built-up areas with a deficit of urban infrastructure and public services (Fig. 13). Over the last years, the RSZ has been undergoing transformations in land use and cover due to the increase of single-family residences. If urban devolvement ignores climatic recommendations presented in the UCMap, new heat spots may appear in RSZ. It was classified as climatopes 4, 5, 6 and ventilation paths that offer the following guidelines: **4.1** and **4.2** for the agricultural zoning areas; **V.1** and **V.2** to ensure the good ventilation; **5.1**, **5.2**, **6.1** and **6.2** to preserve the forest and fluvial ecosystems.

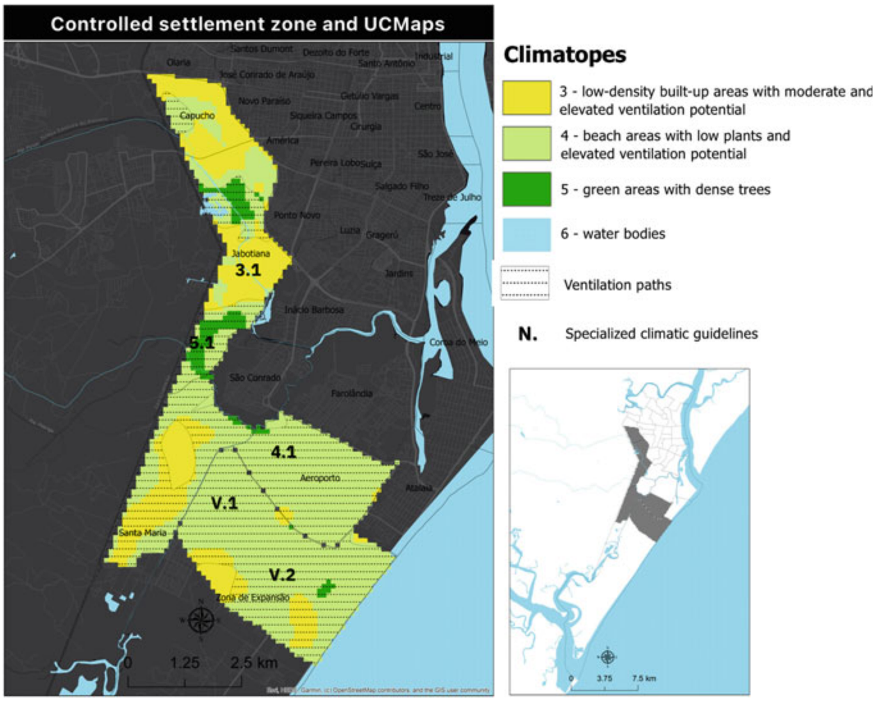


Fig. 12 Controlled settlement zone and UCMap in Aracaju. *Source* By the authors, 2020

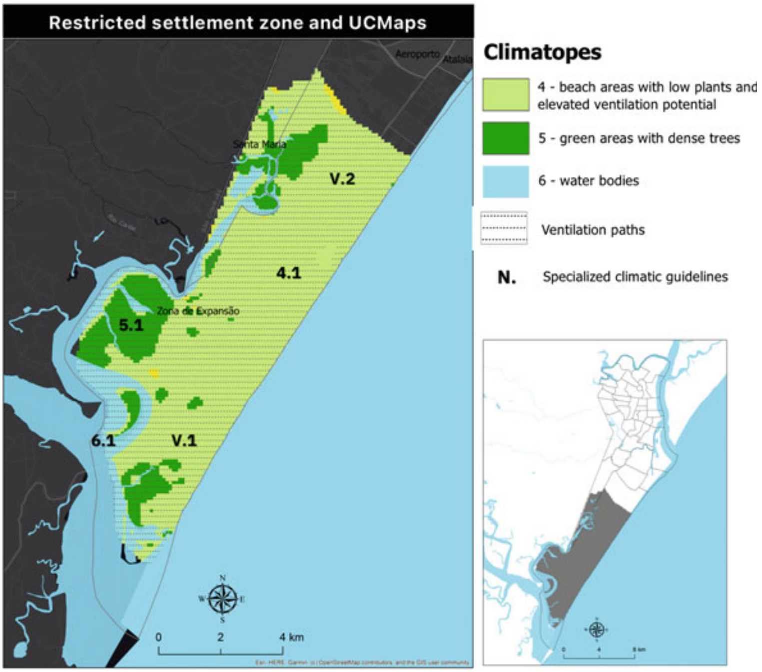


Fig. 13 Restricted settlement zone and UCMap in Aracaju. *Source* By the authors, 2020

5 Conclusion

This chapter demonstrates how scientific knowledge of the climate related to UHI effects can be applied to the urban planning process of a Brazilian city by using the Urban Climatic Maps approach. These maps reveal accessible, easy and decision support tools to planners, architectures and local government to make the right decision in urban planning.

Based on climatopes assessment, climatic guidelines were presented to improve bioclimatic thermal conditions and urban environmental quality. They can be summarized as follows:

- Ventilation paths must be kept free of high and dense construction to ensure adequate ventilation conditions that can promote clean air and neutral heat stress;
- In waterfront areas, new buildings distance to each other must be observed to ensure that sea breezes can go inland and positively affect the urban environment, although warmer days can be produced in SBF development;
- Green spaces, especially street trees, parks and mangrove ecosystems, must be preserved or increased to ameliorate human thermal comfort. Besides that, tree species must be carefully chosen to avoid fallings during strong wind events.

Also, species that spread allergenic pollens must be avoided by maintaining human health.

Cities that take into account such climatic guidelines are proven to be more sustainable and prepared to combat local climate changes.

Acknowledgements Max Anjos held a post-doctoral fellowship with PRINT/CAPES (2019–2020, Brazilian Ministry of Education) and CNPQ/MCTIC (Brazilian Ministry of Science, Technology and Communication). The authors thank the Instituto Federal de Educação, Ciência e Tecnologia Goiano and Laboratory of Climatology (Laboclima) of the Federal University of Paraná (UFPR) for supporting this research.

References

Abreu L, Labaki L, Matzarakis A (2012) Reduction of mean radiant temperature by cluster of trees in urban and architectural planning in tropical climates The case of Campinas, Brazil. In: PLEA2012—28th Conf Oppor Limits Needs Towar an Environ responsible Archit Lima, Perú 7–9 Novemb 2012 Reduct

Abreu-Harbich LV, Labaki LC, Matzarakis A (2014) Thermal bioclimate in idealized urban street canyons in Campinas, Brazil. Theor Appl Climatol 115:333–340. https://doi.org/10.1007/s00704-013-0886-0

Alcoforado MJ, Andrade H (2005) Nocturnal urban heat island in Lisbon (Portugal): main features and modelling attempts. Theor Appl Climatol 84:151–159. https://doi.org/10.1007/s00704-005-0152-1

Alcoforado M, Lopes, A, Andrade H, Vasconcelos J (2005) Orientações climáticas para o ordenamento em Lisboa. Universidade de Lisboa

Amirtahmasebi R, Orloff M, Wahba S, Altman A (2016) Regenerating urban land: a practitioner's guide to leveraging private investment. Urban Development. World Bank, Washington, USA

Anjos M (2017) Application of climatic guidelines to urban planning in the northeastern coast of Brazil: Aracaju city. Phd Thesis. University of Lisbon

Anjos M, Lopes A (2017) Urban heat island and park cool island intensities in the coastal city of Aracaju, North-eastern Brazil. Sustainability 9:1379. https://doi.org/10.3390/su9081379

Anjos M, Lopes A (2019) Sea breeze front identification on the northeastern coast of Brazil and its implications for meteorological conditions in the Sergipe region. Theor Appl Climatol 137:2151–2165. https://doi.org/10.1007/s00704-018-2732-x

Anjos M, Lopes A, Alves L, Lucena AJ (2017) Rede climatológica de mesoescala aplicada ao estudo da Ilha de Calor Urbano: o caso de Aracaju-SE. Caminhos Geogr 18:203–216. https://doi.org/10.14393/RCG186216

Anjos M, Lopes A, Alves E (2019) Uso dos modelos CAL3QHC e I-Tree Canopy na avaliação da qualidade do ar em Aracaju : estimativas da concentração de PM10 em vias de tráfego intenso de automóveis. Geousp—Espaço e Tempo 22:707–728. https://doi.org/10.11606/issn.2179-0892.geousp.2018.139515

Anjos M, Lopes A, Lucena AJ, Mendonça F (2020a) Sea breeze front and outdoor thermal comfort during summer in Northeastern Brazil. Atmosphere (Basel) 11:1013. https://doi.org/10.3390/atmos11091013

Anjos M, Targino AC, Krecl P et al (2020b) Analysis of the urban heat island under different synoptic patterns using local climate zones. Build Environ 185: https://doi.org/10.1016/j.buildenv.2020.107268

Aracaju (2015) Plano Diretor de Desenvolvimento Urbano de Aracaju—Diagnóstico municipal/ Relatórios de Propostas. http://www.aracaju.se.gov.br/userfiles/relatorio-propostas-final.pdf. Acessessed in 18 April 2017

Berkeley UC, Brager GS, Dear R De, De Dear R (2001) Climate, comfort and natural ventilation : a new adaptive comfort standard for ASHRAE Standard 55. Cent Built Environmen 19. https://doi.org/10.1016/S0378-7788(02)00005-1

Bitan A (1992) The high climatic quality city of the future. Atmos Environ Part B Urban Atmos 26:313–329. https://doi.org/10.1016/0957-1272(92)90007-F

Chen L, Ng E, An X et al (2012) Sky view factor analysis of street canyons and its implications for daytime intra-urban air temperature differentials in high-rise, high-density urban areas of Hong Kong: a GIS-based simulation approach. Int J Climatol 32:121–136. https://doi.org/10.1002/joc.2243

De Abreu-Harbich LV, Labaki LC, Matzarakis A (2015) Effect of tree planting design and tree species on human thermal comfort in the tropics. Landsc Urban Plan 138:99–109. https://doi.org/10.1016/j.landurbplan.2015.02.008

Eliasson I (2000) The use of climate knowledge in urban planning. Landsc Urban Plan 48:31–44. https://doi.org/10.1016/S0169-2046(00)00034-7

European Commission: Directorate-General for Research and Innovation (2015) A European research and innovation roadmap for climate services

Gál T, Unger J (2009) Detection of ventilation paths using high-resolution roughness parameter mapping in a large urban area. Build Environ 44:198–206. https://doi.org/10.1016/j.buildenv.2008.02.008

Gál T, Unger J (2014) A new software tool for SVF calculations using building and tree-crown databases. Urban Clim. https://doi.org/10.1016/j.uclim.2014.05.004

Höppe P (1999) The physiological equivalent temperature—a universal index for the biometeorological assessment of the thermal environment. Int J Biometeorol 43:71–75

Lin TP, De Dear R, Hwang RL (2011) Effect of thermal adaptation on seasonal outdoor thermal comfort. Int J Climatol 31:302–312. https://doi.org/10.1002/joc.2120

Lopes A, Oliveira S, Fragoso M et al (2009) Wind risk assessment in urban environments: the case of falling trees during windstorm events in lisbon. Bioclimatology and natural hazards. Springer, Netherlands, Dordrecht, pp 55–74

Matzarakis A, Mayer H (1992) Mapping of urban air paths for planning in Munchen. Wissenschaftlichte Berichte Inst. Meteorol. und Klimaforschung. Univ. Karlsruhe 16:13–22

Mendonça F (2015) The SCU—urban system climate—in Brazil: aplications and chalenges. In: Monteiro CAF et al (eds) The construction of geographical climatology in Brazil. Alinea, São Paulo, pp 155–166

Mills G, Anjos M, Brennan M et al (2015) The green 'signature' of Irish cities: an examination of the ecosystem services provided by trees using i- Tree Canopy software. Irish Geogr 48:62–77. https://doi.org/10.2014/igj.v48i2.625

Monteiro CAF (1976) Teoria e clima urbano. Habiliation Theses, São Paulo

Monteiro CAF, Mendonça F (2005) Clima urbano. Contexto, São Paulo

Monteiro CAF, Santana Neto JL, Mendonça F, Zavatini JA (2015) The construction of geographical climatology in Brazil. Alinea, São Paulo

Ng E (2009) Policies and technical guidelines for urban planning of high-density cities—air ventilation assessment (AVA) of Hong Kong. Build Environ 44:1478–1488. https://doi.org/10.1016/j.buildenv.2008.06.013

Ng E, Chao R (2015) The urban climatic map: a methodology for sustainable urban planning. Routledge, London

Nowak DJ, Crane DE (2002) Carbon storage and sequestration by urban trees in the USA. Environ Pollut 116:381–389

Oke TR (1984) Towards a prescription for the greater use of climatic principles in settlement planning. Energy Build 7:1–10. https://doi.org/10.1016/0378-7788(84)90040-9

Oke TR, Mills G, Christen A, Voogt JA (2017) Urban climates. Cambridge University Press, Cambridge

Prefeitura de São Paulo (2014) City of São Paulo strategic master plan. https://gestaourbana.prefeitura.sp.gov.br/arquivos/PDE-Suplemento-DOC/PDE_SUPLEMENTO-DOC.pdf. Accessed on 16 Jul 2020

Rajagopalan P, Lim KC, Jamei E (2014) Urban heat island and wind flow characteristics of a tropical city. Sol Energy 107:159–170. https://doi.org/10.1016/j.solener.2014.05.042

Reis C, Lopes A (2019) Evaluating the cooling potential of urban green spaces to tackle urban climate change in Lisbon. Sustainability 11:2480. https://doi.org/10.3390/su11092480

Ren C, Ng EY, Katzschner L (2011) Urban climatic map studies: a review. Int J Climatol 31:2213–2233. https://doi.org/10.1002/joc.2237

Scherer D, Fehrenbach U, Beha H-D, Parlow E (1999) Improved concepts and methods in analysis and evaluation of the urban climate for optimizing urban planning processes. Atmos Environ 33:4185–4193. https://doi.org/10.1016/S1352-2310(99)00161-2

Souza SH (2010) Avaliação do desempenho térmico nos microclimas das praças: Piedade e Visconde de Cayrú, Salvador/BA. Dissertation, Escola Politécnica da Universidade Federal da Bahia, Salvador

Street RB (2016) Towards a leading role on climate services in Europe: a research and innovation roadmap. Clim Serv 1:2–5. https://doi.org/10.1016/j.cliser.2015.12.001

VDI (1988) Stadtklima und Luftreinhaltung. Springer-Verlag, Berlin

Vos PEJ, Maiheu B, Vankerkom J, Janssen S (2013) Improving local air quality in cities: to tree or not to tree? Environ Pollut 183:113–122. https://doi.org/10.1016/j.envpol.2012.10.021

Wong MS, Nichol JE, To PH, Wang J (2010) A simple method for designation of urban ventilation corridors and its application to urban heat island analysis. Build Environ 45:1880–1889. https://doi.org/10.1016/j.buildenv.2010.02.019

Max Anjos is Post-doc Researcher at the Federal University of Paraná (UFPR, Curitiba, Brazil, 2019–2020). He has a PhD degree in Physical Geography at the Institute of Geography and Spatial Planning of the University of Lisbon, Portugal, and Master's degree in Physical Geography, Environmental and Planning at the University of Coimbra, Portugal. He was awarded with the National Award of Orlando Ribeiro Geography by the Portuguese Geographers Association in 2019. His scientific field is urban climate, local climate zones classification, urban climatic maps, air pollution, urban carbon mapping and climatic guidelines to urban planning.

António Lopes is Associate Professor at IGOT-ULisboa, Researcher at Centre of Geographical Studies (CEG) and "Climate Change and Environmental Systems–Zephyrus", research group coordinator. He holds a PhD in Physical Geography from the University of Lisbon since 2003. He is Full Member of the "F3—Food Farm and Forestry" College and the Tropical College of the University of Lisbon and Scientific International Associations: International Society of Biometeorology—ISB and International Association of Urban Climate—IAUC. He is Topic Editor of Atmosphere/MDPI journal since October 2019, and Section Editor (climatology) of Finisterra—Portuguese Journal of Geography. His research topics and techniques are urban climate changes; applied climatology; thermal comfort and health, urban environment; atmospheric pollution in cities; micro-meteorology modelling; thermal remote sensing. In the last 30 years, he was involved in national and international projects; among them are: "SECOA—Solutions for Environmental Contrasts in Coastal Areas"; "ADVICE—Annual to Decadal Variations in Climate in Europe; "URBKLIM—Climate and Urban Sustainability Perception of Comfort and climatic Risks"; "KLIMHIST—Reconstruction and Model Simulations of Past Climate in Portugal using documentary and early instrumental sources (seventeenth–nineteenth century)"; National Plan for Territorial Development of Mozambique; Metropolitan Plan for the Adaptation to Climate Change of the Lisbon Metropolitan Area; "The Cape Verde Natural Hazards and Risk Profile of Cape Verde", Drought Risk Assessment coordinator, for the UNPD.

Elis Alves has a degree in Geography from the State University of Goiás (2008) and a masters degree in Environmental Physics from the Federal University of Mato Grosso (2011). He conducted a research internship at the Center for Geographical Studies at the University of Lisbon (2013). He received PhD in Sciences from the University of São Paulo (2016). He received Post-Doctor in Physical Geography at the School of Philosophy, Letters and Human Sciences of the University of São Paulo (2019). He was Professor at the Federal Institute of Education, Science and Technology of Goiás, Campus Ceres. He was Permanent Professor in the Professional Master in Professional and Technological Education (ProfEPT). He works in the areas of general climatology, geography and teaching, agrometeorology, geoprocessing and health, remote sensing, spatial analysis and geostatistics.

Ezequiel Correia is Geographer and Researcher at the Zephyrus—Climate Change and Environmental Systems Research Group, in the Institute of Geography and Spatial Planning (IGOT), University of Lisbon. He has a masters degree in Physical and Regional Geography (specialization in Climatology). Climate variability, climatic hazards and applied climatology are his main scientific interests. Professionally involved during some years in the development of applications to manage and analyse geographic information, actually belongs to a team that is developing a new generation of UCMaps in a GIS environment.

Francisco Mendonça is a geographer and has master (Physical Geography/Environment—USP, 1990) and PhD degrees in Geography (Climate and Urban Planning—USP, 1995), with post-doctorate (Epistemology of Geography—Université Sorbonne/Paris I/France, 2005; Study of Urban Environment/Universidad de Chile, 2014). He is Full Professor at the Department of Geography of the Federal University of Paraná. He was an invited Professor at Université de Sorbonne/Paris I/Institut de Géographie (2002) and Université de Haute Bretagne/Rennes II/France (2004) and invited Researcher at London School of Hygine and Tropical Medicine (London/England 2005) and Laboratoire PRODIG/France (Univ. sorbonne/Paris 1, 2005). He holds a CNPQ researcher grant (PQ-1A) since 2013. He is Member of the Climatology Commission of the UGI—International Geographical Union since 2012, and Board of Directors of International Climatology Association—AIC (2003–2006 and since 2013). He was President of the ABClima—Brazilian Association of Climatology (2002–2004), ANPEGE—National Association for Research and Post-Graduation in Geography (2007–2009) and Member of the ANPPAS—National Association for Research and Post-Graduation in Environment and Society (2004–2008). He has experience in geography and geosciences, focusing on the following research topics: urban environment, climatology, health geography and epistemology of geography.

Experiences from Africa

Aerotropolis and Urban and Regional Impacts: The Case of the King Shaka International Airport in Durban, South Africa

Meghan Crosby and Brij Maharaj

1 Introduction

Air travel has become the fastest-growing means of transportation and also one of the primary contributors to the globalisation of cities. Airports allow cities to invade one another's space and promote both a connection and competition between regions (Kasarda 2008b; Bednarek 2016; Conventz et al. 2016). Airports are promoted as gateways to economic development and expansion (Cidell 2015). Their development is viewed as critical for connecting and expanding business, generating economic growth and employment opportunities, and creating inter-city national and international networks and competition across multiple scales and regions.

Airports are viewed as multi-functional sites of economic activity and therefore fulfil a variety of roles, similar to that of the Central Business District (CBD) of a city. Airports have evolved into commercial destinations and not only places of departure (Kasarda and Lindsay 2011). The concept of the aerotropolis, as outlined by Kasarda (2008b), refers to the metamorphosis of airports as magnets for urban and regional development. In this conceptualisation, the airport, as a driver of regional growth, is

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names, and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

[A version of this paper, "Efficiency at Any Cost? A Critique of Aerotropolis Development for King Shaka International Airport" was presented at the IGU Urban Commission Annual Meeting 2015—Urban challenges in a complex world—Resilience, governance and changing urban systems, 9—16 August 2015, at University College Dublin (Cosby and Maharaj 2016).]

M. Crosby · B. Maharaj (✉)
University of KwaZulu-Natal, Durban, South Africa
e-mail: maharajb@ukzn.ac.za

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_10

expected to become more than merely a regional gateway. Rather, it will function as a city in itself, with living spaces for workers and their families, factories relying on airborne inputs and service industries located around the airport, with major road and rail infrastructure connected to it (Charles et al. 2007:1009).

The neoliberal aerotropolis model is based on speed, efficiency, and economic growth. This model is concerned with the maximisation of economic effectiveness and is built on the concept of "speedy connectivity" (Kasarda and Lindsay 2011). Airport access and efficiency are, therefore, seen to be inextricably linked. Economists and business leaders have always referred to economies of scale and scope in discussing competitive advantages. However, Kasarda (2006) places greater emphasis on economies of speed which is believed to be the most significant contributor to increasing the competitive advantages of cities or businesses operations. Kasarda and Lindsay (2011:11) contend that "there will never be enough time in the day, but space is fungible; it can be overcome with speed".

This notion of the survival of the fastest (Kasarda 2006) is, however, controversial. Kasarda (2006) makes reference to Darwin's evolutionary theory in order to describe aerotropolis development, and by deduction, the model implies a weeding out of the weak (or rather, the slow). Those without access to the speed needed to compete fall behind and are unable to interact within the global system. Only those with the finances and the capabilities to utilise air transport have the ability to become the "fastest" and are therefore able to "survive".

However, there has been criticism that the "aerotropolis profoundly subverts the goal of building inclusive, equitable and sustainable cities. It is not a city designed to enhance the lives and livelihoods of urban dwellers and to provide public space to nurture participatory democracy and civic empowerment" (Pleumarom 2017:115). Hence, the very basis and justification of aerotropolis and airport-centred regional development can produce socio-spatial inequalities. There is, therefore, a need to assess the impacts of neoliberal aerotropolis development strategies in developing cities.

This chapter examines the development of the King Shaka International Airport (KSIA), Africa's first purpose-built aerotropolis in the South global city of Durban. Durban is located in the province of KwaZulu-Natal (KZN). This chapter will reveal that KISA was a neoliberal, public–private project. Key challenges included whether KISA was a hub or spoke, freight and cargo logistics, and airport taxes and tariffs. The data for this paper was drawn from assessments of various company and government documents. There was also a series of in-depth, semi-structured key informant interviews with executives and managers at KSIA and the Dube Tradeport (who, in the interest of confidentiality, have not been named).

This paper is divided into five sections. The first section presents an overview of neoliberal airport development, followed by a discussion of air travel in developing countries. The background to the KSIA aerotropolis development is presented in the third section. In the fourth section, the focus is on the KISA public–private partnerships. The final section assesses the challenges associated with the KSIA aerotropolis project, which included hub or spoke status, freight and cargo logistics, and airport taxes and tariffs.

2 Neoliberal Airport Development

Neoliberalism has emerged as the global hegemonic ideology and is explained as the dominance of market-orientated development strategies. South Africa's development policies and plans are rooted within this hegemony (Bond 2014). The notion of airport-centred development is fundamentally rooted in this neoliberal ideology.

During the 1980s, a global, neoliberal shift in urban governance was experienced with a movement towards corporatisation, privatisation and commercialisation (Freestone 2011). Airport expansion and efficiency planning are being promoted as a key neoliberal urban development strategy (Banai 2017). This resulted in an increase in competition between cities, airlines, and also between airports themselves. It also meant that cities increased the promotion and development of airports in order to gain competitive advantages in global capitalist markets (Freestone and Baker 2011). Airports became strategic tools in the promotion of innovative and modern cities. This has significantly influenced the way in which airports are understood and the way in which their development is planned (Kasarda 2008b; Bednarek 2016; Coventz et al. 2016).

The argument is that airports have the potential to fundamentally influence economic development, attract new ventures, and promote the prosperity of existing firms through increased efficiency (Brueckner 2003; Kasarda and Lindsay 2011). Consequently, this is seen as a justification for the concentration of public funds into large-scale airport-centred development—such as the development of KSIA and the Dube Tradeport.

According to Freestone (2011), airports are fundamental aspects of global commercial entrepreneurialism, and as such, they are significantly reshaping the form and structures of the cities within which they are situated. Pleumarom (2017: 115) contends that the aerotropolis is a:

> …city driven by a combination of private business imperatives and State control, with the high levels of security and controls that go with airports. It constitutes a supercentre of conspicuous consumption with facilities and services primarily catering to privileged and wealthy upper-class air passengers with hyper-mobile and luxurious lifestyles, and to transnational corporations that are keen to get their products swiftly to customers around the world.

Hence, airports represent the contradictions of simultaneous territorial fixity and mobility and are representations of global, neoliberal societies. Airports have been transformed into market-driven, competitive economic spaces, a trend that is also emerging in global South cities (Arthur 2018; Rogerson 2018).

3 Air Transport and Developing Countries

There has been a rapid growth in air transport in developing countries that have tended to follow the examples and experiences of developed nations (Hilling 2003; Bowen 2016). Although globalisation has promoted interconnectedness, Basu

(2004) argues that the interlinking of cities and countries, through technologies like the Internet and advanced air transport networks, is highly problematic. This is because of the technological divide that exists between developed and developing countries and the poorly maintained and unreliable infrastructure.

The air transport industry has become internationalised, but according to Hilling (2003), very little has changed in poverty-stricken developing countries. In fact, very few developing countries have the necessary conditions for a fully operational, high technology aerospace (Hilling 2003). The focus of airport development in the global South is stimulation of economic growth and the associated multiplier effects. The general benefits of air transport (recreational travel, business, entertainment) are less important in developing countries because there are more urgent social and economic priorities. The urban elite benefits from the speed and convenience of air transport. This can include recreational benefits, perishable food delivery, faster mail, and goods delivery, as well as medical services when required (Hilling 2003). However, on a day-to-day basis, the poorest members of any urban society may find these "benefits" limited or irrelevant to their plight.

Improving and increasing trade in developing countries has been a critical priority in the last few decades. The need for efficiency in trade infrastructure has been an important development strategy (Devlin and Yee 2005; Otisa et al. 2011). Most developing cities have challenges with logistical efficiency and have been unable to compete in the global market (Njoya 2016). Therefore, the development focus has shifted towards minimising logistical cost in order to attract business and growth. Hilling (2003) cautions that large airport investments may have negative economic consequences because the aviation industry is extremely capital intensive. Without a good understanding of the opportunity costs of such development, economic losses will be incurred. Invariably, the poorest of the poor have to bear the cost of these losses which are cross-subsidised by the state. There is also an argument that the passenger and cargo market in developing cities is too small to warrant aerotropolis development (Pleumarom 2017).

4 Background to KSIA Aerotropolis Development

KSIA and the Dube Trade Port was the first example of a planned aerotropolis development in the global South. The Durban International Airport (DIA) was city's former, and now decommissioned, international airport. This airport was located in the South Durban Basin (Fig. 1), near the harbour, major roads, and surrounded by industry and warehousing.

KSIA, and the Dube Tradeport, is now located 35 km (in a straight line) from Durban's CBD and along the N2 National Road (Fig. 1). KSIA is significantly larger than the former DIA. The new airport houses a terminal floor of 103,000 m^2 (over three times the size of DIA) and runways and taxiways that cover 400,000 m^2. KSIA has 12 new air bridges, while DIA had none, and the parking

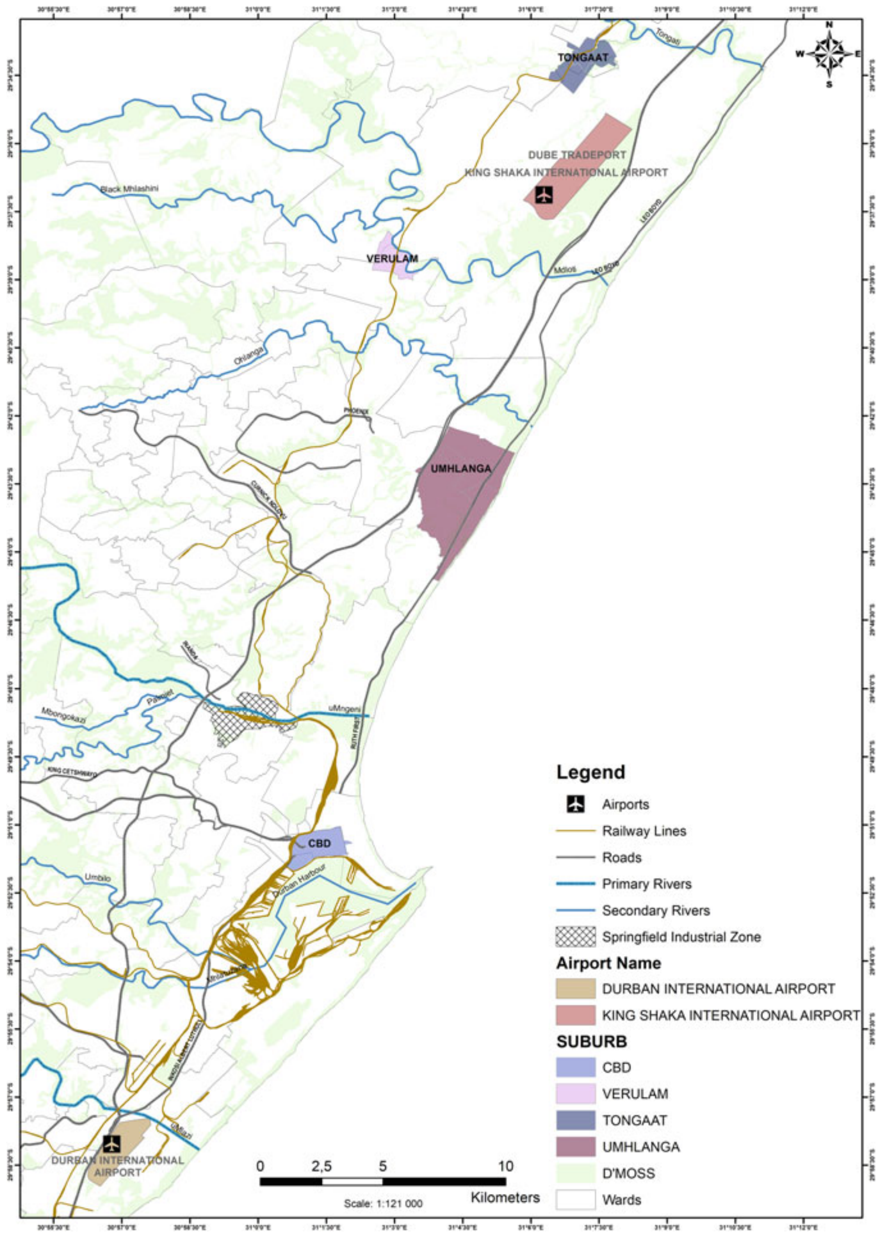


Fig. 1 Location of King Shaka International Airport in Durban. Source: Developed by authors

space at the new airport has increased from 2900 to 6500 m^2. There are 50 retail and restaurant outlets in KSIA, and this is a significant increase from the 14 that were available in the former DIA (ACSA 2011).

The idea of relocating Durban's airport from the south to KSIA's current location in the north of the city emerged in the 1970s. Basic infrastructure for the project was completed between 1975 and 1982. During the 1980s, however, the project was shelved because of the country-wide economic recession and also the increased political and social turmoil experienced at the height of the opposition to apartheid (ACSA 2011). The project remained in the pipeline throughout the 1990s. After the formation of the Airports Company of South Africa (ACSA) in 1993, the ownership of the land on which the new airport was to be built was transferred from the Department of Transport to the new airport company (ACSA 2011).

The KSIA plans were revived in 2006 as part of KZN's plans to host FIFA 2010 soccer world cup matches. This was not the only reason for Durban's airport relocation, but it was a contributory factor to the speed with which KSIA was built. ACSA had originally planned to open KSIA in 2016. However, the "2010 FIFA World Cup gave a kickstart to the decision to commence construction, and it was therefore accelerated by about six years" (Golder Associates 2011:32).

There was agreement that ACSA would own, develop, and manage the new airport and that the (new) Dube Tradeport Company would develop the cargo facilities and promote the metropolis (ACSA 2011). The Dube Tradeport is a multi-modal logistics platform. Amongst other responsibilities, the company manages the air cargo logistics and transportation to and from the airport, plans aviation strategies for KSIA, and markets the airport city to private investors globally (Dube Tradeport 2008, 2012).

Initial estimates placed the costs of the airport's development at R980 million (Nel et al. 2003), but by the time construction started in 2008, this figure increased to R6.8 billion (ACSA 2011). This highlights the significance of the overspend on this facility. The Dube Tradeport was planned to be developed for approximately R2.2 billion (Nel et al. 2003), but recent estimates place its cost at approximately R8 billion instead (Mulder 2009).

KISA was Africa's first, purpose-built aerotropolis and was based on Kasarda's (2006, 2008a, b) model which is highly dependent on the efficiency and speed of transport, and emphasis was placed on public–private partnerships.

5 Aerotropolis: Public–Private Partnerships

The public–private partnership (PPP) to develop the Dube Aerotropolis included the KwaZulu-Natal Provincial Government, the Dube Tradeport, Tongaat Hulett and eThekwini Municipality. Tongaat Hulett owns most of the land in the region: "So significant is this group that its development plans for its property in the northern parts of the city have laid the basis for the city's planning in that region" (Nel et al. 2003:230). The Municipality and the Dube Tradeport had provided plans and guidelines for the growth of the region. However, as the landowner and a private company, decisions made are in the best interests of the company.

According to an executive at Tongaat Hulett Developments, the company was attempting to develop the aerotropolis region for efficiency and to assist in sparking economic growth in the region. Tongaat Hulett Developments can choose to sell land in bulk, or build, subdivide, and sell the land later, at a higher profit. Their control over the land gave them immense influence over the shape and form of the development of the aerotropolis.

All the KSIA planning documents emphasised that the primary reasons for the airport development were the need to promote economic growth in the province (e.g. AECOM-McClier 2002, Dube Tradeport 2004). Improved infrastructure and efficiency would attract national and international investment and create jobs. When completed, the Durban aerotropolis will cover 32,000 ha, and 42 million square metres of property will be developed and will create an estimated 750,000 jobs and attract one trillion rand in investments (Mavunda 2019). This is almost a textbook definition of trickle-down economics, which asserts that the benefits from private sector investments trickle down to all sectors of society through the stimulation of growth (Wisman and Smith 2011; Furlong 2020).

The anticipated benefits of the aerotropolis for the poor were in terms of job creation. However, impact assessments have shown that the Dube Tradeport will create a high demand for skilled and semi-skilled jobs. Mulder (2009) estimated that of the 58,972 predicted jobs resulting from the construction of the Dube Tradeport, 40,542 would be in the skilled and semi-skilled sectors of the economy. According to the Institute for Natural Resources (INR 2007), the economic benefits from the development of the Dube Tradeport and surrounding areas would mainly benefit the wealthy and middle-income coastal regions. According to Pleumarom (2017:115):

Those who benefit most from such projects are not local communities but international investors and corporations such as construction firms, airlines and other transport companies, hotel chains, real estate companies, insurance and security equipment companies, retail businesses as well as manufacturing companies with an export orientation.

It is therefore evident that airports and air transport, though efficient, are also noticeably elite. The direct, long-term benefits do not often trickle down. In fact, they are more likely to spread horizontally amongst elite than vertically to the lower-income sectors of urban society. Hence, there is a worrying disconnect between the grandiose claims in policy documents and the reality of minimum opportunities and benefits for the poor.

This is especially so in KZN, where 25% of the economically active population was unemployed in 2018 (Stats SA 2018). Furthermore, in 2017, 40% of households in KZN earned less than R55,000 per annum. In 2018, 3,938,973 recipients (22.2%) were beneficiaries of social grants, the highest in the country (KwaZulu-Natal Provincial Government 2019:24–26). According to the World Bank (2018:xxiii), KwaZulu-Natal “had the largest share of the poor in South Africa (26%)”. There are serious skills challenges in the province, and only 8.6% of the economically active population had a post-matric qualification (KwaZulu-Natal Provincial Government 2019:31).

Given this bleak social-economic scenario, KSIA is a physical representation of the neoliberal policies of both the KwaZulu-Natal Provincial Government and Durban Municipality. Even though KSIA is not a privatised space, its management, development, and growth are representative of the increased commercialisation of airport spaces. The future plans for KSIA and its surrounding aerotropolis involve increased neoliberal development strategies and show a progression towards a market-orientated space governed by efficiency, investment, and supply and demand.

The integration of Durban, and the KwaZulu-Natal province, into the international market system was believed to have been hampered by the absence of an efficient, multi-modal logistics platform. Hence, the justification for logistics infrastructure and the aerotropolis development at the Dube Tradeport (INR 2007). The main economic benefits from the development of the Dube Tradeport were linked to improved efficiency. These are benefits, as outlined by INR (2007), included a higher Gross Domestic Product (GDP) for South Africa and Gross Geographic Product (GGP) for Durban; an increase in the international competitiveness of the city; increased tourism; an increase in exports directly from Durban; job creation; and opportunities for technological advancement.

According to Mulder (2009), for every one rand invested in the Dube Tradeport, 26c is produced for the Gross Value Added (GVA). Mulder (2009:71) stated that the development of the Dube Tradeport provided a "warm and cozy environment" for businesses to flourish. However, who benefits from these profits? A company may turn a profit, but that does not guarantee the trickle-down of benefits to lower-income sectors of the regional economy. The Dube Tradeport is expected to increase the number of public–private partnerships (PPPs) in Durban and the associated economic and employment opportunities (INR 2007).

The KwaZulu-Natal Provincial Planning Commission (2012) acknowledged that KSIA was not operating at optimal capacity. They recommended that the Dube Tradeport is optimised by increasing public sector investments in the aerotropolis. This will increase the competitiveness and export capabilities of KSIA. Such neoliberal, pro-growth strategies of the KwaZulu-Natal provincial government place economic growth and international connectivity at the forefront of development:

This concept, known as the aerotropolis… essentially recognises the role of airports as drivers for growth. This intervention needs attract foreign direct investment to grow the manufacturing, logistics, commercial, industrial, transport and tourist sectors; attract national and local investment through growth of new business rather than relocation of existing business and provide a framework that encourages and facilitates co-ordinated, aligned and sustainable regional growth (KwaZulu-Natal PPC 2012:63).

The daunting challenge in Durban was to change KSIA from a spoke to a hub airport.

6 KISA—Hub or Spoke?

The increased competition between cities as airports expand has led to the growth of hub and spoke networks. The hub and spoke airport grids are radial forms of networks where important, large-scale, international airports become hub centres, while smaller airports become the spokes that feed into these hubs (Button and Lall 1999). The hub is characterised by high numbers of frequent flights, direct flights, increased opportunities for same-day return flights, international flights and flights that link to non-hub areas. Button and Lall (1999) conclude that it takes more than an already economically dynamic city to create an airport hub. There is a range of factors, including location, the development of complex public–private partnerships, and the diversification of services that contribute to airport hub growth.

Spoke airports are significantly disadvantaged compared to hubs. There are negative consequences and costs for being a non-hub city. These result from the fact that spoke cities often lag behind in economic growth and foreign currency accumulation. This has resulted in cities competing with one another through local political action aimed at the development and expansion of hub airports (Tarry 2000).

The hub and spoke relationship between Johannesburg and Durban is well-established, and DIA historically served as a feeder to Johannesburg—Africa's premier hub airport (Buyck 2011). ACSA and the KwaZulu-Natal Provincial Government's grand goal is to develop KSIA as a hub airport, and not a spoke that feeds into Johannesburg's OR Tambo International Airport. The principle argument for the development of KSIA as a hub airport is that passengers and cargo are more time-sensitive in the global economy of the twenty-first century. Hence, Durban passengers required more direct international flights in and out of the city (INR 2007). However, despite being in operation for a decade, KSIA still remains very much a spoke rather than a hub.

Flight and passenger numbers have been highlighted as key contributors to the success of airports and aerotropoli (Appold and Kasarda 2011). However, the flights from Durban have not increased, and KSIA still maintains very limited regional and international connectivity. KSIA feeds into OR Tambo International Airport for international destinations. Johannesburg is also located within a close proximity to Durban, and OR Tambo International Airport is a 45-min flight away from KSIA. This, combined with the regular flights between the two airports, highlights the ease of connecting from Durban to Johannesburg and therefore serves to limit the viability of the development of a second aviation hub for South Africa.

KSIA and the Dube Tradeport is planned to develop as an airport city. This will be a self-sustaining urban area operating within the zone directly surrounding a multi-functional, international airport (Wang et al. 2011). The airport city, as a multi-dimensional urban space, utilises the international connectivity and efficiencies of an airport to grow effective and resourceful cargo and warehousing facilities and functions in the same manner as a CBD. However, this airport is, currently, only connected to three international airports (Dubai via Emirates; Doha via Qatar;

Istanbul via Turkish Airlines). This means that passengers and air freight from other international destinations still need to travel through Johannesburg, which is the hub.

Many other international airlines have been approached to fly to Durban, but have declined. Lufthansa declined flying directly to Durban because the Durban–Johannesburg flight was frequent and short enough not to warrant another direct flight to South Africa. Air France and TAP Airlines (Portugal) decided not to fly directly to Durban for similar reasons (Inggs 2009).

In November 2011, plans were announced for KSIA to develop as a secondary hub for Southern African Development Community (SADC) countries, using the local airline South African Express and South African Airways as the primary operator. However, these plans and routes have yet to take off (News24 2011).

Hub airports have a considerable amount of control and a monopoly over the aviation industry because they receive the highest numbers of domestic and international flights (Tarry 2000). OR Tambo International Airport, therefore, still holds the monopoly status for airports in South Africa, and this limits the viability of an airport, with the size and magnitude of KSIA, for Durban. Significantly, ACSA was well aware that KSIA was unlikely to achieve hub status:

Durban is still very much a spoke… [It] cannot compete with Johannesburg… We [ACSA] were always in support of the development of a new airport; it was a question of timing. We felt as though they [KwaZulu-Natal Provincial Government] could have postponed it for a few years, but we had a lot pressure from provincial government and were basically forced to move… we could have managed with a few minor adjustments to old airport for a while.

The airports in South Africa grew at 5.7%, below the average African airport growth rate of 8.9% in 2010 (Buyck 2011). This is despite the increase in passenger numbers during the FIFA 2010 World Cup and the opening of KSIA that year. Against this background, it is unlikely that KSIA will emerge as the second hub in South Africa.

Given the fact that South African airports are highly-priced and that competition in the aviation industry is increasing, the viability of the development of the second hub in South Africa is limited. Hub airports cannot be created merely by the construction of infrastructure. There must be a demand without which the project is unable to become self-sustaining (Goetz 1992). Therefore, the execution of large-scale, neoliberal development projects, such as the construction of KSIA and the Dube Trade Port aerotropolis, as a means of generating economic growth, increasing international connectivity, and creating opportunities for the poor, is questionable.

7 Freight and Cargo Logistics

The Dube Tradeport and KSIA was developed to address the infrastructural challenges in KwaZulu-Natal. Logistics and warehousing was identified as the primary driver of economic development in Durban. The Dube Tradeport was designed to be export-orientated and specialising in efficient logistical management. Airports and allied support services and industries were regarded as useful strategies to attract international investment and improve a country's export capabilities (Devlin and Yee 2005). The Dube Tradeport is a business and market-orientated development. Economic growth and the expansion of core business units are primary strategies for this parastatal entity (Dube Tradeport 2008).

According to Freestone (2009), the ability to swiftly shift cargo in and out of a city has meant that airports can influence the function and form of the urban areas in which they are located. The movement of goods is fundamental for economic growth. According to Lindsay (2006), the global GDP and world trade value have grown by 154% and 355%, respectively, in the past 30 years. The value of air cargo, however, has risen by an incredible 1395% during the same period. In fact, in 2006, 40% of the total value of goods produced in the world was transported by aircraft. However, the bulk of the world's cargo is still moved by sea (Lindsay 2006). For example, over 95% of Durban's freight enters the city through the harbour. This is largely due to the cheaper costs of shipping cargo and also the fact that greater volumes can be transported by sea (Hilling 2003).

Investment in trade and logistics infrastructure is vital for developing cities that have fallen significantly behind the developed world in this regard (Devlin and Yee 2005). However, entering into a market and competing with well-established logistics centres in developed countries is not only difficult, but also costly. The development of the necessary infrastructure is capital intensive, and this is problematic for developing countries that already carry high levels of foreign debt (Hilling 2003).

The former DIA was more strategically located for the development of a multi-modal logistics platform because of the close proximity of the airport to Durban's harbour and major highways. The Dube Tradeport's location is still thought, by executives at the company, to be an optimal one because of its positioning along the N2 and between South Africa's two major ports—Richard's Bay and Durban (Dube Tradeport 2008). However, the aerotropolis is located 35 km from Durban's CBD and even further from both major harbours (Durban and Richard's Bay), the source of the bulk of KwaZulu-Natal's cargo. This results in a failure to maximise economic efficiency.

8 Airport Taxes and Tariffs

Airport taxes significantly impact on the viability of airports because high tariffs affect the number of airlines and passengers willing to utilise the facility. High tariffs deter airline companies and reduce the number of flights to and from the airport. This limits the viability of the airport across multiple scales. South Africa has a higher number of airport taxes than all of its neighbouring countries (International Association of Air Transport 2002).

According to the 2011 Leigh Fisher list of airport taxation costs (cited in ACSA 2012b), ACSA's airports were positioned as the 26th most expensive in the world. However, since that assessment was conducted, ACSA has raised its charges by 69.6% and changing South Africa's ranking to between the third and ninth most expensive airports in the world (Ollis 2012). The majority of the 25 most expensive airports in the world was large and highly connected, developed city airports. Another developing city airport on the Leigh Fisher list, Mumbai International Airport, was approximately two fifths cheaper to travel through than ACSA's airports (ACSA 2012b).

Ollis (2012) has argued that South Africa's airport taxes have priced the country out of international markets. These are the very markets to which these airports were designed to become gateways. This proposed connectivity was the primary justification for airport-centred, pro-growth development strategies in Durban. Alienation from such markets has a negative impact on the rate at which South African airports grow and also on the viability of KSIA as a second hub for airport for Durban. It is argued that lower airport taxes would significantly aid efforts to open international gateways from South Africa to other African regions and beyond (D'Angelo 2012). This would also make air transport more affordable for South Africans.

According to D'Angelo (2012:4) ACSA's "[airport] taxes have risen steeply this year at a time when airlines are already struggling as a result of high fuel prices and a drop in passenger numbers". This has resulted in the number of flights in and out of KSIA airports remaining relatively stagnant. It could also be a contributory factor to the inability to increase the number of international airlines flying to and from KSIA airport.

The taxes of South African airports have been significantly increased in recent years to recover the costs of the development of KSIA and the upgrades to other South African airports for the 2010 FIFA World Cup. The increases were 33% in 2010, 35% in 2011, and 31% in 2012 (ACSA 2012a). This increase has not only affected South Africans' ability to pay for and utilise air transport, but has also had an impact in the broader aviation industry, as it has limited the ability of low-cost airlines to compete. This was evident when the Durban-based Velvet Sky Airlines shut down in March 2012, and the closure of low-cost carrier 1Time Airlines in November 2021 (Styan 2012).

9 Conclusion

An airport serves to provide a first and last impression of a city to travellers. It also connects a city to foreign markets and investors. A world-class airport is a very influential resource in the competition between cities. One can argue that the development of KSIA was a political project. The airport was fast-tracked in order to become fully functional for the 2010 FIFA World Cup. This mega-event was a platform to market South African cities (Bond 2011), and the development of a large, world-class airport was also a useful political tool (O'Conner 1995).

This paper assessed the impacts of airport-centred development in Durban with specific reference to KSIA, Africa's first aerotropolis. KSIA was planned and designed to become the centre of the continent's first purpose-built aerotropolis and was expected to promote economic growth and promote opportunities for the poor in KZN, and to market Durban as a primary South African destination.

The grand plan was for KSIA to develop as a hub that services South Africa and international destinations. However, like the former DIA, KSIA remains a spoke airport, serving as a feeder to Johannesburg. In order to keep up with global airport development trends, a nexus of multi-purpose activities and a centre for retail, accommodation, industry, and other functions were established in and around KSIA. In fact, most large international airports obtain the majority of their revenue from non-aeronautical activities (Kasarda 2008a), and KSIA was planned to follow this trend.

The KSIA aerotropolis is evidence of the global trend of increasing private investment in airport-centred development. PPPs and the promotion of commercial investment in this region have resulted in a space that is governed by commercial, market-driven principles. The KSIA aerotropolis is a physical representation of an ideological neoliberal space. It has been developed to maximise economic efficiencies, enhance international market connections, and provide a business gateway from Durban to the rest of the world—the ultimate neoliberal project.

However, this aerotropolis project, as with most neoliberal ventures, comes with costs. Benefits are likely to be distributed horizontally amongst already high-income groups and especially amongst private investment companies, like the property developers. The majority of those living in the KZN province is unlikely to benefit from the trickle-down effects of the aerotropolis and multi-functional airport spaces.

This study suggests that airport-centred development is elitist, especially in developing countries, like South Africa, with high levels of inequality. The KSIA aerotropolis is a neoliberal project serving to benefit a select, affluent minority. It is also suggested that due to high levels of aviation competition, the distance between the airport and the city, and the low level of demand in Durban, the huge investment of public funds in this project may not be justifiable.

References

AECOM-McClier (2002) The Dube TradePort and The King Shaka International Airport: project overview and feasibility analysis (http://www.dubetradeport.co.za/SiteFiles/434/DubeTradePort-Pre-FeasibilityStudy-AECOMMcClier-2)

Airports Company of South Africa (2011) King Shaka International Airport: master document. Airports Company of South Africa, Durban, South Africa

Airports Company of South Africa (2012a) Airport Tariffs. Airports Company of South Africa

Airports Company of South Africa (2012b) Presentation to select committee on trade and international relations. Airports Company of South Africa
Appold SJ, Kasarda JD (2011) Seeding growth at airports and airport cities: Insights from the two-sided market literature. Res Transp Bus Manage 1:91–100
Arthur IK (2018) Exploring the development prospects of Accra Airport city, Ghana. Area Dev Policy 3:258–273
Banai R (2017) The aerotropolis: urban sustainability perspectives from the regional city. J Transp Land Use 10:357–373
Basu S (2004) E-government and developing countries: An overview. Int Rev Law Comput 18:109–132
Bednarek JR (2016) Airports, cities, and the jet age. Springer International Publishing AG
Bond P (2011) Limits of interurban entrepreneurial competition in Durban: structure and agency under neoliberal—nationalist municipal management, presentation at the american association of geographers AGM, 14 April, 2011. Seattle, Washington
Bond P (2014) Elite transition: from apartheid to neoliberalism in South Africa. Pluto Press, London
Bowen JT Jr (2016) "Now everyone can fly"? Scheduled airline services to secondary cities in Southeast Asia. J Air Transp Manage 53:94–104
Brueckner JK (2003) Airline traffic and urban economic development. Urban Studies 40:1455–1469
Button K, Lall S (1999) The economics of being an airport hub city. Res Transp Econ 5:75–105
Buyck C (2011) World airport report. Air Transport World 48(9):24–52
Charles MB, Barnes P, Ryan N, Clayton J (2007) Airport futures: towards a critique of the aerotropolis model. Futures 39(9):1009–1028
Cidell J (2015) The role of major infrastructure in subregional economic development: an empirical study of airports and cities. J Econ Geogr 15(6):1125–1144
Conventz S, Derudder B, Thierstein A, Witlox F (2016) Hub cities in the knowledge economy: seaports, airports, brainports. Routledge
Cosby M, Maharaj B (2016) Efficiency at any cost? a critique of aerotropolis development for King Shaka International Airport. In: Moore-Cherry N (ed) Urban challenges in a complex world—resilience, governance and changing urban systems. Proceedings of the IGU urban commission annual meeting 2015, University College Dublin, Ireland. Geographical Society of Ireland, Special Publication 14, pp 101–106. (https://igu-online.org/wp-content/uploads/2017/01/C12.39-Urban-Commission-Urban-Challenges-in-a-Complex-World-2012-16.pdf)
D'Angelo A (2012) 'Industry boss calls for lower airport tax to drive tourism'. Business Report, 13 September 2012, p 4
Devlin J, Yee P (2005) Trade logistics in developing countries: the case of the middle East and North Africa. Blackwell Publishing
Dube Tradeport (2004) Project scenarios: macro & socio economic impact assessment final report. Global Insight, Southern Africa. (https://www.dubetradeport.co.za/SiteFiles/490/Socio-EconomicFinalReport-pdf.pdf)
Dube Tradeport (2008) Strategic plan 2009/10to 2013/14. Dube Tradeport. Durban, South Africa
Dube Tradeport (2012) The Dube Tradeport. (http://www.dubetradeport.co.za/)
Freestone R (2011) Managing neoliberal urban spaces: commercial property development at australian airports. Geograph Res 49(2):115–131
Freestone R, Baker D (2011) Spatial planning models of airport-driven urban development. J Plan Lit 26(3):263–279
Furlong K (2020) Trickle-down debt: Infrastructure, development, and financialisation, Medellín 1960–2013. Trans Inst Br Geogr 45:406–419
Freestone R (2009) Planning, sustainability and airport-Led urban development. Int Plann Stud. 14 (2):161–176
Goetz AR (1992) Air passenger transportation and growth in the US urban system, 1950–1987. Growth Change 23:218–242

Golder Associates (2011) Economic impact assessment of the 2010 FIFA World Cup in KwaZulu-Natal—Draft Modelling Report. KwaZulu-Natal Department of Economic Development and Tourism
Hilling D (2003) Transport and developing countries. Routledge
Inggs M (2009) New airport 'will not be a white elephant". Business day, 12 March, p 1
Institute of Natural Resources (2007) Specialist community study. Institute of Natural Resources, Pietermaritzburg, KwaZulu-Natal
International Air Transport Association (2002) IATA list of ticket and airport taxes and fees. International Air Transport Association. (http://www.iata.org/SiteCollectionDocuments/Documents/SamplTaxlist.pdf)
Kasarda JD (2006) The rise of the aerotropolis. The Next American City 10(Spring):35–37
Kasarda JD (2008a) Shopping in the airport city and aerotropolis: new retail destination in the aviation century. Res Rev 15(2):50–56
Kasarda JD (2008b) Airport cities: the evolution. Insight Media, London
Kasarda JD, Lindsay G (2011) Aerotropolis: the way we'll live next. Penguin Books, London, England
KwaZulu-Natal Provincial Planning Commission (2012) Provincial growth and development plan: February 2012. KwaZulu-Natal Provincial Government, South Africa
KwaZulu-Natal Provincial Government (2019) Socio-economic review and outlook 2019/2020. (https://www.kzntreasury.gov.za/Socio%20Economic/SERO_FINAL_4_March_2016.pdf)
Lindsay G (2006) Rise of the aerotropolis. Fast Company, July/August, pp 76–85
Mavunda B (2019) Take a look: this is the 'Aerotropolis' that Durban's government hopes will bring in R1 trillion in investment. (https://www.businessinsider.co.za/king-shaka-will-become-an-aerotropolis-2019-9)
Mulder L (2009) Dube Tradeport evaluation system: a socio-economic impact approach. IHS Global Insight Southern Africa, Centurion, South Africa
Nel E, Hill T, Maharaj B (2003) Durban's pursuit of economic development in the post-apartheid Era. Urban Forum 14(2–3):223–243
News24. (2011) Airlines plan SADC Routes. https://www.news24.com/fin24/Companies/TravelAndLeisure/Airlines-plan-SADC-routes-20111116
Njoya ET (2016) Africa's single aviation market: the progress so far. J Transp Geogr 50:4–11
O' Conner K (1995) Airport development in southeast Asia. J Transp Geogr 3(1):269–279
Ollis I (2012) 'SA prices itself out of global markets'. The Mercury, 11 September, p 6
Otisa KM, Derudder B, Bassens D, Devriendt L, Witlox F (2011) Airline connectivity as a measure of the globalization of African cities. Appl Geogr 31:609–620
Pleumarom A (2017) The "aerotropolis" phenomenon—high risk development thwarting SDGs. In: Spotlight on sustainable development 2017 reclaiming policies for the public. Report by the Civil Society Reflection Group on the 2030 Agenda for Sustainable Development (https://www.2030spotlight.org/sites/default/files/download/spotlight_170626_final_web.pdf)
Rogerson CM (2018) Urban tourism, aerotropolis and local economic development planning: Ekurhuleni and OR Tambo International Airport, South Africa. Miscellanea Geographica 22 (3):123–129
Stats SA (2018) Quarterly labour force survey, quarter four 2018, statistical release P0211. (http://www.statssa.gov.za/publications/P0302/P03022018.pdf.pdf)
Styan JB (2012) Hundreds stranded as 1time cancels flights. (https://www.news24.com/fin24/Companies/TravelAndLeisure/Hundreds-stranded-as-1time-cans-flights-20121102)
Tarry SE (2000) Globalisation and the prospect of policy convergence in air transport. Glob Soc 14(2):279–296

Wang KJ, Hong WC, Chen SH, Jiang JT (2011) Strategic development trend and key factors analysis of Airport City in Taiwan. J Transp Geogr 19(4):807–820

Wisman JD, Smith JF (2011) Legitimating inequality: fooling most of the people all of the time. Am J Econ Sociol 70(4):974–1013

World Bank (2018) Overcoming poverty and inequality in South Africa: an assessment of drivers, constraints and opportunities. (https://www.tralac.org/images/docs/12929/overcoming-poverty-and-inequality-in-south-africa-world-bank-march-2018.pdf)

Meghan Crosby is a postgraduate student at the University of KwaZulu-Natal, Durban, South Africa. She has a specialist interest in the geography of aviation.

Brij Maharaj is a senior professor of geographer at the University of Kwazulu-Natal in Durban, South Africa. He has received widespread recognition for his research on urban politics, mega-events, segregation, local economic development, xenophobia and human rights, migration and diasporas, religion, philanthropy and development and has published over 150 scholarly papers in renowned journals such as Urban Studies, International Journal of Urban and Regional Studies, Political Geography, Urban Geography, Antipode, Polity and Space, Geoforum, Migration and Development, Local Economy, and GeoJournal, as well as five co-edited book collections. He is a B-rated NRF researcher. He is a member of the Academy of Science of South Africa.

Drivers of Socioeconomic Development and Underdevelopment in Moroccan Sahara

Suresh Kumar and Deepak Kumar

1 Introduction

The topography is the major reason for the underdevelopment of the Sahara province. Southern Provinces or Moroccan Sahara or Sahara province geographically consists of the southern part of Morocco. The topography is mainly made up of low, flat desert with large areas of rocky or sandy surfaces rising to small mountains in the south and the northeast. The lowest point is the salt flat of SebhetTah at 55 m below sea level, and the highest (unnamed) point is 463 m. The Saharan climate is continental; the winters are cold and dry, while the summers are scorching. The temperature can rise above 50° in the shade. Due to the proximity of the ocean, the humidity is relatively high, so the weather is unpleasantly humid. The dryness of the weather is perceivable by the rainfall statistics, which is utterly minimum with an average value of merely 45 mm, even in Dakhla, lying on the ocean shore. The wind is an active agent and brings significant problems all over the Saharan territory as it carries the sand particles. It can cause skin irritation or inflammation of the eye, which causes the locals to cover their heads and faces with a scarf always. The most unpleasant is the windstorm which is locally called 'Irifi'. The extremely dry and hot wind arriving from the northeast is called 'Sirocco', which covers everything with sands causing minimal visibility between 1 and 2 m. The storms occur between October and March, but sometimes in the summer, though not very frequently (Damis 1983:2).

Sahara province's territory is stretched over a vast area of 102,703 sq miles (266,000 sq km), NW Africa, a northern part of Morocco. It is bordered by the Atlantic Ocean along the west, Algeria along the northeast, and Mauritania along

S. Kumar (✉)
Department of African Studies, University of Delhi, Delhi, India

D. Kumar
Swami Sardanand College, Delhi, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_11

the east and south. The 2007s estimate of population is 382,617 in this province. El Aaiun, having a population of 198,200, is the largest city in this region. The currency is called 'Tala' (Territory 2020: emphasis mine). This region is divided into four districts—Laayoune, Essemara, Boujdour, and Oued Essemara. Essemara is highly arid and almost entirely covered with stones, gravel, or sand. The eastern rocky highlands is reached up to 1500 ft (460 m). The main towns are Laayoune (formerly El Aaiún), Dakhla (formerly Villa Cisneros), Boujdour, and Essemara. Along the coastal area, cold offshore air currents produce fog and heavy dew.

Damis (1983) has classified the Sahara province into two divisions—Saguiet El-Hamra in the north having 31% of the land and Wadi ed-Dahab (Rio de Oro) in the south having 69% of the land. Dry riverbeds characterize the northern zone. Saguiet El-Hamra, the most important one, is known as the 'Red Canal' and lends its name to the region. It accumulates the surface run-off that occurs during the short rainy seasons, generally in the autumn. Because of the high temperatures, most of the water vaporizes before it reaches the sea. Sufficient vegetation for grazing grows along its banks, and barley and corn are cultivated at Smara.

In Wadi ed-Dahab, the ground is too permeable to retain the autumn waters and too flat to flow; hence, water is stored in the subsoil, and there are only a few scattered wells. Around the coastline, apart from a few minor settlements, there are no living habitations.

> The majority of the people earn for a living as fishermen or by raising camels. Their number increases with the approximately 160,000 Moroccan fishermen, who temporarily work on the coastline in the summer and early autumn (Besenyo 2009:17).

Rain is rare, and there are no permanent water bodies. Saharawis faces a significant problem of water scarcity as they had no place for drinking water. This hardship in the life of Saharan tribes compels them to rush to different places, and, consequently, no social organization has come into the forefront in this region.

> The population is predominantly made up of Arabs and Berbers. The pastoral nomads migrate into the territory during the rainy season. Both Hasaniya Arabic and Moroccan Arabic are spoken as most of the population is Sunni Muslim (Territory 2020: emphasis mine).

The political organization of the Saharan tribes was typical. Inter-tribal wars have been a significant feature of desert societies in the past. The hard realities in the desert were that all the tribes used to compete for pastoral resources, water resources, and livestock, all of which were scarce in the desert. There were no significant forms of human organizations or supra-tribal state authority that could maintain order in Sahara. At this backdrop, there were no modern kinds of tribal political organizations. Each tribe or fraction regulated its affairs through an assembly called 'Djemma'. It consisted only of the heads of families who enjoyed due respect because of their bravery, age, wisdom, piety, or wealth (Saxena 1995).

> The Djemma framed laws to supplement the Islamic judicial code, Sharia, and appointed a judge to administer justice. At the tribal level, this assemble was known as the Council of Forty. The Council of Forty used to be called in session in time of war or grave crisis, to organize the tribe's defense or a raid, and to appoint a military commander (Saxena 1995:6).

The inhospitable nature, the vastness of the desert, the sparseness and dispersion of its population discouraged government authorities stop raiding one tribe against another as the other was living hundreds of miles away, which were quite common in those days. The main object of these raids was to capture livestock. Such raids were not difficult for the desert tribes despite the inhospitable terrain. They had enough meant of war such as camels and firearms besides their riding ability and the knowledge about the terrain. Sometimes some tribes would enter into alliances or pacts for mutual protection and assistance necessitated by the insecurity of the violent desert. The crop cultivation did not occupy an important place in the economy of the desert because of the absence of oases. Moreover, the nomads hated rendering services as agricultural laborers. The tribes were employed chiefly as slaves for the cultivation of barley in the rain—collecting depressions. Besides agriculture, fishing also remained an untrusted source of occupation to most of the Saharawi people. They were not engaged in fishing despite the Atlantic Ocean off the Sahara province coast, which was very rich in marine resources and fishes. However, only the tribes with more impoverished economic conditions living in coastal areas were engaged in fishing.

> The camel and the goat meat were their needs as far as the food habits are concerned. Camel's hair was used to weave the nomad's tents; its skin was used as leather, and its milk as part of their diet. In order to meet their other needs, the nomads used to visit important trading centers where they used to exchange their camels or their wool and skins for cereals, tea, sugar, weapons, and other manufactured goods (Damis 1983:7).

Sometimes they also acted as guides for caravans passing through the desert. These are the most important things for the tribal people in the region as they were totally dependent on this kind of works. It is difficult to say about the total population of the Saharawi population in Sahara province as it is not possible to have exact head-counts.

The desert's physical conditions are mainly responsible for the underdevelopment as the indigenous people living here move from one area to another in search of water and pastures for their animals regardless of international frontiers. Therefore, at any time, their numbers within a fixed territory have fluctuated considerably. Moreover, a large number of the Saharawi population had to leave or were forced out of the territory in the wake of armed resistance against Spanish and French forces in the late 1950s.

> Many Saharawi settled in Morocco after being forced out of the territory of Western part of Sahara. A large number of Saharawi left the territory (even before 1975) for economic or other reasons to live temporarily or permanently along with their tribal kinsfolk beyond the

> frontier. Further, because of the close affinity Saharawi of Western part of Sahara and interference of the neighboring countries, made it difficult to decide which Saharawi are indigenous to Sahara and which are not (Saxena 1995:7).

In contrast, Morocco always used to be a hereditary monarchy enjoying absolute powers, and in Mauritania, it was the strongest tribe used to rule over the weaker ones. The Sahara tribe rarely used to assemble at one place as they were scattered over huge distances in small groups.

Sahara's economy is dependent on pastoral nomads, fishing, and phosphate mining (Table 1). Along with it, the history of economic exploitation, under the privilege of four districts of Sahara province such as Laayoune, Essemara, Boujdour, and Oued Essemara, demands a considerable degree of autonomy within Morocco (Ottaway 2012). It will forge a sociopolitical culture characterized by interpersonal interchanges and better marketing relations. Specifically, this is a move toward the decentralization of geo-natural resources, strengthening the cooperation of provinces toward the Center, the Center provides the necessary minimum basic needs (bread, cloth, and shelter) to all, and it is a move toward the development of civil society (Achy and Sekkat 2014: emphasis mine).

The traditional economy is limited to raising goats, camels, and sheep and the cultivation of date palms. There is a limited scope of coastal fishing as well. Large deposits of phosphates at Boukra (near Laayoune) were first functioned by a Spanish-controlled firm in the early 1970s, and at present, Morocco has taken control of the firm. Potash and iron deposits exist at Agracha. There is a growing tourist industry also (Table 1).

It is the time to visualize and analyze the economic plunder and exploitation of natural resources by the colonial powers and leave the Sahara province's future in the geopolitical conflicts. A limited transportation network severely hinders the region. The main seaports are Dakhla and Laayoune, through which the phosphates and dried fish are exported, while fuel and foodstuffs are the principal imported commodities. The mineral industry serves as the largest foreign exchange earning sector in Morocco. It usually accounts for about 35% of foreign trade and about 6% of the gross domestic product (Harold 2008).

Table 1 Southern Sahara Region

Languages	Hasaniya Arabic and Moroccan Arabic
Ethnicity/Race	Arabs, berbers, and nomadic
Religion	Islam (Sunni)
Agriculture and livestock	Cultivation of date palms, sheep, and camel
Industries	Dry fish, phosphates, potash, iron, and tourism
Natural resources	Phosphates, iron ore, manganese, lead, zinc, fish, and salt
Communication	Mobile and wireless

Source The Columbia Electronic Encyclopedia (2010), 6th ed. 2007. Columbia University Press. http://www.infoplease.com. Accessed on 22 Oct 2010: emphasis mine

> Current mining legislation in Morocco is based on Mining Code Bill No. 1-73-412 of August 13, 1973. Regulations concerning the management of petroleum and natural gas resources were revised in 1992 to provide further international companies incentives. The gross weight of Phosphate rock as per the available data of 1997 that includes Western Sahara was 23,084 thousand tons (Harold 2008: emphasis mine).

2 Geopolitical Drivers of Underdevelopment

Sahara province, geopolitically being rich natural resources, has become a bone of attraction for the neighboring countries, particularly Algeria. The Popular Front for the Liberation of the Saguia el Hamra and Rio de Oro (Polisario), based in the Tindouf region of Algeria, is demanding the separation of Sahara from Morocco.

> That the conflict has fallen into the grip of an apparently irreconcilable political stalemate suggests that for each party the status quo is something between tolerable, at least preferable to the likely alternatives, and for some perhaps even desirable (Zoubir and White 2016:128).

The costs are also regional, as the unresolved conflict impedes North African integration (Zoubir 2010:72). Today, the Polisario is working from the Tindouf camp, a territory from Algeria bordering the western part of Sahara, and is involved in the political disruption.

Mohamed Cherkaoui pointed out that sociologically, it concerns the social bond between Saharawis and the rest of the Moroccan population.

> It has never been dealt with as systematically and rigorously as it deserves. I devoted the bulk of analyses of it and tested the hypothesis that these bonds do exist, that they are not just historically established but that they form today a social fabric of such homogeneity, density, and power that can hardly be ignored in any final settlement of the Sahara problem (Cherkaoui 2007: x: emphasis mine).

It is noteworthy that today Morocco continues to complete its integrity like India who got independence in 1947, achieved complete territorial integrity and unity after the recuperation of Goa, Diu and Daman from the Portuguese in 1961 and Pondicherry from French colonizers in 1963. Geopolitics, regionalism, and territorial integrity issues remind the world that the Polisario during the Cold War had received the military armaments through the USSR and other socialist camps (Algeria, Libya, and others) of Africa. However, the post-1990s hard reality is that Polisario has no weapon support from anywhere except Algeria. The common Saharawis are looking forward to an amicable solution on the issue of development of the Western part of Sahara. Moroccan Government has raised this issue of Sahara in the UNO several times, but it became the 'action-reaction' story of Cold War politics. As a result, this issue is still debated on different platforms.

Mr. Pranab Mukherjee, the then President of India, reiterated during his opening speech on July 25, 2012, and reminded the world:

> Peace is the first ingredient of prosperity. History has often been written in the red of blood; but development and progress are the luminous rewards of a peace dividend, not a war trophy. The two halves of the 20th Century tell their own story. Europe, and indeed the world, reinvented itself after the end of the Second World War and the collapse of colonization, leading to the rise of great institutions like the United Nations. …We are in the midst of a fourth World War; the third was the Cold War, but it was very warm in Asia, Africa, and Latin America till it ended in the early 1990s. The war against terrorism is the fourth; and it is a World War because it can raise its evil head anywhere in the world. India has been on the frontlines of this war long before many other recognized its vicious depth or poisonous consequences (The Hindu 2012).

The revised Moroccan constitution of 2011 is an initiative to resolve the Sahara dispute and work for territorial integrity within the new constitution's framework. The Finance Minister of India has expressed India's support on the Sahara issue for the UN-led political process and acknowledges Morocco's effort to reach a long-lasting and mutually acceptable solution to the territorial dispute (India Opinion 2020: emphasis mine).

The Indian Finance Minister, on the Western Sahara issue, has expressed India's support for the UN-led political process. He has also expressed India's acknowledgment of Morocco's efforts for reaching a long-lasting and mutually acceptable solution to the territorial disputes.

It has adopted the chapter on regionalism. Regionalism has frequently been associated with tribalism in some of Africa's new nations, and Morocco is not an exception. Article III of the Constitution of Morocco confirms the fundamental constituents of the diversified Moroccan identity. These tribal communities, whether in India, South Africa, Nigeria, Ethiopia, or Morocco, are reinforced by marked linguistic, cultural, and other traditional peculiarities. The Morocco constitution's characteristic feature provides enough space for the growth of regionalism (see Article XI, Regional and local democracy, and advanced regionalization) (The Constitution of Morocco 2011). However, 'the Moroccan State certainly retain its powers in the royal domains, especially those related to defense, external relations and the constitutional and religious prerogatives of His Majesty the King' (El Ouali 2012: emphasis mine) (Figs. 1 and 2).

Geographically, the post-1990s globalization has broken the backbone of the Polisario Naxalite Movement and monetary assistance related to it. Supporters of this divisive ideology have collected millions of dollars as income in the name of freedom, redistribution of wealth, and equality until the 1990s (shared during my meeting with the Saharawi people in 2018). The Western Sahara Separatist Polisario Front's 'unilateral' decision to evacuate all foreign aid workers from its Tindouf refugee camps is yet another indicator of the volatility of the Sahara's security situation.

> The Algerian-backed separatist guerilla movement is headquartered in Southwest Algeria, where hundreds of Polisario fighters are stationed. Recent press reports indicate that dozens of former Polisario fighters who fled the refugee camps to join terrorist camps in Northern Mali have returned to Tindouf since the beginning of French military operations in Mali (Hassan Masiky 2013).

Fig. 1 Typical Moroccan Sahara topography, snapped in 2018. *Source* Suresh Kumar

Polisario's vicious ideology presently does not get any income or political support from the world community in the name of the revolution. Polisario has changed its financial income tactics and has given it the name of humanitarian donation, medical support and roof for all, hygienic food for all, and support for Polisario in UNO since the 1990s. The author (S. Kumar) has spoken in the Special Political and Decolonization Committee (Fourth Committee) of the United Nations Organizations at New York on October 09, 2012, and received the Polisario activities' details based on its ideology.

> Mr. Braham Ghali, Secretary-General of the National Secretariat of Polisario, has used these millions of dollars in his personal use and found drowned in corruption (MAPE, 29 May 2020: emphasis mine).

The historical 'truth' of the 'revolutionary' leader's corruption cases has come out only after the political change in their countries. Polisario's vicious ideology has befooled the Saharawi's people at large. Their leadership has enjoyed a lavish lifestyle on humanitarian donations and having significant bank balances of black money. Reviewing the historical development of Morocco shall be twofold.

- Firstly, to delineate the politico-geographical factors that were primarily responsible for creating among the constituent units strong regional identities and the consequent desire for separate existence and

Fig. 2 Tan-Tan Festival, Moroccan Sahara, 2018. *Source* Suresh Kumar

- Secondly, to isolate the factors that overwhelmed their feelings for separatism and persuade them to unite into a functioning regionalism.

From the two sets of factors, one would proceed to infer the general relationships among the Center and Sahara region. It has helped to raise the geopolitical regionalism in each case and arrived at specific hypotheses regarding the origin of regionalism in Morocco (Kumar 2013: emphasis mine).

3 Sahara Autonomy and Issues of Development

Sahara province has been experiencing the approach of self-determination of decentralization for the last decade. The statute of autonomy resulting from negotiations will be subject to consultation with affected populations through a referendum under the guarantee of the new Constitution's relevant provisions (El Ouali 2008: emphasis mine). This approach has initiated the process of territorial democracy cum autonomy in Sahara province. The region has started work from scratch to develop and move toward sustainable development while sharing power between the Center and local communities. The division of power and practices in the democratic system of governance marks popular sovereignty. It further strengthens the idea of economic decentralization in which the provinces enjoy the autonomy to spend the finance for development in the true sense. However, this approach is not appropriate unless the communities concerned have both the capacity and the desire to form an independent central government and form independent regional governments. Sahara is working on it (Kumar 2013: emphasis mine).

Moroccan constitution enshrines advanced regionalization under Article 2 to redistribute the powers between constitutional institutions based on a democratic reorganization of powers between the State and the regions (The Constitution of Morocco 2011:4). The central and regional governments are each within a sphere, coordinated and independent, limiting the powers of both central and regional governments. It guarantees the Saharan demands for constitutional autonomy. Article 63 further explains the regionalization system in which 'one-third of seats are elected through regional councils by direct suffrage' (The Constitution of Morocco 2011:18). This was one of the significant demands of the Saharawis to have a right to elect the members of their Regional Councils. Article 36 says, 'The principle of free administration assures the participation of the population concerned in the management of their affairs and favors their contribution to a complete and lasting human development' (The Constitution of Morocco 2011:35). The self-management system in Sahara autonomous region works for regional planning, promotion of investment, trade, industry, power generation, transportation, tourism, and agriculture. Sahara's self-management system will raise taxes, duties, and regional levies, work to explore natural resources, and build the self-sustained Sahara region. The Latin American trade block, comprising Chile, Colombia, Mexico, and Peru, has expressed its support for Morocco's Autonomous Plan in Sahara province (Latin America 2020: emphasis mine).

Decentralization is based on the principle that the central government should coordinate and operate through the regional governments in some important matters (infrastructure development, house, education, health, employment, and social security). During the 75th session of the UN General Assembly's Special Political and Decolonization (Fourth) Committee, Jordon supported Morocco's position in Sahara province to find a mutually acceptable political solution (Jordon 2020: emphasis mine). The duly elected Head of Government needs to coordinate with the regional governments of the different regions, including Sahara, to strengthen development projects. Moreover, Saudi Arabia and United Arab Emirates (UAE) have expressed their support for Morocco's territorial integrity. They also expressed trust before the UN General Assembly Fourth Committee concerning the Autonomous Plan and the UN-led processes to solve the lingering territorial dispute (Saudi and UAE 2020: emphasis mine).

The National Human Development Initiative (INDH) 2007 is designed to improve inclusiveness, accountability, and transparency of the decision-making and implementation processes at the local level to enhance the use of social and economic infrastructure and services by the poor and others vulnerable groups. 'The program covers eradicating poverty in rural areas, social exclusion in urban areas, the eradication of extreme vulnerability while also maintaining INDH governance mechanism and strengthening institutional capacity' (Arnold Guy 2009:81).

INDH works to fight against poverty alleviation, development of infrastructure, and socioeconomic development.

> The most recent survey data that were publicly available for Morocco's MPI estimation refer to 2011. In Morocco, 18.6 percent of the population (6,636 thousand people) are multidimensionally poor, while an additional 13.2 percent are classified as vulnerable to multidimensional poverty (4,700 thousand people). The breadth of deprivation (intensity) in Morocco, which is the average deprivation score experienced by people in multidimensional poverty, is 45.7 percent (Human Development Report 2019:6).

The poverty alleviation program under IDH shows affirmative implementation, and it will work for societal and economic development.

4 Drivers of Socioeconomic Development

Sahara province's natural resources consist mainly of phosphate deposits which are used for commercial fertilizer. However, it is valued particularly for its uranium content. The phosphate deposits were discovered in 1960 by the Spanish, and the Moroccan Government launched the mining. Phosphate revenue is one of the main reasons to attract other neighboring countries to Morocco. Sahara region's annual phosphate production is around two million metric tons only, and the reserves allow continuous and profitable mining for several more decades. According to the latest research and findings,

> Southern Morocco is extremely rich in minerals, particularly in iron ore, uranium, titanium, natural gas, and oil. Some geologists say that vanadium is also abundant in this territory enough to consider its mining, which then would result in high profit. The Spanish found oil already in the 1960; however, they did not attempt to launch offshore drilling due to the underdevelopment of the area in economic terms (Janos 2009:17).

The phosphates sector contributes to positive growth (6% of RGDP) and employment. Apart from phosphates, mining prospects are potentially interesting. However, it needs more effort to explore the region's underground by both the government and private stakeholders, provided that the institutional framework is clarified. In parallel, transport is the sector that needs massive investment as part of the government's infrastructure development despite some persisting projects, such as the trunk road-I at Guelmim and the Dakhla Atlantic Port project. Air transport remains insufficient primarily and constitutes a handicap for the region and its development.

The author personally visited the southern coast of Tan-Tan province and found that about 1500 km of this coastal area is rich in the fishery and other marine resources. Fish industries having processing and packing facilities in the Tan-Tan province engage the local people to a limited extent. The southern coast needs to invite the industrial sectors having onsite processing capacity, the market valuation of seafood, and refrigeration facilities of the fishmeal. The government should issue offshore fishing licenses and start the skill development program for the local youth in fishing and its marketing. There are several claims that this coast has a rich reserve of oil, hydrocarbon, and marine resources to strengthen the Moroccan Sahara economy. The source of renewable energy (of wind and solar) is rich in the southern coast, needs investment in generating the potential power, its connection to the national supply chain, and needs industrial training institutes of power to train the local youth.

Property and construction activities have become a feature of almost all the Saharan towns of Southern Morocco today.

> This speculation in real estate, coupled with demographic growth and an especially high level of urbanization in the region (71.5 percent in 2004, compared to an average of 55.1 percent for Morocco), has also contributed to the appearance of areas of unregulated, informal, or precarious housing in some towns, such as Laayoune (McDougall and Scheele 2012:220).

The government should attract investment in the housing infrastructure and share the blueprints of the urban development plans.

Sahara province should attract the business environment with tax exemption, liberal rules on land grant policies, adopt single-window clearance for business investments, and transparent business policies to strengthen its economic goals. The government white paper trade policy will minimize the unstructured form of the economy dominated by the informal sectors and strengthen logistics services. In meetings with the different tribal groups of Sahara province, the author (S. Kumar) has been stunned to know that they incorporate rich traditions of art and craft, weaving, tapestry, leather goods, jewelry, food and drink culture. These ethno-cultural products can be globalized through proper training to the artisans. Providing an attractive market could promote the local people.

The territory has real potential in agriculture and livestock, practiced in the form of oasis, high added-value vegetable gardening, and camel breeding. Reportedly, southern provinces' 1.2% area is the utilizable agricultural area (UAA), and it is primarily located in the Guelmim-Es-Smara region. However, despite a diversified production, the agricultural sector's contribution to RGDP does not exceed 2% and contributes only 5–10% of employment (Green Morocco 2018). The main limiting factor in this sector is the challenge of mobilizing water resources. Livestock farming is predominant in the southern provinces. It involves camels, goats, sheep, and, to a lesser extent, cattle for milk production. Camel breeding has great potential for the development of youth employment in the region. However, it suffers from the absence of a valuation framework for the entire value chain, including developing rangelands, organizing breeders, encouraging downstream structured aggregators, modernizing and creating derivatives, and adapting distribution and marketing channels.

> The territory is experiencing major water stress combined with minimal water resources. These limited resources (180 mm^3 per year) are strongly dedicated to drinking water, 63% of the total consumption in the Saharan basin versus 4-9% elsewhere (CES 2020).

The limited water resource hinders the agricultural potential in Dakhla and Guelmim and over-pumping of water is a threat in protecting the deep groundwater. Insufficient exploration budget, the high cost of financing dams in Guelmim, and the constraints to setting up a desalination plant have arisen as the major hindrances.

The southern provinces have a rich natural and cultural heritage. The territory is located at the intersection of two significant cultures (Amazigh and Hassanya). It boasts a solid and unique cultural identity in Sahara. However, tourism's economic impact is still low, not exceeding 1.5% of RGDP and 2% of jobs (Tourism 2020). There are several constraints—poor promotion, lack of sufficient air connections, high air travel costs, and private entrepreneurs' timidity to develop niche products in Saharan oasis tourism by highlighting local cultural aspects. Large-scale projects can contribute to enhancing connectivity, such as the achievement of the South Atlantic harbor at Ntirift, north of Dakhla, and the upgrading of existing ports and facilities. The creation of a regional airline would allow air services targeting specific countries for tourism and export purposes. It is crucial to improve connections with the southern regions to promote their effective integration into the vast maritime economic area from the northern coast to West Africa and the Canary Islands.

The settlement is significant in the Sahara for the socioeconomic development of society. It will generate the fulfillment of basic needs of education, health, employment generation, and social security. Retail businesses come second (84 cases), and other property, including tele-boutiques (privately owned public telephone booths), third (53 cases), followed by cafes, transportation services, livestock herds, and travel agencies (James McDougall 2012:220). These are the parameters of the socioeconomic development and need to expand in the whole Sahara region. The Laayoune-Boujdour region is a diversified economic hub leveraging the region's strengths and assets in the development of the primary economic sector, e.g., fishery, camel industry, and agriculture. The development of an industrial center for the South phosphate processing as part of an integrated chemical complex may produce a wide range of fertilizers and construction materials. In the tertiary sector, trade and logistics platforms, niche craft, and tourism hubs may be the rational decision. The region will consolidate its position as an administrative center, evolving into a hub for the southern provinces and sub-Saharan Africa. The Oued Ed-Dahab-Lagouira region economic hub is having sectors of fisheries, agriculture with high added value, renewable energy, niche tourism, and logistics and trade. The region can potentially play a key role in terms of integration with sub-Saharan countries. The Guelmim-Es-Smara region's development could link the Kingdom's northern and southern parts. It will be based on the emergence of a vibrant, diversified social and agrarian-based economy (agriculture, livestock, crafts), responsible seaside tourism, oases, mountain ecotourism, and measures to catch up with human development and poverty eradication indicators.

The southern provinces boast assets, which can enable them to establish themselves as leaders in the production of renewable energy, 'particularly wind energy, in Dakhla, Tiskrad, Boujdour, Tarfaya, Akhfennir, and Laayoune, ensuring a 400 kva interconnection of Dakhla to the national grid, as a prelude to a connection with the Mauritanian network' (CES 2020).

5 Special Economic Development Drive

Moroccan Government's regional development model mandated for elaborating model to the Economic, Social and Environmental Council (ESEC) in November 2012 and proposed development spanning between 10 and 15 years. The ESEC was formed for the development of Sahara province through boosting up the economic and social growth. The ESEC focuses on diverse aspects—fundamental rights and services, developing knowledge training and culture, preventing marginalization, supporting social and civil dialogue progress, protecting the environment, making strong governance and economic security, and promoting the private initiative and social democracy. The ESEC aims to promote the establishment of a regional economic system that stimulates growth, creates wealth, and generates jobs, especially for young people. It targets mobilizing all segments of society in the southern provinces, fostering their fulfillment and well-being, and promoting their integration while respecting their cultural specificities (Regional Development 2020).

The government has impressed the global market economy by appointing Mr. Chakib Benmoussa as the Head of the New Development Committee (NDC). NDC is designed to make practical contributions to the country's development perspective (MAPE, 20 November 2019: emphasis mine), principal of which are the followings:

- The NDC acts as an advisory body that works as a check and balance in the different economic development parameters. It focuses on the different ongoing economic reform programs in the different provinces in various sectors such as education, health, agriculture, investment, and taxation.
- The NDC is authorized to make the proposals to strengthen the effectiveness of the different development reforms in the country and submit its reports from time to time.
- The NDC objectively focuses on the competence and performance of the public and private sectors in the impartial services of the country's development. This model involves populations living in the recovered provinces and connecting them with their history and social ties.

5.1 *Sports Investment in Sahara*

Morocco in Africa has created several economic investment opportunities in all sectors and has become a favorite destination for investors. Moroccan vision of 31 million dirhams' sports projects is the new initiative to develop the Olympian skill training among the national and international sports players. These projects refer to building international swimming pool facilities under a green environment to enhance sports professionals' stamina and attract international investors to work in this field. Morocco has already established good ties among chemical industries, pharmaceutical and renewable sector such as plastic recycling sector, fiber optic components manufacturing and automotive industry. Morocco today focuses on the building of international standard universities infrastructure, developing education and professionals along with the idea of developing world-class education hub (Renewable 2020: emphasis mine).

5.2 Bank Reforms for Rural Development

Morocco understands the backbone of economic development and focuses on its rural infrastructure investment. It has created several economic investment opportunities in all sectors. HM King Mohammed VI, in continuation of the investment-friendly environment, has announced the lowest interest rate of 2% on bank loans to the investment beneficiaries of the Integrated Program for Enterprise Support and Financing (SME Financing 2020). Ministry of Economy, Finance and Administration Reform, the Bank Al-Maghrib, and the Groupement Professionnel des Banques du Maroc (GPBM) have coordinated this program. The scheme could be effective for the small- and medium-sized enterprises and young project holders who require a significant reduction in these rates to promote entrepreneurship, create employment, and gradually mark a shift in the mindset related to bank loans. The banking sector highlights that the scheme will further establish an unlimited refinancing mechanism. A preferential rate will increase the global market's guaranteed rate and maneuver the international investors in developing Morocco's rural infrastructure. In addition to it, HM King Mohammed VI has further strengthened the Hassan II Fund and announced the amount of 2 billion dirhams without interest rate for the development of entrepreneurship and financing sector in the rural areas. No doubt, it will promote the emergence of the rural middle class. It will further strengthen the rural development sector's investment opportunities irrespective of temporary weather vagaries and fluctuation in the agriculture goods price in the domestic and international market. These reforms will work in the current international market smoothly on the one hand and respecting the WTO guidelines on the development of the agricultural sector, including rural development on the other hand (MAPE, Bank Reforms, 29 January 2020: emphasis mine).

5.3 Social Development for Sahara Youth

Souss-Mussa borders the southeast of Tindouf province of Algeria. The youths of the Souss-Mussa region get a plethora of multi-cuisine activities under 'Argana' for listening and guidance, houses reception, entrepreneurship, employment and listening spaces, auditorium, workshops, media library, sports hall and mini football field of nearly 07 million dirhams, recently announced by His Majesty King

Mohammed VI. The budget of 18 million dirhams has been granted under the third phase (2019–2023) of the National Initiative for Human Development (INDH) in the Souss-Moussa region. It aims to preserve the dignity of citizens and improve their living conditions and the development of human capital. The *Dar Momkin cultural space* of Lagouira and *Les etoiles du Souss* in the El Farah neighborhood focuses on 18–28 years youth in developing their new skills of reading, writing, theatre, music, and video activities. It needs a budget of another 6.7 dirhams under the INDH program. Similarly, *Les etoiles du Souss* enrolls 350 youngsters of 6–28 years old and offers different courses on theatre, plastic arts, dance, drama, music, and foreign languages. The inauguration of the prefecture of *Inezgane-AitMelloul* will improve young people's income and economic inclusion by providing a variety of tools in strengthening entrepreneurship and guaranteeing them better socioeconomic integration. 'This plan encourages the labor market, better job opportunities, and young business entrepreneurship not only to set up their business only but producing more employment opportunities for the local people in the region. The government has provided 28 mini-buses for school and sports transport' (MAPE, Youth, 13 February 2020: emphasis mine).

5.4 Women Empowerment in Sahara

The continuous women-centric systematic development program has been launched under the government's guidance. Consequently, the different sectors will nourish the holistic development of women in Morocco. The UNDP Sustainable Development Goals mention women empowerment and focuses on professional education, medical and engineering, technocrat, legal education, entrepreneurship, and political and economic empowerment. In the Africa Summit of 2018, the Moroccan monarch emphasized additional efforts to achieve gender equality across the continent. 'As a result, women today account for 11.8% of professionals that Morocco appointed to senior positions in public institutions between 2012 and first semester of 2020 as per the Human Resources in the 2021 Finance Bill' (Women empowerment 2020: emphasis mine).

The slogan of '*Equality to All*' in Morocco has been enshrined and practiced in the society, which has been clearly visible even during the Global Women's Forum 2020 in the USA. Her Highness Madam Ivana Trump has praised Morocco's efforts in strengthening women's empowerment and achieving the goals of SDG. Moroccan women's contribution in the global development process has been appreciated that will lead to real entrepreneurship in terms of employment generator and not employment seeker in the country and the world (MAPE, 18 February 2020: emphasis mine).

5.5 Diplomatic Development in Sahara

The government is extending the fraternity in the neighborhood countries. The Moroccan Government has opened the office of the Consulate General in Dakhla region on October 23, 2020. It connects the Republic of Equatorial Guinea, the Republic of Guinea Bissau, and Burkina Faso. The inauguration ceremony of these consulates was chaired by Mr. Nasser Bourita, Minister of Foreign Affairs, African Cooperation and Moroccans Abroad, and his counterparts Mr. Simeon Oyono Esono Angue of Equatorial Guinea, Mr. Suzi Carla Barbosa of Guinea Bissau, and Mr. Apha Barry of Burkina Faso. This connectivity builds rapid transactions in trade and commerce, encouraging tourism and people-to-people connectivity. It is noteworthy here to mention that the Moroccan Government has already started working from the newly inaugurated offices of the Consulate General in Gambia (January 7, 2020), the Republic of Djibouti (February 28, 2020), and the Republic of Liberia (March 12, 2020) for the development of North and South Corridor in general and development of Sahara region in particular (MAPE, Consulate, 24 October 2020: emphasis mine).

6 Post-Pandemic Development in Sahara

The good health of every citizen reflects the health of the country. It builds a healthy nation that produces good wealth and wise people. Marocco has successfully fought against the epidemic of COVID-19. His majesty underlines that the government, various public authorities, and health workers took stringent measures and hard resolutions to control the coronavirus and deserve a big thanks and note of appreciation. As a result, the country has protected the citizens and acted in the Nation's best interest. The royal family and all the citizens pay the indebtedness toward the role of medical and paramedical, civil and military executives, members of the Royal Armed Forces, Royal Gendarmerie, officials and auxiliaries of authority, components of the National Security, Auxiliary Forces, Civil Protection, all workers involved in the production and distribution of foodstuffs, and all those stood in the front line to fight against the pandemic.

Along with it, the people's spirited discipline and responsibility and civil society actors, working with a good spirit and a level of awareness during the lockdown period, provided mutual aid and voluntary services to the elders and needy families. It is noted that most of the production houses have been badly affected and need special treatment. His Majesty Mohammed VI has created a special fund to revive these sectors and has enabled 33 billion 700 million dirhams for it. The procurement of necessary medical equipment and the Central Guarantee Funds has enabled the country's economy getting recovered in the post-pandemic period (MAPE, Corona Virus, 30 July 2020: emphasis mine).

The government has focused on the health sector and future economic plans. As far as the health concerns of the Moroccan citizens, the government's thematic committee will act to reform this sector by collaborating with the private health sector in preserving the safety and good health of the people. The post-pandemic fund focuses on the Small and Medium Enterprises (SME) in strengthening the health sector and other production units. This affirmative step is expected to generate employment opportunities and revive the different income sources. It should carry the benefit to more than 20,000 business units having the state-guaranteed loans amount to MAD 26.1 billion. This investment fund during the lockdown period is expected to strengthen various sectors such as Banking, Central Guarantee Fund, and Businesses and Professional Associations and strengthen public–private partnership (PPP) projects and promote the recovery plans. This fund is expected further to restructure the industry, innovation, high-potential sectors, SME, infrastructure, agriculture, tourism, and others. The government's Action Program will review the appointment of senior officials and encourage the competent officials to improve the performance of state assets, work for good governance, and put forward their accountability. This transparency in the functioning of all accountable officials could deliver the desired result. It will strengthen the well-being of the people's development and work for national unity and social solidarity (MAPE, Parliament Session, 10 October 2020: emphasis mine).

7 Conclusion

Morocco has joined the African Union on January 31, 2017, with the overwhelming support of the member states. African Union (AU), in its last meeting held on July 1, 2018, explained that the organization has complete faith in the functioning of the United Nations dealing with the Moroccan Sahara issue. AU is not convinced to draw a parallel process in the Moroccan Sahara issue and will strengthen the efforts of the UN in the management of the issue of the Moroccan Sahara. The AU report further explained and justified their support to the UN in resolving it, and the creation of parallel proceedings will lead to chaos and confusion only. AU supports the resolutions of the UN Security Council dealing with the Moroccan Sahara. It is the only mechanism to support the UN and respect the UN's mandate.

Morocco has shown its keen interests in the continent's socioeconomic developments and revised its constitution in the year 2011. The regional developmental approach refers to political democracy, economic development for the society, and social cohesion keenly working under the global village approach. The self-management system in Sahara autonomous region has worked wonderfully in promoting investment, trade, industry, power generation, transportation, tourism, and agriculture. The self-management system in Sahara has raised the taxes, duties, and regional levies and is working for the exploration of natural resources in the building of the self-sustained Sahara region since 2011.

> They will have, for this purpose, financial resources, appropriate and adequate for the development of the region. These financial resources collect from local taxes, contributions and other territorial revenues. The (exploitation of natural resources and heritage of the region as well as grants from the state fund inter-regional units of governance and promote solidarity" (Arnold Guy 2009: emphasis mine).

Today, the unresolved issue of the Sahara, propagated by the neighboring State, has become a block in supporting the idea of the global village of Marocco and fuels the regionalism in the African continent, hampering the peace and security in the region.

Along with it, Article XI of the Constitution of Marocco supports the idea of the global village and enshrines to develop all the regions of Morocco and establish peace and security. This peace and security will attract global investors to contribute to the development of infrastructure, telecommunication, transportation, power generation, mining, housing, education, health, and other projects in the undeveloped region of Sahara. The idea of self-management (Section 35) by the regional governments is a step to attract global investors and sign the agreements for different development projects. This scheme will support all the regions, including Sahara. This approach will connect Sahara and other regions of Morocco with the world nations and move toward international integration. The autonomous regionalization would guarantee the best future for the Sahara, strengthening Maghreb's idea of peace, unity, integration, and sustainable development.

Overall, according to the principles of democratic procedures, populations of the Sahara autonomous region will act through legislative, executive, and judicial authorities within the region and have broad skills, particularly in the economic, social, cultural, and environmental aspects. They will have, for this purpose, financial resources appropriate and adequate for the development of the region. These resources could be arranged from local taxes, contributions, and other territorial revenues. The Sahara autonomous region's population should be represented in the national parliament and other national institutions, and they should participate in all national elections. The statute of autonomy resulting from negotiations will be subject to consultation with affected populations through a referendum under the guarantee of the new Constitution's relevant provisions.

Sahara province has become one of the favourite destinations for investors with creating several economic investment opportunities in all sectors. With 16 international airports, two shoreline ports, and 38 ports, of which thirteen are dedicated to foreign trade, the development of urban infrastructure in terms of highways, high-speed trains, and 4G network connectivity has been proliferating. The Industrial Acceleration Plan (IAP) 2014–2020 of Morocco has drawn up a road map to create 500,000 jobs in the industry, of which half of them would be through foreign investment (IAP 2018). The IAP is the cornerstone of the Industrial Cluster Strategy, and developing clusters is a key to modernize and integrate each industry under this plan. The government has adopted supportive measures and announced the industrial fund of 20 billion MAD, allotted 1000 ha of land exclusively for industrial development, having dedicated financial products, coordinated training programs, and developing import substitution. The IAP strategy is to raise 23% of the GDP share in the industry for value addition (Kumar 2019:18). The IAP's cross-functional aims are to rebalance the trade accounts by prompting exports and substituting local sourcing for imports, including the informal economy, and work for inclusive development. Morocco has made tremendous strides in chemical industries, pharmaceutical, renewable sectors such as the plastic recycling sector, fiber optic components manufacturing, and automotive industry, along with the export of phosphate used in the agriculture fertilizer. It is today focusing on the building of international standard universities and developing a world-class education hub. Besides, the IAP focuses on the agriculture sector under Green Morocco Plan, tourism under 2020, mining sector, liquefied natural gas, IT plan under 2025, renewable energy plan, and Logistics Plan under 2030 (The Green Moroccan Plan 2018). The foreign economic policy of Morocco, under globalization, has adopted a rational and pragmatic approach of openness in trade and commerce. This openness will meet the needs of young people in terms of work, employability, and better social life. On the other hand, it will generate abundant opportunities in the digital industry, renewable energy, health, tourism, and the automotive industry.

References

Achy L, Sekkat K (2014) Decentralization and regional economic performance in Morocco. http://www.academie.hassan2.sciences.ma/fse/docpaper/69-43.pdf. Accessed on 29 April 2018

Arnold Guy (2009) Morocco in the 21th century. North South Book, London

CES (2020) Assessing effective access to basic human, economic, social, cultural and environmental rights in the southern provinces. http://www.ces.ma/Documents/PDF/Web%20Rapport%20Effectivite%20des%20droits%20VEng%2003052013.pdf. Accessed on 25 Oct 2020

Cherkaoui M (2007) Morocco and the Sahara. The Bardwell Press, UK

Damis J (1983) Conflict in northwest Africa: the Western Sahara dispute. Hoover press, California

El Ouali A (2008) Saharan conflict. Stacey International, London

El Ouali A (2012) Territorial integrity in a globalizing world. Springer, London

Green Morocco (2018). http://www.agriculture.gov.ma/en/pages/strategy. Accessed on 29 April 2018

Hassan Masiky (2013). http://www.moroccoboard.com/viewpoint/68-hassan-massiki/5788-western-sahara-separatists-and-terrorism-in-the-sahel. Accessed on 25 Jan 2013

Human Development Report (2019) Inequalities in human development in the 21st century. UNDP, Morocco

IAP (2018) Industrial acceleration plan (IAP), Minister of Industry. http://www.mcinet.gov.ma/en/content/renewable-energy. Accessed on 29 April 2018

India Opinion (2020). https://www.moroccoworldnews.com/2020/10/323503/morocco-india-aim-to-build-on-great-impetus-in-bilateral-cooperation/. Accessed on 26 Oct 2020

Janos B (2009) Western Sahara. Published by ID Research Ltd. Publikon Publishers. http://www.kalasnyikov.hu/dokumentumok/besenyo_western_sahara.pdf. Accessed on 07 Non 2014

Jordon support (2020). http://moroccoworldnews.com/2020/10/323326/western-sahara-jordan-reiterates-support-for-moroccos-autonomy-plan/. Accessed on 24 Oct 2020

SME Financing (2020). https://northafricapost.com/37438-financing-of-smes-banks-to-apply-lowest-interest-rates-ever.html. Accessed on 26 Nov 2020

Kumar S (2013) Geopolitics regionalism under New Moroccan constitution and autonomy of Sahara. Indian J Afr Studies, vol XVIII, April and October 2012, No 1 and 2. University of Delhi

Kumar S (2019) Morocco: fast tracking progress. Afroasian Business Chronicle, vol 9, no 1. Delhi

Latin America (2020). https://www.moroccoworldnews.com/2020/10/323119/pacific-alliance-supports-moroccos-autonomy-plan-in-western-sahara/. Accessed on 26 Oct 2020

MAPE (2019). www.map.ma.AgenceMarocaine. De Presse

MAPE (2020). www.map.ma.AgenceMarocaine. De Presse

McDougall J, Scheele J (2012) Saharan frontiers. Indiana University Press, Bloomington

Newman HR (2008) The mineral industries of Morocco and Western Sahara. Morocco and Western Sahara [advance Release]. Minerals Yearbook, Morocco

Ottaway M (2012) Morocco: "Advanced Decentralization" meets the Sahara autonomy initiative. Senior Scholar, Woodrow Wilson Center. Middle East Program. http://www.wilsoncenter.org/sites/default/files/morocco_advanced_decentralization_meets_sahara_autonomy_initiative.pdf. Accessed on 29 April 2018

Regional Development Model for the Southern Provinces (2020). http://www.ces.ma/Documents/PDF/Note%20de%20cadrage%20VEng.pdf. Accessed on 17 April 2020

Renewable energy (2020). http://www.mcinet.gov.ma/en/content/renewable-energy. Accessed on 20 Sept 2020

Saudi and UAE (2020). https://www.moroccoworldnews.com/2020/10/323586/western-sahara-saudi-arabia-uae-reaffirm-support-for-morocco/. Accessed on 26 Oct 2020

Saxena SC (1995) Western Saharan alternative to armed struggle. Kalinga Publication, Delhi

Territory WS (2020) The Columbia electronic encyclopedia, 6th (ed). Columbia University Press. http://www.infoplease.com/ce6/world/A0851917.html. Accessed on 20 Oct 2020

The Constitution of Morocco (2011) Official bulletin. ISSN 0851-1217

The Green Moroccan Plan (2018) A challenge strategy for a green economic growth. https://www.researchgate.net/publication/269699953. Accessed on 29 April 2018

The Hindu (2012) Delhi

Tourism (2020) Ministry of Tourism. http://www.tourisme.gov.ma/fr/vision-2020/capital-humain/emplois-et-metiers-du-tourisme. Accessed on 29 April 2020

Women empowerment (2020). https://www.moroccoworldnews.com/2020/10/323554/morocco-appoints-only-137-women-to-senior-public-positions-in-8-years/. Accessed on 26 Oct 2020

Zoubir Y (2010) The Western Sahara conflict: regional and international repercussions. Bulletin of Concerned African Scholars 85

Zoubir YH, White G (2016) North African politics. Change and continuity. Taylor & Francis, UK

Suresh Kumar is Professor in the Department of African Studies at the University of Delhi. He shouldered the responsibilities as Head of Department and Coordinator of Centre for African Studies, UGC Area Study Program for 2015–19. He is Chief Editor of peer-reviewed and UGC-indexed journal—Indian Journal of African Studies and Africaindia.org (http://www.africaindia.org). Professor Kumar is a passionate traveler who has visited forty countries for research and teaching assignments. He is Chief Collaborator of the Indian Council of Social Science Research-National Institute for the Humanities and Social Sciences (ICSSR-NIHSS) International Joint Research Project on Religion, Yoga, and Education in India and South Africa. He articulated his opinion on different aspects of Africa before the International Geographical Congress (IGC, IGU 2004 & 2008), Ronald H. Brown Institute (2008), World Policy Council (WPC 2014), European Commission of African Studies (ECAS), Council for the Development of Social Science Research in Africa (CODESRIA 2015), IBSA, BRICS-IKS (2016, 2018 and 2019),

and many others. He has been visiting since 2012 in Rabat, Casablanca, Marrakesh, and Tan-Tan, southwestern part of Morocco. He has extensively visited Sahara province and met different tribal groups of Sahara in the year 2018.

Deepak Kumar is an Assistant Professor (Guest) in Department of Political Science, Swami Sardanand College of the University of Delhi. He has finished his Ph.D. on Center Province Relations in Morocco with special reference to Sahara Province, Department of African Studies, University of Delhi in the year 2019 successfully.

Indian Scenario

An Overview of Climate Change Over South Asia: Observations, Projections, and Recent Advances

Bhupendra Bahadur Singh, Manmeet Singh, and Dharmaveer Singh

1 Introduction

The advent of climate change has become a significant global problem with far-reaching effects on electricity, food, water, natural resources, biodiversity, ecosystems, culture, and social well-being. Via a series of assessment papers, the United Nations Intergovernmental Panel on Climate Change (IPCC) has periodically presented evidence of significant human impact on the climate system. Observations indicate a substantial increase in the carbon footprint caused by anthropogenic activities, which is unprecedented and more robust than the natural variations. Although climate change effects are seen worldwide, its devastating effects have varied across regions and nations. For example, surface temperature increase, sea-level rise, intense storm frequency, amplitude, etc., were highly variable over various parts of the world (Stocker et al. 2013). Climate change effects on a global scale are relatively well understood and documented, while definitive regional assessments still remain gray (Flato et al. 2013). Sparse observational networks and inadequate knowledge of region-specific physical processes have generally been attributed to this limited understanding of regional climate change consequences.

The weather and climate over major parts of Asia exhibit significant spatiotemporal variability owing to its unique geographical location and land–sea connections. The rainfall and atmospheric circulation over the region are dominated by coupled ocean–atmosphere interactions. The South Asian region (cf.

B. B. Singh (✉) · M. Singh
Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, Pune, India
e-mail: bhupendra.cat@tropmet.res.in

D. Singh
Symbiosis Institute of Geoinformatics, Symbiosis International (Deemed University), Pune, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_12

Figure 24-1 in Hijioka et al. 2014), which includes countries of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, has been assessed to be at increased risk of climate change consequences (Islam et al. 2009). The region lies majorly in the tropical latitudes of the northern hemisphere which is surrounded by the Indian Ocean in the south, by the Himalayan mountain range to the north, by the highlands of Baluchistan to the west, and by the north–south chain of mountains in the east. These distinct geographical settings in South Asia constrain the flow of air masses across the continent. Highly variable topography consisting of upland and lowland regions alongside rivers, gulfs, and bays significantly modulates the weather over the region. These regional features cause distinct climate conditions which are dominated by the monsoon season during boreal summer (Xue and Yanai 2005; Yadav and Singh 2017; Singh et al. 2021a). Substantial precipitation over the western Himalayas is received through the western disturbances in the winter and early spring months (Sabin et al. 2020). Rainfall and glaciers contribute significantly to the river inflows, which irrigates the alluvial soils of the great river deltas and valleys. The region houses the largest delta with vast floodplain on the earth, i.e., the Bengal delta, apart from other significant river deltas. These deltas serve as major sources of freshwater supply and freshwater ecosystems. Such favorable conditions contribute significantly to the overall agricultural production over the region. Over time, conducive living conditions have resulted in a substantial rise in the population over the region. It accounts for close to one-fourth ($\sim$24%) of the total population of the world (2019 estimate by the World Bank[1]). By population, this subregion stands top in Asia, where more than 60% of the region's total population is still rural and relies heavily on agriculture, natural resources, and allied sectors for livelihood (Islam et al. 2009). The unique geographical settings and socioeconomic–demographic structure of the region make it highly vulnerable to the risks posed by climate change.

The monsoon-dominated regions of South and Southeast Asia have experienced the effects of extreme weather and climate events in the era of climate change, which has mostly been non-uniform in time and space (see Yang et al. 2021). Studies have documented the evidence of anthropogenic climate change post the Industrial Revolution Era over the region. Through observations and dedicated studies done using the state-of-the-art climate models, human-induced climate change signatures alongside natural variations have been noted in the form of increasing extremes (e.g., cyclones, droughts, floods, heatwaves, thunderstorms, etc.), rising sea level, and changing monsoon patterns over the region (Hijioka et al. 2014; Vellore et al. 2016, 2020; Krishnan et al. 2020). Additionally, new developments as a result of population growth are putting further pressures on the urban environment, which contributes to the proliferation of slums, water scarcity, and pollution of air, soil, and water resources. This has brought adverse effects on ecological resources and is disturbing the sociocultural ethos and general psychological well-being. It presents a more significant challenge to society and the

[1]For World Bank data, see Web site https://data.worldbank.org/.

environment of the region. This highlights the need for an improved understanding of physical processes and feedback among them to have better climate projections, which can help in better planning and sustainable development over South Asia. It requires enhanced observations, modeling capabilities, and usage of advanced scientific techniques to extract more meaningful information from the data. The present chapter synthesizes the observed climate change and projections as available in the published literature, mainly (but not limited to) over the Indian region in South Asia. A brief discussion is also presented about the ongoing efforts and emerging methodologies to help better understand the science behind climate change and its attribution over the region.

2 Climate Change Over South Asia

Climate change manifests in various forms, including changes in frequency and magnitude of precipitation, temperature, extreme storms, sea-level rise, warming trend, etc. Several research studies have quantified these changes in the mean state of the climate using long-term observational records and model projections of meteorological variables. Already visible impacts of climate change are seen over Asia in the form of gradually rising surface temperatures, increased variability in the precipitation, and surge in extreme weather events (Hijioka et al. 2014; Yang et al. 2021). Figure 1 shows interannual variability through 1950 to 2019 in annual mean 2 m air temperature and precipitation rate shown as anomalies (climatology used for the same period) averaged over the land area in South Asia (averaged between 5° N–40° N and 60° E–100° E; data obtained from NCEP/NCAR Reanalysis, Kistler et al. 2001). It can be seen that the interannual variability in surface temperatures has been considerably large during recent decades. Post-1970s, there has been a significant rising trend in observed temperatures with pronounced warming since the late 1990s. Since the 1970s, the annual mean temperature has risen by almost 1.5 °C, while positive departures are seen every year since 1995. On the other hand, though the annual mean precipitation rate showed less variability between the periods 1960 and 1990, positive departures are noted in the decade of the 1950s and during recent years. Post-1990, the variability has increased, and it has been more erratic since then. In recent years, a slight rise is seen in the precipitation, which has shot close to 0.4 mm/d.

Figure 1 clearly shows that temperature and precipitation over South Asia have shown large variations in the recent period when seen in the context of annual mean variability. However, significant changes in seasonal means have been documented by the previous studies. IPCC, through its series of exhaustive reports, has documented the observed and projected changes in climate and its implications over different geographical regions of the world, including Asia (Hijioka et al. 2014; Yang et al. 2021). Recently, a comprehensive climate change assessment report over India has been brought up by the Ministry of Earth Sciences (MoES), Government of India (Krishnan et al. 2020). Since the regional climate of South

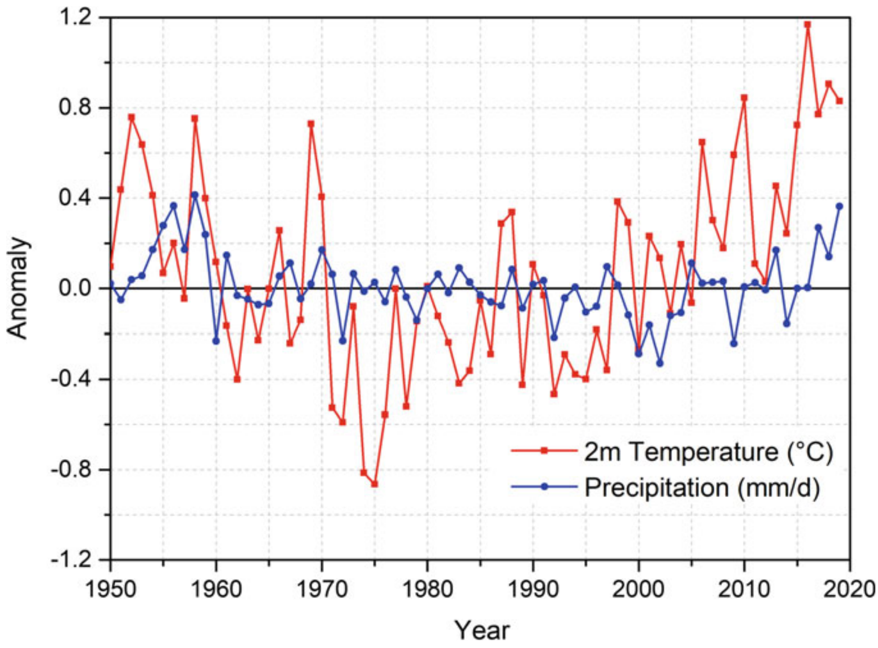


Fig. 1 Interannual temperature and precipitation anomalies over the land region of South Asia averaged between 5° N–40° N and 60° E–100° E (climatology used for the full period 1950–2019)

Asia is dominated by the changes over the Indian region, henceforth, the discussion would be mainly based on the climate change aspects as reported over India. The following sections summarize the findings from these reports and other published literature regarding the observed and projected climate change over the region. Particularly, the statistics provided here are based on the reports by Hijioka et al. (2014; and references therein) and Krishnan et al. (2020; and references therein).

2.1 *Information from the Past Observations*

Temperature and precipitation have significantly varied over most parts of Asia, including significant changes over South Asia. The region has witnessed increasing annual mean temperature during the twentieth century, with 0.7 °C warming observed over India during the 1901–2018 period. This observed trend in recent decades has been largely attributed to anthropogenic activities. There has also been a decline in the number of cold days and nights and a rise in the number of warm days and nights. With the rise in temperatures, the frequency and severity of heatwaves have also increased over the region. Precipitation has significantly varied and with considerable heterogeneity in patterns over different parts and seasons of South Asia. The seasonal mean rainfall over South Asia shows inter-decadal variability, with a noticeable declining trend and frequent occurrences of deficit monsoon years. Over India, there has been an increase in the number of monsoon break days and a decline in the number of monsoon depressions, which have resulted in an overall decrease in seasonal mean rainfall post-1950s. At the same time, an increase in extreme rainfall events has been reported over the central India region. These changes have been linked to anthropogenic aerosols and regional LULC patterns over the region. With the changes in temperature and precipitation patterns since 1950, there has been an increase in drought frequency along with expansion in areas affected by drought. There has been a concurrent rise in flash flooding over different parts of the country due to a rise in occurrences of localized extremes in rainfall. Observations show that the higher elevation regions of the Himalayas have warmed significantly at a rate of about 0.2 °C per decade. Though in recent decades, a significant decline in snowfall over Hindukush Himalayas was observed, parts of the Karakoram Himalayas experienced increased wintertime frozen precipitation assisted by the western disturbances.

The Indian Ocean has warmed significantly in recent decades, with sea surface temperatures in the tropical Indian Ocean rising by 1 °C on average over the 1951–2015 period. The observed warming is linked to anthropogenic radiative forcing and long-term changes in monsoonal wind patterns. With the warming, thermal expansion of the water has led to sea-level rise over the region. The sea-level changes in the Indian Ocean are linked to changes in monsoon circulation, Hadley, and Walker cells. There has been a decline in annual tropical cyclone activity over the North Indian Ocean. However, observations indicate that frequency of very severe cyclonic storms has increased during the post-monsoon period in recent decades.

2.2 Future Projections

Various studies and reports have documented the increased susceptibility of South Asia to climate change consequences based upon the results from the global and regional climate model simulations (Hijioka et al. 2014 and references therein; Krishnan et al. 2020 and references therein). The rise in annual mean temperature over India relative to the 1976–2005 period is projected to be in the range of 2.4–4.4 °C across greenhouse gas warming scenarios. With ongoing efforts to curb anthropogenic emissions and reducing carbon footprint over India, the aerosol emissions are anticipated to reduce. With such reductions in northern hemisphere aerosol emissions, monsoon is shown to be impacted more by the greenhouse warming effects in the latter part of the twenty-first century. As the temperatures rise, the increased atmospheric moisture can lead to a significant rise in the mean, extremes, and interannual variability of seasonal monsoon precipitation. Rise in rainfall extreme projects increased flood occurrences in the future, while increased interannual variability of seasonal rainfall can lead to increased occurrences of drought along with expansion in drought-affected areas. With elevation-dependent warming in force, warming over the Himalayan region can cause faster glaciers and snowmelt, enhancing the streamflow and compounding the flood risk over the river basins. The sea surface temperature over the tropical Indian Ocean is projected to continue the warming trend. However, for the trade and monsoon wind regions, negligible changes or even a decline is projected in mean significant wave heights. With continued global warming and a rise in Indian Ocean sea surface temperatures, very severe cyclonic storms are projected to increase over the region during the twenty-first century. Table 1 summarizes the discussions made in Sects. 1 and 2 and highlights the observed and projected changes in regional climate over the region.

3 Recent Efforts Toward Understanding the Regional Climate Change

3.1 Advances in Observational and Modeling Capabilities

Reliable understanding about regional climate change is more complicated as it is not only influenced by natural variability and global climate change patterns, but also affected by local changes in land cover land use patterns, emission sources, air pollution in the backdrop of development, and urbanization. A better understanding of the science behind climate change over South Asia requires an enhanced understanding of the physical processes acting and interacting with each other. This highlights the need for better observations and improvement in model physics for reliable projections at all scales in space and time. Many steps are being taken under the aegis of international and regional programs to have an increased observational network over the region consisting of measurements from direct, remote-based, and other platforms.

Along with an increase in the observational network, the need for better regional climate change information has led to unprecedented efforts in climate modeling over the region. India has taken up the challenge, and dedicated efforts on these lines have been made at the Centre for Climate Change Research at Indian Institute of Tropical Meteorology (CCCR-IITM), Pune. Significant contributions have come in the form of generating an ensemble of high-resolution dynamically downscaled future projections of regional climate over South Asia (Sanjay et al. 2019) and developing an earth system model to make better climate projections with emphasis on the regional monsoon (Swapna et al. 2015). The high-resolution downscaled projections of regional climate over South Asia have been developed as a part of the World Climate Research Programme (WCRP) regional activity Coordinated

Table 1 Observations and projections of climate change over South Asia

Variable	Observed changes	Projected changes
Temperature	1. Annual mean near-surface temperature has increased over south Asia 2. Trends largely due to anthropogenic activities 3. Decline (increase) in the number of cold (warm) days and night 4. Increase in heatwave frequency over large parts of Asia 5. Significant warming over higher elevation regions of Himalayas 6. With global warming, significant decline in snowfall over Hindukush Himalayas, while increased wintertime frozen precipitation over parts of the Karakoram Himalayas assisted by western disturbances	1. Projected rise in annual mean near-surface air temperature 2. With anticipated cuts in the anthropogenic emissions, greenhouse warming is projected to dominate later 3. Warming over high regions in the Himalayas can continue further
Precipitation	1. Increase in the number of monsoon break days along with a decline in the number of monsoon depressions 2. Overall decrease in seasonal mean rainfall post-1950s 3. Increase in extreme rainfall events over the central Indian region 4. Observed changes are likely linked to anthropogenic aerosols and regional LULC changes	1. Projected increase in mean, extremes, and interannual variability of seasonal monsoon precipitation 2. Changes are projected to be dominated by greenhouse gas warming leading to increased atmospheric moisture content
Droughts and floods	1. Increase in drought frequency along with expansion in areas affected by drought since 1950 2. Increase in flash flooding 3. Changes are coherent with the observed changes in temperature and precipitation patterns	1. Projected increase in flood occurrences with the rise is rainfall extremes 2. Enhancement in the streamflow by faster glaciers and snow melt over the Himalayas due to warming can compound the flood risk over the river basins 3. Increased drought occurrences along with expansion in drought-affected areas likely due to large interannual variability in seasonal monsoon rainfall
Ocean SSTs and sea level	1. 1°C increase in tropical Indian Ocean SSTs over the 1951–2015 period 2. The observed warming likely linked to anthropogenic radiative forcing and long-term changes in monsoonal wind patterns 3. Rise in sea level due to thermal expansion	1. SST over the tropical Indian Ocean is likely to increase further 2. Negligible changes or even a decline in mean significant wave heights over the trade and monsoon wind region

(continued)

Table 1 (continued)

Variable	Observed changes	Projected changes
	4. Changes in the sea level likely linked to changes in monsoon circulation, Hadley, and Walker cells	
Tropical cyclonic storms	1. Decline in annual tropical cyclone activity over the North Indian Ocean 2. Increase in the frequency of very severe cyclonic storms during the post-monsoon period in the recent decades	1. Very severe cyclonic storms likely to increase over the twenty-first century 2. The rise in frequency likely linked to global warming and increase in the Indian Ocean SSTs

Based on Hijioka et al. (2014) and Krishnan et al. (2020)

Regional Climate Downscaling Experiment (CORDEX[2]). Under the CORDEX activity, the high-resolution downscaled projections of regional climate and monsoon over South Asia till the end of the twenty-first century have been generated by the center using a regional climate model (ICTP-RegCM4; Giorgi et al. 2012) at 50 km horizontal resolution. The datasets are deemed useful for impact assessment studies and for quantifying uncertainties in the regional projections. As the earth system models have emerged as a reliable tool to understand the interactions among atmosphere, ocean, land, cryosphere, and biosphere systems, these models are increasingly used to understand the impacts of human-induced perturbations on the climate system. CCCR-IITM made an important achievement by developing an earth system model to understand global and regional climate response to long-term climate variability and climate change. The first version (IITM-ESMv1) was developed by transforming the state-of-the-art seasonal prediction model—the Climate Forecast System version 2 (CFSv2, Saha et al. 2014) into a climate model. The updated version of IITM-ESMv2 has been developed recently. It is the first climate model from South Asia to participate in the CMIP model intercomparison project and contribute to the IPCC AR6 assessment report. A brief overview of these dedicated modeling activities of the center has been provided in the Interim Report on Climate Change over India (Krishnan and Sanjay 2017). The Earth System Grid Federation Data Node at CCCR-IITM supports the CCCR-IITM climate model datasets (CORDEX-South Asia and CMIP6) and allows access to the climate data.

3.2 *Advances in New Technology and Tools*

With the availability of improved observations and model outputs, the need for better extraction of meaningful information has become a necessary requirement. In

[2]For detailed information, visit http://cordex.org/.

the last two decades, several advanced techniques have shown promising results. This section briefly presents some of these methodologies, such as usage of complex networks, phase coherence analysis, causal theory, artificial intelligence and deep learning, and cloud computing-enabled GIS techniques and their applicability in advancing the science of climate change over South Asia.

Complex network is a graph consisting of non-trivial topological functionality, which is often present in networks of real systems. This theory has recently been applied by Stolbova et al. (2014) to reveal that the Indian summer monsoon (ISM) network has three basic spatial domains: North Pakistan (NP), Eastern Ghats (EG), and Tibetan Plateau (TP). These structures are distinguished by a high degree, high betweenness, and the longest average lengths of geographic ties. The patterns observed in the NP, TP, and EG regions are important for the synchronization of extreme rainfall during the ISM. The study identified the central Gangetic plains and parts of Pakistan as the main sinks with high levels of moisture deposition during the South Asian monsoon season. Their findings suggest that ISM's timing and strength can be determined by tracking the evolution of dominant patterns by means of complex networks. Agarwal et al. (2018) proposed a new, complex network-based method using a statistical approach known as Z-P space to consider the qualitative and quantitative dimensions of group participants over a single rainfall station in the region. It reported that the high elevation, the northern part of India, was isolated from other areas while the southern peninsular area had good intra-community and inter-community ties. The study demonstrated that extreme rainfall events in South-Central Asia, East Asia, and Africa's monsoon systems are substantially associated. And there are succinct connections between South-Central Asia and the extratropics of Europe and North America. These studies clearly highlight that complex network approaches can help determine main node positions in climate networks that play a major role in influencing the community's climate. Similarly, usage of recurrence analysis is now being used on time series data to study variation or similarities, which can help understand nonlinear dynamics and non-stationary processes, e.g., temperature and precipitation changes over the region. The usage of recurrence plots can reveal significant insights into the nonlinear processes governing climate change over the South Asian region.

The current state-of-the-art earth system data analysis is still dominated by correlation and regression approaches. Established causality approaches can provide deeper perspectives from hypothesis testing to a causal assessment of physical models. However, a significant challenge to broader acceptance of causal inference approaches is the absence of a credible benchmark database. Runge et al. (2019) address this void with causeme.net, which includes links to open software products. Sensibly applied causal inference methods promise to advance the state-of-the-art understanding of complex dynamical systems. Di Capua et al. (2020) used causal discovery algorithms to assess the ISM circumglobal teleconnection hypothesis. They also implemented causal maps, a modern implementation of the causal influence network definition, and highlighted how this approach would solve correlation map limitations by eliminating false ties. The study showed that the technique could provide superior skills in 2–4-month lead-time seasonal monsoon forecasts, enabling better socioeconomic planning for the region. Phase coherence, first observed by Christian Huygens in 1665, brings out the synchrony of periodic signals. The long-term natural modes of climate variability are often periodic, and therefore coherency among signals should be considered to better understand the physical science of the earth system. Using the phase coherence methodology, a recent study by Singh et al. (2020) reports that the strong volcanic eruptions facilitate improved synchronization of ENSO and ISM oscillations, which enhances prospects for better seasonal monsoon predictions.

Alongside these advanced analysis techniques, weather and climate sciences need to process vast and rapidly growing volumes of data to provide more reliable, less unpredictable, and physically compatible inferences of the complex earth system in the form of estimation, simulation, and understanding. Machine learning in general and deep learning, in particular, provide promising resources to create new data-driven models for earth system elements, building our understanding of earth. For example, weather and climate over major parts of Asia exhibit significant spatiotemporal variability caused by highly nonlinear processes arising primarily from the coupled ocean–atmosphere interactions. Such nonlinear processes pose a challenge to scientific research community involved in weather and climate studies. Deep learning approaches are often able to capture the nonlinear variability in the data which is difficult to extract using simple linear analysis or other standard statistical techniques. This is where the deep learning can become important. Study by Zeiler and Fergus (2014) provides a comprehensive analysis highlighting the capabilities of deep learning.

Recent studies indicate that deep learning has potential applicability in advancing climate science at all spatial and temporal scales. For example, Dasgupta et al. (2020) have reconstructed the Madden–Julian oscillation index using machine learning for the pre-satellite era, which is an essential component of coupled ocean–atmosphere variability and crucial for the weather patterns over South Asia. Therefore, recent progress in deep learning and allied technologies present a more significant opportunity to work on different aspects of climate change science over South Asia and globally. With further advancements, data-driven machine learning approaches to geoscientific science will not substitute, rather than supplement and enrich it highly. Reichstein et al. (2019) envisaged multiple synergies between physical and data-driven models, with the ultimate objective of hybrid modeling approaches for a better understanding of the earth system science. Deep learning is now widely being used across various sectors, and Table 2 lists the potential scientific issues and associated deep learning techniques that can be applied for better understanding and decision making over the South Asian region.

The advent of space-based remote sensing technology has revolutionized the ways of spatial data collection. Satellite data offers a synoptic and global overview of the land, water, and air. This promotes an interdisciplinary approach to studying the earth as a whole. However, with the scientific and technological advancements, a surge has been observed in the data collection instruments/tools. It has increased the volume and heterogeneity of the data and raised concerns for the proper handling and storage of datasets. For the monitoring and assessment of earth's related

Table 2 Scientific issues and applicable deep learning approaches in climate science and allied sectors

Scientific issue	Applicable deep learning-based techniques
Extreme events, land use land cover change, nowcasting	Classification by convolutional neural networks (CNNs)
Downscaling	Generative adversarial networks and convolutional neural networks
Modeling fluid flows	Physics inspired convolutional neural networks
Seasonal forecasting	Convolutional long short-term memory networks (ConvLSTMs)
Forecasting electricity demand and supply	LSTMs and CNNs
Modeling emissions from various sources and modeling transportation system demand	Various feedforward deep neural networks
Building energy forecasting	Deep belief networks, reinforcement learning, and others
Smart buildings	Deep neural networks (DNNs)
Collecting infrastructure data	Computer vision methods based on remote sensing data
Precision agriculture, monitoring peatlands, forests, ecosystems, biodiversity	Convolutional neural networks with unmanned aerial vehicles
River runoff prediction from unmeasured catchments	Regression-based convolutional neural networks
Predictions of atmospheric fluxes and vegetation properties forecast	LSTMs, RNN, GRU, 1d CNNs
Climate finance and analytics	Deep learning-based time series models

Source Rolnick et al. (2019)

processes and hazards, the fast retrieval of the data collected from these instruments is required. But, heterogeneity in data, e.g., lack of integration and interoperability, has limited our ability to interpret the processes. The issues of integration and interoperability among the datasets of the different origins are resolved with the advent of geo-intelligence, which encourages the use and assimilation of intricate, multidisciplinary data for providing resolutions to earth science and social sciences-based challenges. The emergence of open-source cloud computing and GIS tools such as Google Earth Engine and QGIS has revolutionized the use of high-resolution satellite datasets for applications in urban meteorology and building ready-to-use applications for societal benefits (Gorelick et al. 2017). For example, Singh et al. (2021b) utilized Google Earth Engine based approach to estimate changes in the global air quality due to reduced anthropogenic emissions during COVID-19 pandemic. At present, more and more data products such as reanalysis and ground-based observations are being added to the Google Earth Engine to facilitate ready-to-use analysis of datasets that were previously out of reach of common researchers due to their large size or complexity.

Alongside the increasing observations and physics-based earth system modeling approaches, the climate science community can utilize these emerging methodologies to better understand climate change science over South Asia.

4 Summary and Future Outlook

Observations and climate modeling studies have documented a definite anthropogenic impact on climate change over South Asia. The region houses close to one-fourth of the total population of the world, where more than half of the region's total population relies on agriculture, natural resources, and allied sectors for livelihood. The unique geographical settings and socioeconomic–demographic structure of the region make it highly vulnerable to the risks posed by climate change. Therefore to have better clarity about the science of climate change, it requires an improved understanding of the physical processes and feedback among the earth systems. Through the available literature, the chapter lists out past changes and future projections of climate over the region and briefly discusses the recent advancements in observational–modeling–analysis approaches for a better conception of the involved processes. Overall, the effects of changes in the global climate, in general, and regional climate, in particular, have already been noted which has affected the economy, social well-being, and development of the region. The observed and projected heterogeneity in the signals of regional climate change over Asia demands closer cooperation among the economies for sustainable development.

It is also noteworthy that more and more people across South Asia are accepting climate change as an anthropogenic problem. This increased awareness about climate change impacts has led to the development of various national and state action plans and assessment reports on the subject. In recent times, there has been a surge in focus on manpower development and expansion of observational networks across South Asia. There have been dedicated observational and modeling efforts led by India lately to better understand past climate and generate better climate projections. Moreover, the emergence of new computing hardware such as GPUs and TPUs is expected to make the process of data-crunching increasingly easy and thus can offer greater insights for the science of climate change over the region. It is anticipated that by the next decade, when industrial quantum computing becomes a reality, climate models can be the first to take advantage of the computational power, and very high-resolution forecasts and projections might become a reality. Already, artificial intelligence-based techniques are showing promise in improving the forecasts generated by the climate models. The age of cloud computing-enabled HPC with advanced computer hardware and paradigm shifts in the computational world is poised to bring a revolution in the regional science of climate change over South Asia. With more and more reliable observations and advances in earth system modeling, these new technologies, statistical models, user perception-based models, and modern machine learning algorithms are now being widely used in advancing regional climate science information applicable in all allied sectors.

References

Agarwal A, Marwan N, Maheswaran R, Merz B, Kurths J (2018) Quantifying the roles of single stations within homogeneous regions using complex network analysis. J Hydrol 563:802–810

Dasgupta P, Metya A, Naidu CV, Singh M, Roxy MK (2020) Exploring the long-term changes in the Madden Julian Oscillation using machine learning. Scientific Reports

Di Capua G, Kretschmer M, Donner RV, van den Hurk B, Vellore R, Krishnan R, Coumou D (2020) Tropical and mid-latitude teleconnections interacting with the Indian summer monsoon rainfall: a theory-guided causal effect network approach. Earth Syst Dyn 11(1):17–34

Flato G et al (2013) Evaluation of climate models. In: Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM (eds) Climate change 2013: the physical science basis. Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge

Giorgi F, Coppola E, Solmon F et al (2012) RegCM4: model description and preliminary tests over multiple CORDEX domains. Clim Res 52:7–29. https://doi.org/10.3354/cr01018

Gorelick N, Hancher M, Dixon M, Ilyushchenko S, Thau D, Moore R (2017) Google Earth Engine: planetary-scale geospatial analysis for everyone. Remote Sens Environ 202:18–27

Hijioka Y, Lin E, Pereira JJ, Corlett RT, Cui X, Insarov GE, Lasco RD, Lindgren E, Surjan A (2014) Asia. In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds) Climate change 2014: impacts, adaptation, and vulnerability. Part B: regional aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp 1327–1370

Islam AKM, Nazrul & Sultan, Salma & Afroz (2009) Climate change and South Asia: what makes the region most vulnerable? MPRA Paper 21875, University Library of Munich, Germany

Kistler R, Collins W, Saha S, White G, Woollen J, Kalnay E, Chelliah M, Ebisuzaki W, Kanamitsu M, Kousky V, van den Dool H, Jenne R, Fiorino M (2001) The NCEP-NCAR 50-year reanalysis: monthly means CD-ROM and documentation. Bull Am Meteor Soc 82:247–267. https://doi.org/10.1175/1520-0477(2001)082%3c0247:TNNYRM%3e2.3.CO;2

Krishnan R, Sanjay J (2017) Climate change over India—an interim report. Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, pp 1–38

Krishnan R, Sanjay J, Gnanaseelan C, Mujumdar M, Kulkarni A, Chakraborty S (2020) Assessment of climate change over the Indian region: a report of the Ministry of Earth Sciences (MoES), Government of India

Reichstein M, Camps-Valls G, Stevens B, Jung M, Denzler J, Carvalhais N (2019) Deep learning and process understanding for data-driven Earth system science. Nature 566(7743):195–204

Rolnick D, Donti PL, Kaack LH, Kochanski K, Lacoste A, Sankaran K, Ross AS, Milojevic-Dupont N, Jaques N, Waldman-Brown A, Luccioni A (2019) Tackling climate change with machine learning. arXiv preprint arXiv:1906.05433

Runge J, Bathiany S, Bollt E, Camps-Valls G, Coumou D, Deyle E, Glymour C, Kretschmer M, Mahecha MD, Muñoz-Marí J, van Nes EH (2019) Inferring causation from time series in Earth system sciences. Nat Commun 10(1):1–13

Sabin TP et al (2020) Climate change over the Himalayas. In: Krishnan R, Sanjay J, Gnanaseelan C, Mujumdar M, Kulkarni A, Chakraborty S (eds) Assessment of climate change over the Indian region. Springer, Singapore. https://doi.org/10.1007/978-981-15-4327-2_11

Saha S, Moorthi S, Wu X, Wang J, Nadiga S, Tripp P, Behringer D, Hou YT, Chuang HY, Iredell M, Ek M (2014) The NCEP climate forecast system version 2. J Clim 27(6):2185–2208
Sanjay J, Ramarao MVS, Mahesh R, Ingle S, Singh BB, Krishnan R (2019) Regional climate change datasets for South Asia. Bull IMSP 18:4–8
Singh M, Krishnan R, Goswami B, Choudhury AD, Swapna P, Vellore R, Prajeesh AG, Sandeep N, Venkataraman C, Donner RV, Marwan N (2020) Fingerprint of volcanic forcing on the ENSO–Indian monsoon coupling. Sci Adv 6(38):eaba8164
Singh BB, Krishnan R, Ayantika DC et al (2021a) Linkage of water vapor distribution in the lower stratosphere to organized Asian summer monsoon convection. Clim Dyn (2021). https://doi.org/10.1007/s00382-021-05772-2
Singh M, Singh BB, Singh R, et al (2021b). Quantifying COVID-19 enforced global changes in atmospheric pollutants using cloud computing based remote sensing. Remote Sens Appl Soc Environ 22:100489. https://doi.org/10.1016/j.rsase.2021.100489
Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM (2013) Climate change 2013: the physical science basis. In: Contribution of working group I to the fifth assessment report of the intergovernmental panel on climate change, pp 1535
Stolbova V, Tupikina L, Bookhagen B, Marwan N, Kurths J (2014) Topology and seasonal evolution of the network of extreme precipitation over the Indian subcontinent and Sri Lanka. Nonlinear Process Geophys
Swapna P, Roxy MK, Aparna K, Kulkarni K, Prajeesh AG, Ashok K, Krishnan R, Moorthi S, Kumar A, Goswami BN (2015) The IITM earth system model: transformation of a seasonal prediction model to a long-term climate model. Bull Am Meteor Soc 96(8):1351–1367
Vellore RK, Kaplan ML, Krishnan R, Lewis JM, Sabade S, Deshpande N, Singh BB, Madhura RK, Rao MR (2016) Monsoon-extratropical circulation interactions in Himalayan extreme rainfall. Clim Dyn 46:3517–3546. https://doi.org/10.1007/s00382-015-2784-x
Vellore RK, Deshpande N, Priya P, Singh BB, Bisht J, Ghosh S (2020) Extreme storms. In: Krishnan R, Sanjay J, Gnanaseelan C, Mujumdar M, Kulkarni A, Chakraborty S (eds) Assessment of climate change over the Indian region. Springer, Singapore. https://doi.org/10.1007/978-981-15-4327-2_8
Yadav RK, Singh BB (2017) North equatorial Indian Ocean convection and Indian summer monsoon June progression: a case study of 2013 and 2014. Pure Appl Geophys 174:477–489. https://doi.org/10.1007/s00024-016-1341-9
Yang S, Wu R, Jian M, Huang J, Hu X, Wang Z, Jiang X (2021) Climate change in southeast Asia and surrounding areas. https://doi.org/10.1007/978-981-15-8225-7
Xue Y, Yanai M (2005) Asia, climate of south. In: Oliver JE (eds) Encyclopedia of world climatology. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3266-8_20
Zeiler MD, Fergus R (2014) Visualizing and understanding convolutional networks. In: European conference on computer vision. Springer, Cham, pp 818–833

Bhupendra Bahadur Singh presently works as Scientist at the Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune, India. His primary research work focuses on monsoon variability, dynamics of upper troposphere/lower stratosphere (UT/LS) processes, extremes, and climate change. He has rich experience in field observations and regional climate modeling. He has been awarded twice with the prestigious Research Fellowship jointly offered by Indian Academy of Sciences (IASc), Indian National Science Academy (INSA), and National Academy of Sciences (NASI). He represented the Ministry of Earth Sciences at the 106th Indian Science Congress (2019) and was awarded with the best interactive Pavilion.

Manmeet Singh presently works as Scientist at the Centre for Climate Change Research, Indian Institute of Tropical Meteorology, Pune, India. His primary research work focuses on aerosol impacts on the Indian summer monsoon, ENSO–monsoon relations, and application of deep learning in atmospheric and oceanic sciences. He is an expert in climate modeling. Recently, he has been awarded with the prestigious Fulbright Kalam Doctoral Fellowship offered by the J. William Fulbright Foreign Scholarship Board (FSB), Washington, D.C., USA, and Department of Science and Technology, Ministry of Science and Technology, Government of India.

Dharmaveer Singh is Assistant Professor at Symbiosis Institute of Geoinformatics, Symbiosis International (Deemed University), Pune, India. He served in the capacity of a Research Scientist C at National Institute of Hydrology, Roorkee, India, from 2016 to 2018. He, a Ph.D. in geoinformatics (2015) from Motilal Nehru National Institute of Technology Allahabad, has been conferred by several academic awards: UGC Early Career Research Grant in 2019; Postdoctoral Fellowship from Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences in 2016, and CSIR JRF (NET) in 2009 and 2010. His main research interests include water resources management, water security and economics and climate change and modeling. He has published 15 research papers in peer-reviewed journals (SCI and Scopus Indexed) and participated in 22 conferences and workshops organized in India as well as abroad. He is a reviewer for the several scientific journals of the international reputes.

Environmental Vulnerability and Women Trafficking: Exploring the Bengal Sundarban Deltaic Region of India

Priyanka Biswas and Nilanjana Das Chatterjee

1 Introduction

Environmental crises have an unprecedented association with the development of a region. In fact, the environmental crises impede proper resource utilization of a region, manifest unsustainable human development, and improvise regional crisis. Environmental crises, or more specifically say environmental challenges, have diversified dimensions. They range from deforestation, soil erosion, land degradation, biodiversity loss, resource depletion, pollution, hazards to global environmental problems, particularly climate change (Elliott 2001). The environmental crises, particularly when exacerbating the already existing tensions, impose substantial social and economic costs at the local, regional, and national levels. Continued high level of environmental crises improvises imbalances in productivity, improper resource utilization, uneven distribution of goods and services, threaten regional economic growth, undermine the quality of life, diminishing societal stability, potentiality, and increase regional insecurity (Elliott 2001). The consequences of an enormous environmental crisis may endorse large-scale resource depletion, unsustainable regional growth, livelihood insecurity, less ecological diversification, and make a region environmentally vulnerable (Asian Development Bank 1997). In addition, poor or non-existent disaster infrastructure and lack of institutional support aggravate the adverse outcomes (Molinari 2017).

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

P. Biswas (✉) · N. D. Chatterjee
Department of Geography, Vidyasagar University, Midnapore, West Bengal, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_13

Thus, large-scale regional crises might emerge that further results in socio-economic adversity and stop the further progress of society overtly and covertly. Considering all these aspects, the present study tries to imprint how environmental challenges significantly shape the socio-economic adversity of a region, intensify livelihood insecurities, and make the region extremely disorganized and exacerbate human vulnerability.

2 Environmental Challenges in Sundarban Deltaic Region

Environmental crisis and consequence vulnerabilities how continuously force a region to face enormous challenges can clearly be sensed from the plight of the people in the Indian Sundarban. The Indian Sundarban Deltaic Region is situated at the coastal deltaic area of the Indian border state, West Bengal. This deltaic region consists of 19 low-lying densely populated riverine blocks with an intricate network of tidal creeks and explicitly located at the extreme southern segment of the North and South-24 Pargana district of West Bengal. These riverine blocks incorporate Canning I and II, Basanti, Gosaba, Joynagar I and II, Mathurapur I and II, Kultali, Patharpatima, Kakdwip, Namkhana, and Sagar in South-24 Pargana district and Hingalganj, Sandeshkhali I and II, Hasnabad, Haroa, and Minikhan in North-24 Pargana district (Fig. 1). Low human development, wider gender inequalities, poverty, malnutrition, landlessness, forced, and risky migration characterize this region. For its strategic geographical location, this deltaic region has been faced many environmental challenges and accountable for immense social and economic costs.

Geographically, this deltaic region is situated at the confluence of major river systems of the Bay of Bengal. The daily encroachment of tidal water through the complex networks of tidal creeks makes the soil of this Gangetic delta uncultivable and isolates this region from the rest of the civilization of Bengal. For this disadvantageous physiographic setting, the Sundarban deltaic region of West Bengal is highly vulnerable to climate change and prone to extreme natural calamities (Ghosh 2012). This deltaic region is constantly affected by extreme weather situations for its location near the Bay of Bengal (Jana et al. 2013). The threat of frequent tropical cyclones, monsoon, sea-level rise, and consequent flood and other natural hazardous situations makes a wide swath between this deltaic region and the mainland. Throughout the year, this region has experienced extreme severe to less severe cyclonic storm surges, specifically in the duration of the month of April to December (Chakraborty 2015). The shoreline of Mousuni, Bulcherry, Halliday, Jambudwip, Ajlmalmari, Hamilton, East Dulibhasani, Henry's, Bhangaduni, Gona, Chulkati, Khatuajhuri, Lothian, Dhanchi, Bagmara, Harinbhanga, Gosaba, and Chandkhali islands of the Sundarban deltaic region is in continuous threat of cyclonic storms situations and is physically and socio-economically very much vulnerable. As per the IMD (India Meteorological Department (IMD)) report, the devastating cyclones namely '*Aila*' (occurred 25 May 2009; average speed 110 km/

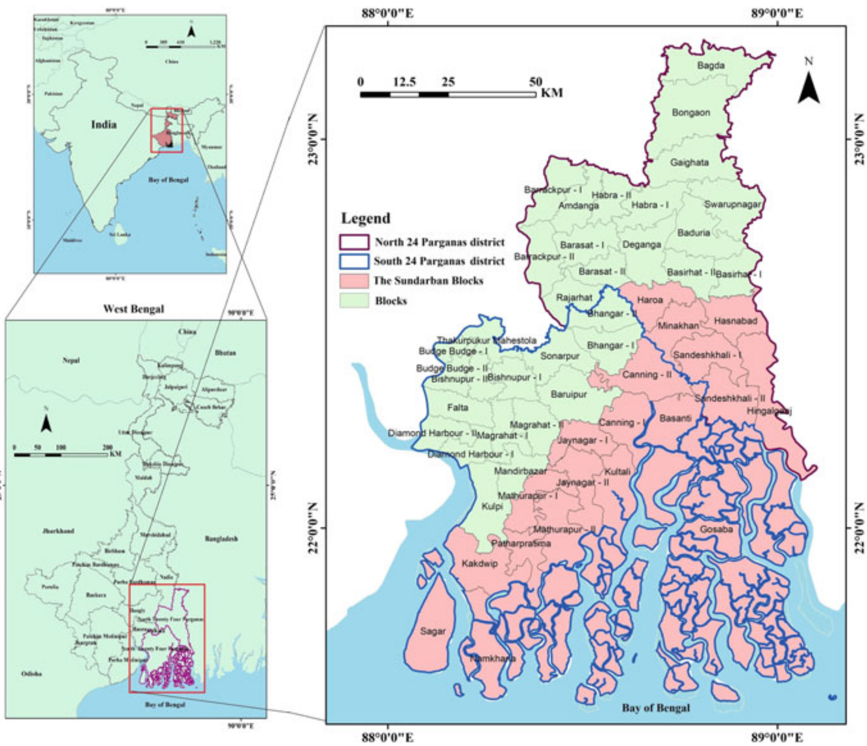


Fig. 1 Sundarban deltaic region—the study area

h or 70 mph),'*Komen*' (26 July 2015; average speed 75 km/h), '*Roanu*' (May 2016; average speed 85 km/h), '*Fani*' (May 2019; speed 185 km/h), '*Amphan*' (21 May 2020; average speed 240 km/h) continuously threaten this region to face massive environmental challenges. This region is inherently highly fertile and rich in biodiversity. The world's largest contiguous mangrove ecosystem (10,200 km^2) has been found here and makes this deltaic region an ecologically enrich biodiversity hotspot (Dwivedi et al. 1999; Giri et al. 2014). Besides, due to its physiographic location along the transitional zone between the terrestrial and marine environment, this region has significant ecological as well as socio-economic significance. The mangrove forest tracks in the Indian Sundarban region protect the inland areas from extreme weather events and resists soil erosion. But repeatedly climatic hazards, storm surges coupled with sea-level rise and coastal inundation resulted in the submergence of mangrove swamps under the saline water and cause large-scale damage of mangrove forest and aquatic ecosystem. Another important aspect of vulnerability in the Sundarban deltaic region is its borderland location. Part of the riverine blocks of this region, such as Basanti, Gosaba, Canning I and II, share a 'porous' international border with the neighbouring country of Bangladesh. The problem of illegal immigration of Bangladeshi migrants, illegal trade is predominant here. Besides, socio-economic crises such as impoverishment, poor accessibilities, lack of basic amenities make this region too much vulnerable (Sánchez-Triana et al. (eds.) 2014; Molinari 2017; Jana et al. 2013). Acute poverty is a very burning issue in this deltaic region, specifically blocks that fall under the South-24 Parganas district. According to the Human Poverty Index (HPI), the district South-24 Parganas scores 41.0, which indicates acute poverty situation exists in this region (District Level Household Survey (DLHS) 2002–2004). Another block-wise study by Rural Household Survey 2005 indicates a high poverty rate in all the thirteen Sundarban blocks of South-24 Parganas district registers poverty ratios above 30% (DHDR 2009). Lack of resource availability, limited options of alternative livelihoods, unremitting expansion of marginal and less secure forms of works, and crisis for secured forms of work have largely been noticed here, resulting in high unemployment and under-employment situations and creating a crisis for survival (DHDR 2009; Molinari 2017). These physiographic and socio-economic vulnerabilities of the Sundarban delta increase everyday forms of insecurities among people, create high-level social disorganization, increase livelihood struggle, and cherish, to an extent, organized criminal rackets in this region (Molinari 2017). It is reported that after any disastrous event, the higher rates of gender inequalities in different areas, including educational attainment, work participation, and gender-based atrocities, exploitation, human trafficking, particularly of women and minor girls in this remote deltaic region, happen due to acute stress and family fragmentation, loss of livelihoods and support networks, disruption of social norms and values, displacement in unsafe disaster relief camps and increased physical and socio-economic precarity (Nellemann et al. 2011). Therefore, the present study carefully sheds light on how the social disorganization and organized criminogenic activities, specifically the inhumane practice of human trafficking, have been emerged as a consequence of adverse physiographic location, frequent environmental challenges, and consecutive socio-economic threats in the Sundarban deltaic region and put the local inhabitants especially the poor women and minor girls at high risk of threats.

3 Limited Livelihood Opportunities

The vulnerable physical environmental settings and unremitting environmental challenges in the deltaic Sundarban region of West Bengal inevitably challenge the local inhabitants' livelihood in this region. Strong winds during cyclones damage local dwellings, felling down of trees, disrupt communications, and cause massive loss of property and lives in this region. Heavy and torrential rains throughout the cyclone caused river flooding situations across the region. Moreover, storm surges during cyclones result in sea-level rise and the coastal cataclysm that further cause submergence of low-lying areas of the Sundarban delta. Many houses get completely damaged; people lose their habitable lands. Such catastrophic situations devastate the entire economy of this deltaic region also. Most of the villagers in this deltaic region are solely rely on crop cultivation and pisciculture for their livelihood (Hazra et al. 2002). But the periodic storm surges and intrusion of tidal water especially devastating for the cultivators. The increasing salinity and pH level in the soil directly affects low productivity (Ghosh 2012).

Such a disastrous situation has emerged in the Sundarban deltaic region during the severe cyclonic storm (SCS) 'Aila' held on 25 May 2009. 'Aila' hit the Sagar Island in South-24 Parganas at a speed of 120–140 kmph with heavy rainfall of about 400 mm (India Meteorological Department (IMD) 2009 report; Chakraborty 2015; Gayathri et al. 2015; Mitra et al. 2011). The entire 19 blocks of the Sundarban deltaic region (including both North and South-24 Pargana districts) were aggrieved badly by storm 'Aila' (Chakraborty 2015). The most affected Sundarban blocks are Sagar, Namkhana, Basanti, Gosaba, Kakdwip, and Patharpratima of South-24 Parganas. The major rivers like Gosaba, Matla, Kalindi, Piyali-Bidyadhari, Muri Ganga, Harinbhanga, Hugli, and Saptamukhi flowed above the danger line. The onshore inundation along the Sundarban region ranges between 400 and 600 m (Gayathri et al. 2015). The entire coastal region was immersed entirely by the storm surge during 'Aila'. The brackish water rushed over the embankments through the river channels, tidal creeks, flooded thousands of hectares of agricultural lands, destroyed thousands of mud and thatched houses, killed more than 50,000 livestock animals (West Bengal Disaster Management and Civil Defence department (WBDM&CD) report), and leaving millions of people marooned in the embankment areas (Das 2011; Chakraborty 2015). The villagers of Khasimara Char, Baisnabpara of Sagar Island, Ghoramara Island, etc., had had to leave their habitable lands after the devastating storm 'Aila'. Stagnant of brackish water for a long time results in soil erosion and altering soil's physical properties. The thin veneer of salt in the soil has been noticed after the saltwater drained out. The high salinity and pH level in the soil after 'Aila' harshly result in low agricultural productivity. The estimated total crop affected areas only in South-24 Pargana district was around 69,150 ha (Chakraborty 2015). A large section of farming communities in these 'Aila' affected areas were facing substantial economic recession and loss of their livelihoods. Besides, the stagnation of brackish water for a long time after 'Aila' results in alteration of hydrological properties of freshwater (Debnath 2013; Mitra et al. 2011) that further affects aquatic ecosystems and hamper the productivity in pisciculture.

Furthermore, peoples in Sundarban solely depend on mangrove forests for their livelihood (Molinari 2017). They collect fuel woods, non-timber forest products (NTFP); catch fishes, crabs from the mangrove swamps and mudflats (Hazra et al. 2002). However, the rapid eradication of mangrove forest after 'Aila' threatened the local inhabitants' livelihood sustainability and put the government on high red alert. People had no choices of alternative livelihoods. Not just 'Aila' continuous cyclonic storm surges repeatedly affect this deltaic region and raise economic recession and livelihood vulnerability and make the villagers very insecure.

4 Struggles for Existence—Social Disorganization

The menace of adverse physiographic location and frequent climate change-induced natural hazards continuously exacerbate vulnerabilities of the entire Sundarban delta, arouse struggle for survival of the local inhabitants, and are highly accountable for breaking the social ties. The enormous damage of the ecosystems, net shown areas, inhabitable lands, loss of livelihoods, basic amenities results in large-scale resource depletion in this deltaic region and make the area disorganized. The population pressure in this region has reached a high risk for the past few decades. If the decadal growth rate of population is being considered, it is observed that from 1911 to 2011, a positive growth has been noticed in both the 24-Parganas districts (Table 1). Not only in remote villages but population pressure is followed a higher increasing trend in the adjoining urban areas of this deltaic region also (Table 2). Furthermore, Table 3 shows the immigration scenarios of 24-Parganas districts from 1951 to 1991.

It reflects that the immigration rate, which did not vary to a wide extent in the past few decades, is still a continuing process. The porous border endorses the large-scale illegal immigration of the poor Bangladeshi peoples in this deltaic region to find better job prospects in India (Ramachandran 2005; Sanjog 2011). It results in high population density in the entire villages of the Sundarban delta and adjacent urban areas. Continuous conflicts exist in between limited resource availability and huge population pressure in this region. This huge population creates enormous pressure on the entire economy of this region as well. Besides, optimal resource utilization is not happening as most of the people are uneducated and unskilled. About half of the families in this region are landless and dependent on wage labour (DHDR 2009; Molinari 2017). Large-scale disguised unemployment has been noticed in agricultural and fishery sectors as the cultivable lands are under constant threat of environmental challenges. Due to illiteracy and lack of ample skills, people have no other options for alternative livelihoods to run their families. In addition, the numbers of industries in the region are minimal. Peoples are engaged in agriculture, fisheries, auto driver, collections of fuel woods and other non-timber forest products etc. The installation of automatic machinery in factories limits the needs of human workers. Therefore, most of the unskilled workers in those factories lose their jobs and work as disguised labour. The government has already put efforts to alleviate poverty from this region and focused on employment generation programs. The government has created job opportunities for the local inhabitants in this region under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme, yet the rate of success is very low. According to the official records of the Ministry of Rural Government, during the 2017–18 financial year, the total numbers of active beneficiaries (including SCs, STs, and others) under this scheme in North and South-24 Parganas districts were 5,95,565 and 10,51,896, respectively (Table 4). Many skilled and semi-skilled male and female workers from this region have already get beneficiaries under this scheme. However, the number is very less compared to the total inhabitants of this deltaic

Table 1 Decadal growth rate of population in North and South 24-Parganas districts

District	1911–1921	1921–1931	1931–1941	1941–1951	1951–1961	1961–1971	1971–1981	1981–1991	1991–2001	2001–2011
24-Parganas (North)	+6.31	+9.53	+26.07	+23.50	+40.84	+23.53	+31.42	+31.66	+22.64	+12.04
24-Parganas (South)							+19.42	+30.08	+20.89	+18.17

Source Census of India

Note Till 1981 both North and South-24 Parganas were under undivided 24 Parganas District, which was bifurcated subsequent to 1981. So the figures for both the districts are common till 1981

Table 2 Decadal variations of rural–urban population in North and South 24 Parganas districts

District	T/R/U	Year		% changed in 2011 over 2001
		2001	2011	
24-Parganas (South)	Total	6,906,689	8,161,961	18.17
	Rural	5,820,469	6,074,188	4.36
	Urban	1,086,220	2,087,773	92.21
24-Parganas (North)	Total	8,934,286	10,009,781	12.04
	Rural	4,083,339	4,277,619	4.76
	Urban	4,850,947	5,732,162	18.17

Source Primary Census Abstract, Census of India

region. Misfortunes come to those who are unskilled workers and have very limited opportunities for jobs. This limited work availability exacerbates the severe poverty situation in the remote villages of Sundarban delta (Molinari 2017). People are starving. The situation worsened after the severe cyclone 'Aila'. As this region is extensively inaccessible for its physiographically vulnerable position, the lack of basic amenities and improper resource distribution is manifold in a wide rate. Livelihood threats have emerged as post-disaster consequences in terms of food insecurities, seasonality in cultivation, exposure to high risk of flood, harvest failure, lack of resources, limited government interventions, and lower resilience of the poor peoples (Molinari 2017). The situational environmental vulnerabilities and consequent socio-economic recession highly impact on making the society disorganized. The limited access to resources intensifies animosity among the inhabitants for existence and weakens the neighbourhood's ties. The environmental stresses accompanied by acute poverty, illiteracy, lack of skills, unemployment, and homelessness compel the wretched deprived local inhabitants of Sundarban delta and adjacent areas to migrate to economically well off regions for better livelihood opportunities as '*Climate Refugees*' (McLeman and Brown 2011; Ganguly 2016). Even after 'Aila', three-quarters of households in Sundarban reported labour migration of at least one family member (Ghosh 2012). As a result of such disorganized situations in society, criminogenic activities are continuously increasing in this region (Molinari 2017). People themselves are engaged in various antisocial behaviours. Existing literature also exhibited a close association in between environmental stresses and related socio-economic insecurities, social disorganization, forced migration, and eventually exacerbate criminogenic activities in a region (Laczko and Aghazarm 2009; Sarraf et al. 2011; Foresight 2011; Martin et al. 2017; Martin 2010). Besides, some privileged people take ultimate advantage of these disadvantageous situations and open syndicates of trafficking rackets in the name of job placement agencies (Molinari 2017). The job placement agencies are very much active in the Canning, Gosaba, Basanti region. Where sustainable livelihoods become a great challenge to everyone in this region, the dream to get a prosperous life is nothing but a fantasy of human imagination. The placement agencies take advantage of these poverty situations. They offer jobs to the poor young men and women of this region in Delhi, Pune, Kolkata, Mumbai, Chennai, and Andaman.

Table 3 Number of immigrants to 24-Parganas districts from 1951 to 1991

District	1951	1961	1971	1981	1991
24-Parganas	599,939 (13.45)	1,213,791 (−19.33)	1,235,422 (14.62)	1,492,605 (13.90)	1,350,876 (10.39)

Source Census of India
Note Till 1981 both North and South-24 Parganas were under undivided 24 Parganas District, which was bifurcated subsequent to 1981. So the figures for both the districts are common till 1981

Therefore, the poor people, especially the younger ones from the remote villages of the Sundarban deltaic region, go far off places via the placement agencies to hope for a better life. However, they are often forced to act like bonded labours, work in hazardous industries and other filthy jobs where it will be difficult for them to return home. Moreover, the traffickers lure the local peoples and induce them to engage in such heinous acts. Sometimes, the poor local peoples themselves are compelled to take this as a profession to run their families.

Such disorganization in society can be illustrated following the theory of social disorganization (Shaw and McKay 1942, 1969). This theory depicts that criminogenic situations cannot be better understood without having an exact understanding of the demographic, socio-economic, and geographical facets within which it happens. Unlike other theories, this theory of crime relies on the effects of ‘kinds of places’ rather than ‘kinds of people’. It contextualizes that neighbourhood ecological characteristics shape individuals’ behavioural patterns. This theory stresses the inbuilt socio-economic and physical environment of an area, social ties, and connectivity among the neighbours that might create conditions favourable or unfavourable for crime and delinquency. As per this theory, extreme poverty, residential mobility, ethnic heterogeneity, and weak social ties lessen the neighbours’ ability to controlling public behaviour and hence increase the likelihood of criminal acts. Therefore, it can be summarized that the neighbours’ ecological conditions largely shape the crime rate of Sundarban deltaic region and also affects the characteristics of individual residents.

4.1 Vulnerability of Women and Girls and Trafficking

The effects of such a disorganized society can largely be observed in the life of poor women and minor girls in the Sundarban region. The disorganized society in the remote villages of the Sundarban is immensely responsible for the plight of poor women in this region. Many women from these remote villages are highly vulnerable to human trafficking. The racketeers target those young girls and women from these remote villages whose families are struggling financially. The isolated riverine villages and the forested islands in the deltaic Sundarban region are increasingly considered as significant trafficking hotspots. The frequent climate change-induced natural hazardous situations in the Sundarban delta intensify socio-ecological pressure such as worsening the poverty situations, limiting access to resources, losing livelihoods, waning living standards, and intensifying homelessness, forced migration, and increasing desperation among the inhabitants that eventually affects trafficking dynamics in this region. It becomes much harder to bear acute poverty situations and the constant battering of nature. Poverty itself is a problem in this deltaic region. Economic marginalization and livelihood threats make peoples incompetent to run their family well and continue their children's education. Therefore, school dropout has been increasing. For the poor parents, it becomes hard to feed their children properly, marry off their daughters. These troublesome situations make the young girls and women in this region too vulnerable to trafficking. The racketeers take advantage of these distress situations and lure the poor parents into sending their daughters to nearby cities for better education, better jobs, and prosperous lives. Even more surprisingly, poor parents are not very sure where their daughters actually go to work or whether they are safe in their workplace or not. Even the agents seduce the poor minor girls and young women by giving false promises of jobs in metros. Sometimes, dreams of city life trap the poor young girls in trafficking. This led to many incidences of organized crime of women trafficking in this remote deltaic region.

The location at proximity to the international Indo-Bangladesh border has made the area vulnerable to these activities. As the Sundarban deltaic region shares a porous international border with the neighbouring country Bangladesh, the proliferation of illegal trade of drugs, syrup, and cow is more here (Sanjog 2011). Peoples' livelihoods are solely dependent on illegal cross-border trading. Besides, illegal immigration of Bangladeshi migrants is happening through the porous border. Near about 70–80% of people, including males and females in this region, are working as 'Linkman', 'Lineman', and 'Dhur' to help the Bangladeshi immigrants illegally enter the Indian sub-continent (Shewly and Nadiruzzaman 2017; INCIDIN 2002). For each successful trading, they receive rupees 2000–2500 (Shewly and Nadiruzzaman 2017). For more secured border areas, the charges will be higher or depend on the economic condition of the immigrants. The brokers seduce the local people to engage in such illicit jobs. They act as *Dhur* and provide shelter to the Bangladeshi immigrants in their home for a few days as their relatives. Afterwards they enter the mainland and migrate to the metros in India. As the physic, language, and cultures of the two nations are quite similar, it becomes challenging for the BSF (Border Security Force) to differentiate a Bangladeshi after entering India.

Similarly, the traffickers bring the poor Bangladeshi women and girls in India with the help of Dhurs by enticing them with false promises of getting jobs, marriage, and eventually selling them to the red light areas. In the meantime, the traffickers provide financial support to the *Dhurs* to meet the immigrants' daily needs. Thus, the riverine border areas of the Sundarban, namely Gosaba, Canning, Basanti, Jibontala of South-24 Pargana district, and Basirhat, Nazat, Hasnabad, Sandeshkhali of North-24 Pargana district become the important *transit areas* of women trafficking. However, in many situations, the *Dhurs* face challenges of being caught by the BSF and customs officials, specifically during the high alert

Table 4 Number of beneficiaries under MGNREGA in West Bengal in financial year 2017–2018

District/state	Number of job cards	Registered workers						Number of active job cards*	Active workers*				
	Applied for	Issued	SCs	STs	Others	Total workers	Women		SCs	STs	Others	Total workers	Women
2	3	4	5	6	7	8	9	10	11	12	13	14	15
24-Parganas (North)	709,744	695,209	467,587	71,201	956,226	1,495,014	600,377	426,696	194,782	30,358	370,425	595,565	276,854
24-Parganas (South)	983,929	933,041	366,842	15,730	1,612,179	1,994,751	814,076	678,052	233,652	9553	808,691	1,051,896	450,738
Total West Bengal	11,903,961	11,593,184	7,312,903	2,164,470	17,277,875	26,755,248	11,295,578	8,335,783	4,202,706	1,145,427	8,297,678	13,645,811	6,088,795

Source Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), 2005: Ministry of Rural Government'
*Anyone in the households who has worked any one day either in last three economic years or in the current economic year

time (political turmoil situations) when border security is tightened. This situation can be epitomized by Paula Banerjee's observation that '……borders are understood to be marker of control not only over territories but over human bodies as well' (Banerjee 2011).

These situations affect their livelihood also. For those poor, uneducated, unskilled peoples, no alternative choices of livelihoods are there. Particularly women workers have very limited opportunity for livelihood. Moreover, these borderland areas have been threatened by many physiographic and socio-economic crises such as poor accessibilities, impoverishment, malnutrition, lack of basic amenities, and continuous political unrest situations. These threats make the local inhabitants in these border villages too insecure. Such insecurities compel the young villagers to migrate metros to enjoy better livelihoods (McLeman and Brown 2011). Such insecurities also put the poor minors or young women like Heema, Sahana, Mamoni, Neha of the border villages of the Sundarban deltaic region at the continuous risk of threats and increase victimization of trafficking the racketeers take advantage of such misery situations and mislead them in a wrong way. The poor girls from these remote riverine villages are offered jobs like domestic helper, housekeeping, call centres jobs, in spa and beauty clinics, in brick kiln fields, etc. with high salary in metros like Kolkata, Mumbai, Delhi, Pune, Chennai, Bangaluru, Kochi even abroad like Singapore, Andaman, and Dubai (Paul and Hasnath 2000) and are then forced to do the filthy job like organ trading, illegal drug transferring, bonded labour, begging, strip dancer in hotels or pubs, and sex workers in brothels and streets.

Physiographic vulnerable position, environmental challenges, and the growing prevalence of misery of women trafficking in the Sundarban deltaic region are continuously being nurtured by large-scale gender discrimination and the dominance of patriarchal culture in society. Like the other Indian society, women play subordinate roles in the remote villages of Sundarban. The supremacy of patriarchy does not allow women to express their views. Literature reveals that in patriarchal societies, women may be more affected by social confrontment and broader socio-economic dislocation (UNDP 2009). According to Anwary (2003), patriarchal societies develop an elusive mindset of male supremacy and draw an invisible fence between men and women based on women's appearances and sexuality. Thus, women's subordinate position in society creates large-scale gender discrimination, makes them vulnerable, and brings misfortune to them (Joffres et al. 2008; Danailova-Trainor and Belser 2006; Clawson et al. 2007; Bettio and Nandi 2010). The patriarchal society in Sundarban believes in the practice of the early age marriage of their daughters. This belief holds their family honour in the society. Therefore the patriarchal society in the remote Sundarban villages does not think seriously about girls' education as they believe women are born only for reproduction. Patriarchal societies try to free themselves from all responsibilities by arranging marriages for their daughters at a very early age. As a result, girls' school dropout rate in the remote deltaic villages of Sundarban is increasing. Such gender discriminations in society exacerbate the gender gap in education.

Education is considered necessary to enrich women with knowledge of the outer world, enhance their inner strength to endure the upcoming challenges, improve their societal status, and increase self-esteem. However, the dominance of patriarchal society in the remote villages of the Sundarban hinders the advancement of women education in the society. In such circumstances, the traffickers offer dowry-free marriage to the poor parents for their minor daughters. The so-called grooms convince the poor parents by providing wrong information concerning their identity, economic conditions, residence, family backgrounds, etc. Sometimes, they say that they are working in the Indian army and come to their home for a month on leave. So in the meantime, they want to marry and settle. The poor parents do not want to miss the chance to get a bright groom for their daughters. Due to acute poverty and large family size, it becomes difficult for the poor parents in this deltaic region to properly nourish their children, educating them, or arrange money for their daughters' marriage. So, the poor parents accept the dowry-free marriage proposals thinking that their daughters do not have to starve and live a healthy life. They arrange marriage secretly for their minor daughters without considering their opinions. The poor underage girls, mostly ages 9–15 years, are unable to protest their parents' decisions and are forced to marry at a very early age.

Moreover, traffickers often take advantage of such existing gender inequalities in society and offer love and marriage proposals to the minor girls. Moreover, due to the growing pressures on their family, the minor girls of the remote villages of Mandir Bazar, Patharpratima, Mathurapur I and II, Kulpi, Kakdwip blocks show their eagerness to accept the proposals and run away from home. However, after marriage, the girls discover themselves in brothels as their husbands sell them for money. Thus, patriarchal society, nourishing gender inequalities in society, and over and above acute poverty situations promote the possibilities of women trafficking in the remote villages of Sundarban.

4.2 Conclusion: Undertaken Strategies and Recommended Measures

The vulnerable geographical position, frequent climatic hazards, and the emerging environmental challenges in the Indian Sundarban deltaic region are continuously put the local inhabitants in enormous threats and intensify insecurities among them. The continuous environmental crisis and consequent livelihood threats, economic recessions, acute poverty, and forced migration make society too disorganize and stimulate criminal activities in this deltaic region's remote villages. Moreover, vulnerable borderland locations also provoke large-scale disorganization in society by exacerbating the criminal nuisance of illegal immigration and illegal trading. In such a disorganized environment, the racketeers are very active in this remote deltaic region and put the poor women at continuous high risk of threats and increase their vulnerabilities to trafficking. Each year, many young women and minors remain missing from the remote villages of the Sundarban. The immense environmental challenges and socio-economic susceptibilities make this region one of the primary source areas of women trafficking. The situation worsened after the severe cyclonic storm '*Aila*'. Most of the low-income families in this region have a solitary earning member with multiple numbers of dependents. The continuous socio-economic and environmental challenges limit the livelihood options and exacerbate poverty at a maximum level. It is difficult enough for the poor people in this region to have a meal for half day. These situations seduce the poor, uneducated parents' not to miss the dowry-free marriage proposals for their daughters or opportunities to send their daughters to far cities for better earnings so that their daughters do not have to starve. It seems like a blessing for the low-income families when the agents offer Rupees 2000–3000 instantly for sending their daughters' to metros to work as domestic helpers and promise to send money by every month so that their families can live well. However, their daughters have to pay indemnification for their families' worthless attitudes. Many young girls and women are trafficked for commercial sexual exploitation. They cannot come out from the dark world. The trafficking rackets active in the remote villages of Sundarban not only target the poor minors and young women; rather, the married women, widowed, separated women, and the raped ones who are unaware, helpless, and economically dependent or treated as unfit in society due to social stigma are also their targeted 'prey'. Despite the vulnerable geographical location and rising socio-economic and environmental challenges, the dominance of patriarchal society, the practice of child marriage, negligence attitude among parents, innocent and ordinary village lifestyle, illiteracy, desire for a luxurious life, and above all extreme unawareness among inhabitants facilitates the traffickers to continue their illicit activities fearlessly in this remote region.

The West Bengal State Government and different local NGO's (Non-Governmental Organizations) are active here to prevent the victimization of trafficking among women. In July 2016, the South-24 Pargana district police introduced '*Swayangsiddha*' scheme to combat human trafficking and prevent early marriage practice in the remote areas of deltaic Sundarban. The term '*Swayangsiddha*' itself aims to make women 'self-reliant'. This scheme envisions empowering the youngsters (especially girls) with knowledge and skills to become aware of abuse and violation of human rights, make informed choices, and are less vulnerable to human trafficking. Under this scheme the '*Swayangsiddha*' groups have been formed in every school and colleges in the South-24 Pargana district with interested students' age between 12 and 21 years. These groups collect information concerning missing girls, child marriage, sexual harassment in their own localities and notify law enforcement officials. Moreover, these groups share information regarding human trafficking, child rights, adverse effects of underage marriage, emergency helpline numbers with their friends and other community members. The Child Protection Committees of the State Government are supervising and governing these groups. Initiatives have been undertaken to establish such groups at all the Panchayats levels in this region. This '*Swayangsiddha*' scheme has been achieved great success in the last three years. Apart from raising awareness about trafficking, child marriage, and prevention techniques, the scheme '*Swayangsiddha*' also tries to ensure the trafficked victims' rehabilitation. Besides the South-24 Pargana district police, the North-24 Pargana district police also work rigorously to break the chain of trafficking rackets from the remote villages of Sundarban delta (the Sundarban blocks fall under North-24 Pargana district).

Furthermore, NGO's like *Bandhan Mukti* (Canning), '*Goranbose Gram Bikash Kendra*' (GGBK) (Canning), '*Childline*' (Jibontala), '*Chetana*' (Patharpratima), '*Teghoria Institute for Social Movement*' (Basirhat), Kolkata based NGO '*SANJOG*'; the local panchayat; BDO's (Block Development Officer's); school teachers'; *Anganwadi* workers and the *Asha* workers are vigorously active in the remote riverine villages of the Sundarban delta to make awareness among the poor people regarding human trafficking. The police and NGO's are quite successful in rescuing the trafficked victims each year. But problems arise when the rescued victims are not accepted by their family and society. After rescue from a frightening past, it becomes difficult for the rescued girls and women to lead a normal life. Many times, they are affected by chronic diseases like HIV/AIDS and have to go through psychologically traumatic situations. Even with these physical and psychological tussles, they have to fight incessantly with the attached social stigmas. They are viewed with hostility in society. So to secure their basic livelihood, many times, the rescued victims decide to return to the dark world. They also act as trafficking agent and lure the poor girls and women in their locality for wealthy life in metros and abroad. Thus the societal ignorance attitudes towards the rescued victims covertly and overtly play an important role in bringing misery in their lives. The poor families often show careless attitudes regarding their daughters' missing and do not lodge any complaint to the police. It may be due to extreme unawareness, a general fear of the police, attached social stigmas, fear of reprisals, or the parents themselves do not want to get their daughters' back due to harsh economic conditions. Continuous awareness campaigns are underway.

Nevertheless, trafficking from this region is not being entirely eradicated. Traffickers are now pursuing a new modus operandi for trafficking their targets. They are now smart enough to find new pathways to exploit the weakness of the so-called conscious people. Earlier, the traffickers themselves worked as agents, and due to disclosure of their identity by the police and NGO's, the local women started to avoid them. However, these days, the traffickers are employing young, good-looking men from the locality who have better credibility to marry a girl formally. Thus trafficking rackets are still very much operative in the remote villages of the Sundarban delta and make this region one of the hubs of women trafficking. The environmental vulnerability and socio-economic adversity inherently result in social disorganization, breaking the social ties, and increasing livelihood threats that put the poor women and minors in this region at continuous high risk and increasing victimization of trafficking. The Trafficking of Persons (Prevention, Protection, and Rehabilitation) Bill, 2018 has already passed in Lok Sabha that is supposed to provide prevention, rescue, and rehabilitation of the trafficked victims. The state government has to be strict enough and careful about the proper execution of laws and orders. To address immense environmental challenges and women trafficking, adaptation of diversified approaches, long-term commitment, and comprehensive and socially transformative strategies are to be needed. Anti-trafficking efforts must focus on underlying socio-economic and environmental context that contribute to vulnerability. So, priorities should be given to protect the existing local economies, strengthen social support and entitlements, generate job prospects, ensure labour rights, maintain a proper register of the local job placement agencies, support community resource management, and diversify local livelihoods and ensuring meaningful climate actions. The state government should have to adapt innovative situational crime prevention measures that might increase the effort of the traffickers and eventually eradicate such organized crime from this region. The government has to work in collaboration with local NGOs, local governing bodies, and civil society so that people can overcome the adversity of physical as well as socio-economic, environmental challenges, and a trafficking-free society might evolve.

References

Anwary A (2003) Acid violence and medical care in Bangladesh: women's activism as carework. Gend Soc 17(2):305–313

Asian Development Bank (1997) Emerging Asia: changes and challenges. Asian Development Bank, Manila

Banerjee P (2011) Bengal-Bangladesh borderland: chronicles from Nadia, Murshidabad and Maida. In: Banerjee P, Chaudhury ABR (eds) Women in Indian borderlands. SAGE Publications India. ISBN 978-81-321-0650-0

Bettio F, Nandi TK (2010) Evidence on women trafficked for sexual exploitation: a rights based analysis. Eur J Law Econ 29(1):15–42

Chakraborty S (2015) Investigating the impact of severe cyclone Aila and the role of disaster management department—a study of Kultali block of Sundarban. Am J Theor Appl Bus 1 (1):6–13

Clawson HJ, Layne M, Smalls K (2007) Estimating human trafficking into the United States: development of a methodology: final phase two report. ICF International, Fairfax VA

Danailova-Trainor G, Belser P (2006) Globalization and the illicit market for human trafficking: an empirical analysis of supply and demand. ILO, Geneva

Das TK (2011) An interdisciplinary study of natural disasters. In: Das TK, Das Gupta I, Lohar D, Bhattacharya B (eds) Diasters in West Bengal: an interdisciplinary study. ACB Publications. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1933446

Debnath A (2013) Condition of Agricultural Productivity of Gosaba CD Block, South24 Parganas, West Bengal, India after Severe Cyclone Aila. International Journal of Scientific and Research Publications 3(7):1–4

District Human Development Report (DHDR) (2009) South-24-Pargana. Department of Planning, Statistics and Programme Monitoring. Government of West Bengal. http://www.wbpspm.gov.in/HumanDevelopment/DHDR. Accessed 20 Nov 2019

District level household survey (DLHS) (2002–2004). http://rchiips.org/ARCH-2.html. Accessed 17 Sep 2019

Dwivedi RS, Rao BRM, Bhattacharya S (1999) Mapping wetlands of the Sundaban Delta and it's environs using ERS-1 SAR data. Int J Remote Sens 20(11):2235–2247

Elliott L (2001) Environmental challenges. ISEAS—Yusof Ishak Institute. In Southeast Asian Affairs:68–81

Foresight (2011) Migration and global environmental change: future challenges and opportunities. Final project report, UK Government Office for Science, London. https://eprints.soas.ac.uk/22475/1/11-1116-migration-and-global-environmental-change.pdf. Accessed 7 Oct 2018

Ganguly C (2016) The lost of daughters of the Sundarbans, West Bengal—the source, transit, and destination of human trafficking. core sector communique, 10 Sep. http://corecommunique.com/lost-daughters-sunderbans-west-bengal-source-transit-destination-human-trafficking/. Accessed 20 Nov 2019

Gayathri R, Bhaskaran PK, Sen D (2015) Numerical study on storm surge and associated coastal inundation for 2009 AILA cyclone in the head Bay of Bengal. Aquat Procedia 4:404–411

Ghosh A (2012) Living with changing climate—impact, vulnerability and adaptation challenges in Indian Sundarbans. New Delhi, Centre for Science and Environment, p 91

Giri S, Mukhopadhyay A, Hazra S, Mukherjee S, Roy D, Ghosh S, Ghosh T, Mitra D (2014) A study on abundance and distribution of mangrove species in Indian Sundarban using remote sensing technique. J Coast Conserv 18(4):359–367

Hazra S, Ghosh T, DasGupta R, Sen G (2002) Sea level and associated changes in the Sundarbans. Sci Cult 68(9/12):309–321

INCIDIN (2002) Rapid assessment on trafficking in children for exploitative employment in Bangladesh. IPEC ILO Trafficking in Children-South-Asia (TICSA) Project. Bangladesh. ISBN 92.2.113513.6

India Meteorological Department (IMD) (2009) Report. https://mausam.imd.gov.in/imd_latest/contents/cyclone.php. Accessed 22 Nov 2018

Jana R, Mohapatra S, Gupta AK (2013) Integrating climate change adaptation and disaster resilience: issues for Sundarbans. Disaster & Development. J Natl Inst Disaster Manage (NIDM) 7(1&2). New Delhi. ISSN: 0973-6700

Joffres C, Mills E, Joffres M, Khanna T, Walia H, Grund D (2008) Sexual slavery without borders: trafficking for commercial sexual exploitation in India. Int J Equity Health 7(1):22

Laczko F, Aghazarm C (2009) Migration, environment and climate change: assessing the evidence. International Organization for Migration (IOM)

Martin M, Kang YH, Billah M, Siddiqui T, Black R, Kniveton D (2017) Climate-influenced migration in Bangladesh: the need for a policy realignment. Dev Policy Rev 35:O357–O379

Martin S (2010) Climate change, migration, and governance. Glob Gov: Rev Multilateralism Int Organ 16(3):397–414

McLeman R, Brown O (2011) Climate change and human migration. In: Koser K, Martin S (eds) The Migration-displacement nexus: patterns, processes, and policies, vol 32. Berghahn Books, New York, pp 168

Mitra A, Halder P, Banerjee K (2011) Changes of selected hydrological parameters in Hooghly estuary in response to a severe tropical cyclone (Aila). Indian J Geo-Marine Sci 40(1):32–36

Molinari N (2017) Intensifying insecurities: the impact of climate change on vulnerability to human trafficking in the Indian Sundarbans. Anti-Trafficking Rev 8

Nellemann C, Verma R, Hislop L (2011) Women at the frontline of climate change: gender risks and hopes. A rapid response assessment. United Nations Environment Programme, GRID-Arendal, Norway

Paul BK, Hasnath SA (2000) Trafficking in Bangladeshi women and girls. Geogr Rev 90(2):268–276

Ramachandran S (2005) Indifference, impotence, and intolerance: transnational Bangladeshis in India. Glob Migr Perspect:42

Sánchez-Triana et al (eds) (2014) Building resilience for sustainable development of the Sundarbans through estuary management, poverty reduction, and biodiversity conservation. South Asian Region. Sustainable Development Department, Environment and Water Resource Management Unit. The World Bank. Strategy Report No-88061 IN

Sanjog (2011) Crossing boundaries: cross-border mobility of boys between India and Bangladesh: an explorative study. Sanjog, India. http://www.sanjogindia.org/wp-content/uploads/2015/10/CROSSING-BOUNDARIES.pdf. Accessed 26 Nov 2019

Sarraf M, Dasgupta S, Adams N (2011) The cost of adapting to extreme weather events in a changing climate. Bangladesh development series paper 28(10.1596):26890

Shaw CR, McKay HD (1942) Juvenile delinquency and urban areas. University of Chicago Press, Chicago

Shaw CR, McKay HD (1969) Juvenile delinquency and urban areas. University of Chicago Press, Chicago

Shewly HJ, Nadiruzzaman M (2017) Invisible journeys across India-Bangladesh borders and bubbles of corrupt networks: stories of cross-border rural-urban migration and economic linkages. In: Chiodelli F, Hall T, Hudson R (eds) Corrupt places: the illicit and illegal in regional and urban governance and development. Routledge, pp 37–50

United Nations Development Programme (UNDP) (2009) Human Development Report (HDR) (2009) Overcoming barriers: human mobility and development. Palgrave Macmillan, New York

West Bengal Disaster Management and Civil Defense department (WBDM&CD) report. Cyclone. Government of West Bengal. http://wbdmd.gov.in/Pages/Cyclone.aspx. Accessed 9 Nov 2019

Priyanka Biswas is a senior research scholar in department of Geography, Vidyasagar University, West Bengal, India. Her areas of research interest are criminological studies especially crime against women, urban environment and crime, and statistical modelling. She emphasizes multidisciplinary efforts to visualize the crime scenarios and evaluate policy-level change to make society crime-free.

Dr. Nilanjana Das Chatterjee is a professor in the Department of Geography, Vidyasagar University, Midnapore, West Bengal, India. Her principal areas of research interest are environmental studies, criminological studies, criminal psychology, and associated socio-economic milieu. She emphasizes to use evaluation strategies to develop community level awareness and support policy-level change to enhance the quality of society.

Women Beyond the Politics of Presence in Urban Local Governance: Exemplifying Purulia in West Bengal, India

Anindya Basu and Asha Bauri

1 Introduction

Governance has several aspects. It is related to politics, administration, leadership building, and infrastructural development (Pierre 1998; Bovaird and Loffler 2002; Harpham and Boateng 1997). It can be said that governance is the process by which public institutions, representatives, and people or civil society can interact with each other to achieve the greater goal of development (Paproski 1993; Pierre 1998). Hence, it is of utmost importance for the public institutions, representatives, and general people to participate in the governing process, maintaining accountability and transparency among several stakeholders, especially between the elected representatives and the local inhabitants (Baud and Wit 2008; Slack and Cote 2014). So, governance is a sociological exercise rather than a technical one as it is rooted in the society in which it grows (Chakraborty and Pandey 2019).

The average proportion of women local councillors worldwide is 20%, whereas fewer than 5% of the world's mayors are women (UCLG 2020). So, better political participation of women is the need of the hour for the attainment of true democracy.

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

A. Basu (✉)
Department of Geography, Diamond Harbour Women's University, Diamond Harbour, West Bengal, India

A. Bauri
Department of Geography, Kashipur Michael Madhusudan Mahavidyalaya, Kashipur, West Bengal, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_14

Political participation constitutes the first and foremost step in that direction (Narayanan 1999). Women's political representation is the core element of gender equality and good governance at the local level (OECD 2014; Araujo and Tejedo-Romero 2016). The international organization promotes gender equality (EC 2013). Some countries make efforts to promote gender equality through laws, quotas, and constitutional amendment (OECD 2014; Araujo and Tejedo-Romero 2016). Such as 74th Constitutional Amendment Act in India, which is considered as a yardstick for urban governance as it reforms the local urban structure by enabling some provisions in the governing process. One of the important provisions of the amendment is the women candidates' reservation in the local-level politics, which ensured one-third seats for the women in the urban local bodies, e.g. municipalities and municipal corporations. Women got a chance to enter the political arena, which was far away from their comfort zone. Reservations only ensured presence in politics, i.e. a certain number of seats for the women, but the nature of participation is totally dependent on the awareness of the candidates or representatives. The role, interaction, and decision-making capability of the representatives are considered as the aspects beyond the politics of presence that made them empowered. There are several factors that influence the nature and degree of political empowerment.

United Nations Centre for Human Settlements (2000) defines empowerment as a strategy to help the disadvantaged and the marginalized to gain the power to change the quality of their lives (Women UN 2013). For that, active participation in decision-making is needed. Women are one of the target groups for such an empowerment strategy, which strives to eradicate all forms of exclusion they generally face in the patriarchal society.

The term 'political empowerment' is, to a larger extent, collective, including the authority to attain specific goals not for the self but for society. To be politically empowered, a person needs the support of other people of the community (Zaman 2012), and also, their political socialization is needed, which increases their level of political awareness.

By examining specifically the women's political participation, the present paper seeks to identify the nature of women's political empowerment, women's political awareness, and most influencing factors of empowerment from a municipality perspective in India.

2 Prior Works in This Domain

Half of the population of the world is women, but they do not have a significant role in the governing process, specifically policy formation and decision-making process (Prasad 2014). So, women have the least participation in governing process. Some international organizations like the Federation of Canadian Municipalities (FCM) and the Canadian International Development Agency (CIDA) have played an influential role in the participation of the citizens in twenty countries of Asia, Africa and Eastern Europe, Latin America, and the Caribbean, where women have been marginalized from the mainstream of politics (Federation of Canadian Municipalities 2009). United Nations Economic and Social Council (ECOSOC) recommended increasing women's proportion in the leadership position at 30% by 1995 and equal representation of male and female by 2000 (Equal Opportunities Commission 2003; Prasad 2014).

One of the important steps is the allocation of 33% seats in local government in South Asia (Mahmood 2004). For instance, in Bangladesh, there are three articles that are related to the women entrants in the political arena. Those are Article 10, which ensures women's participation in national politics, Article 65 (3) ensures women's reservation in the Parliament, and Article 9 gives the chance to enter into the local-level politics (Zaman 2012). In India, there is no such constitutional rule which ensures women entrant in national- and state-level politics, but there are 73rd and 74th Constitutional Amendment Act which provides 33% reservation for the women in local-level politics, i.e. panchayats for rural areas and municipalities for urban areas, respectively (Government of India 1992). Quota plays an important role for the women participants as it gives a chance and grows the interest towards politics which extends the empowerment possibility in the near future (Mahmood 2004). Women's participation in local government is comparatively higher; the reasons behind this high participation are because it is easier to access the responsibilities as both a family person and a public representative, reserved seat and less competition in the local government, and the extension of responsibility for the local community and the women representatives practise transformative leadership in the form of rising different issues, style of leadership, and equity concern (Drage 2001). For strengthening the democracy at both the local and national levels, women's participation is essential (Islam 2002). Several initiatives have been taken for the local governance in both the rural and urban areas, but there is still discrimination after entering into the arena of politics. Reservation is an important factor for women's political participation but what is required more is effective representation in the policy formation. It has been identified that social and economic connections are the influential factors for getting a chance in politics (Ghosh and Lama-Rewal 2005).

West Bengal was one of the pioneer states who followed the act beyond its provisions (Government of West Bengal 1993). In West Bengal, a ward committee has to be formed in each and every ward (Government of West Bengal 2001). It was one of the important components of urban governance. But a large majority of women councillors are economically dependent and educationally not sound, which ultimately leads to being a proxy or namesake councillors in the two urban local bodies in West Bengal (Ghosh 2010). Even family political linkage has emerged as an important factor in urban local governance (Ghosh 2010).

Some studies in India have found that though as a new entrant of politics, women representatives have faced problems, still the implementation of the 74th Constitutional Amendment Act has largely increased political participation of women, specifically their decision-making power, to a considerable extent (Rao 2014). The 74th Constitutional Amendment Act has been enacted to strengthen local-level governance by seeking to ensure adequate active participation of women in municipal bodies through the mechanism of reservation of seats for women

(Government of India 1992; Ghosh 2010) and the representatives developed in different ways in the course of five years in office, some becoming significant political players in their own right (John 2007). This affirmative action has created a space for women and provided them an opportunity to actively participate and perform in the local governing structures (Sharma 2016). There are several factors (such as geographical location, educational status, social status and age) which determined the degree of women empowerment in India (Kumari 2006; Prasad 2014).

There are two objectives behind women's inclusion in urban local government; the first is the women's political empowerment, and the other is the developmental aspect of the city (Beall 1996). Women's role in urban governance is one of the most important questions for considering women's political, social, economic, cultural, administrative empowerment. Women's participation in urban governance, affairs, and decision-making is very low, and they are not participating effectively and actively in the urban governance, except few who are aware of urban governance. Without the effective participation of women, it is impossible to achieve the socio-economic and political development of the nation (Alsop and Heinsohn 2005).

3 Women's Participation in Governance: Tier-Wise Overview

The dream of joining the realm of politics by women seemed distant initially, but gradually the scope opened up, giving women a chance to compete for positions in the different tiers of the governance. Still, many countries do not have any separate provisions for encouraging women to take part in governance by giving them some kind of headspace. Several international and national organizations have given special attention to the policies, regulations, and their impact in strengthening women's participatory role in local-level politics at the grass-roots level.

3.1 Global Trend of Women's Participation in Governance

Women have been excluded from several aspects of life, especially from the political arena (Narayanan 1999). The world average of women representation as legislators is 24.5% in both houses (Inter-Parliamentary Union 2019). The single or lower house has a slightly higher share than the upper house or senate (Table 1). Hence, the national-level political participation of women is growing at a slower rate because there are still some countries that do not have any reservation policy for national representation.

Table 1 Women participation in both houses across the world

Houses	Total MPs	Men	Women	Percentage of women
Single or lower	39,013	29,423	9590	24.6
Upper or senate	7205	5455	1750	24.3
Both houses	46,218	34,878	11,340	24.5

Source Women in National Parliaments, Inter-Parliamentary Union, October 2019

Table 2 Global scenario of women participation in National Parliaments

	Single house or lower house (%)	Upper house or senate (%)	Both houses combined (%)
Nordic countries	44.0	–	–
Americas	30.6	31.5	30.8
Europe (Nordic countries included)	29.6	28.5	29.4
Europe (Nordic countries not included)	28.1	28.5	28.2
Sub-Saharan Africa	24.1	23.9	24.0
Asia	20.1	16.7	19.7
Middle East and North Africa	17.7	10.7	16.8
Pacific	16.6	43.8	19.4

Source Women in National Parliaments, Inter-Parliamentary Union, October, 2019

The highest women representation in the lower house is found in the Nordic countries (Table 2) followed by Americas, Europe (including the Nordic countries), Europe (excluding the Nordic countries), Sub-Saharan Africa, Asia, the Middle East, and North Africa, and the lowest is in Pacific (Inter-Parliamentary Union 2019). But the highest representation of women in upper house is found in the Pacific (Table 2) followed by the Americas, Europe (both Nordic countries included and not included), Sub-Saharan Africa, Asia, the Middle East, and North Africa.

Though the participation of women in lower house in some of the developing countries secured top ranks (Rwanda ranks first followed by Cuba and Bolivia (Plurinational State of) (Table 3), the overall average of women representation in lower houses for the developing countries is 21.92% (Inter-Parliamentary Union 2020) which is lower than the share of women in Parliament in the developed country, i.e. 27.38% (May 2020). The Constitutions of several countries in the world theoretically guarantee the political equality of men and women, but matters often work out quite differently in practice.

Table 3 Representation of women in Parliament of selected countries

Rank	Country	Election year	Share of women (%)
1	Rwanda	2018	61.25
2	Cuba	2018	53.22
3	Bolivia (Plurinational State of)	2019	53.08
4	United Arab Emirates	2019	50.00
40	Netherlands	2017	33.33
43	Nepal	2017	32.73
50	Australia	2019	30.46
76	China	2018	24.94
99	Bangladesh	2018	20.92
105	Pakistan	2018	20.18
139	Bhutan	2018	14.89
144	India	2019	14.36
181	Sri Lanka	2015	5.33

Source Women in National Parliaments, Inter-Parliamentary Union, May, 2020

3.2 South-East Asian Context of Women's Participation in Governance

South Asia, where one-fifth of the world's population resides, is one of the least developed regions in terms of human development (HDI value is 0.642, 2018). The average GDI value of South Asia is 0.828. Politics, especially electoral politics, is an expensive hobby for the women in South Asian societies, who are treated as second-class citizens. So, it is difficult for them to fight elections without the support of their family or strong political ties. Despite these facts, South Asia had the honour of having the world's first lady prime minister. India, Pakistan, Bangladesh, and Sri Lanka all have been led by women prime ministers. But in general, women in South Asia are not politically socialized enough to participate in the political arena, they have strong determination, ability, and devotion; so, what they need is awareness and guidance (Zaman 2012).

An international survey conducted by Inter-Parliamentary Union demonstrates that representation of women in South Asian Parliaments is far from satisfactory; Nepal, China, Bangladesh, Pakistan, Bhutan, India, and Sri Lanka ranked 43th, 76th, 99th, 105th, 139th, 144th, and 181th, respectively, out of 187 countries in terms of women representation in National Parliament. In South Asia, Bhutan, India, and Sri Lanka secured lower ranks in the National Parliament, whereas Nepal, China, Bangladesh, and Pakistan secured comparatively better positions. However, still, the share was below one-third. India documents a marginal representation of women in Parliament, which is even lower than the neighbouring countries such as Nepal, China, Bangladesh, Pakistan, and Bhutan.

In the case of the upper house, the data of only 79 counties is available in Inter-Parliamentary Union, May 2020. In South Asia, Nepal has a higher share of

Table 4 Share of women representatives in upper house (senate) in selected countries

Rank	Country	Election year	Share of women (%)
1	Antigua and Barbuda	2018	52.94
2	Mexico	2018	49.22
3	Australia	2019	48.48
4	Bolivia (Plurinational State of)	2019	47.22
16	Rwanda	2019	38.46
17	Nepal	2020	37.93
22	France	2017	33.33
51	Pakistan	2018	19.23
61	Bhutan	2018	16.00
71	India	2018	10.42
72	Thailand	2019	10.40
78	Yemen	2001	2.70
79	Haiti	2017	0.00

Source Compiled by authors from Inter-Parliamentary Union, May 2020

women in the upper house, whereas Pakistan and Bhutan have only the least women representation (Table 4). The share of women representation in India in upper house is even lower than the neighbouring countries–Nepal, Pakistan, and Bhutan.

3.3 Current Scenario of Women's Participation in Governance in India

India has an abysmal track record on gender equality which is reflected through its GDI value of 0.829. According to the UNDP's 2018 Gender Inequality Index, India ranks 129 out of 189 countries with 0.501, and as per World Economic Forum's 2012 Global Gender Gap Index it ranks 105 out of 135 countries. The percentage of women in the Lok Sabha in relation to the total number of seats was 4.4% in 1952. After several ups and downs, it has increased but has not crossed 15% till date. The presence of women in the upper house was 7.31% in 1952, which was comparatively higher than that of Lok Sabha, which has increased slightly over time. India ranked 144 globally out of 187 countries in the lower house in 2019 elections (Table 3) and 71 out of 79 countries in upper house in 2018 elections (Table 4). The share of women in lower house in 2019 elections is highest in the state of Meghalaya and Tripura, followed by Odisha, Chhattisgarh, and West Bengal (Parliament of India 2020) (Table 5). It is noteworthy to mention that there are some states of India which do not have women's representation at all.

Though the share of women in higher-level politics in India is very low, in the case of local-level politics, the share is reasonably high because of the provision of

Table 5 Women in Parliament in some selected states of India, 2019

Rank	States	Share of women
1	Meghalaya	50
1	Tripura	50
2	Odisha	33.33
3	Chhattisgarh	27.27
4	West Bengal	26.19
20	Telangana	5.88
21	Kerala	5.00

Source Compiled by author from Parliament of India, May 2020

the 73rd and 74th Constitutional Amendment Act, which guarantee women participation in local-level politics through the reservation of one-third seats in panchayats and municipalities which ultimately increases the share of women in local governance.

The act also helped to increase the share up to 50% in some urban local bodies. For instance, Purulia Municipality (2015–2020 term) is located in Purulia district of the state of West Bengal of India.

3.4 Women's Participation in Local Governance: A Reality Check of Purulia Municipality, India

After the enactment of the 74th Constitutional Amendment Act in 1992, West Bengal and Kerala were the states who implemented the provisions immediately. This act has a statutory provision that guaranteed women the right to participate, i.e. one-third seat, in the urban local bodies, which drastically increased the women's share. West Bengal secured 4th rank (26.19%) in terms of women's share in parliamentary seats while the women's share secured is only 13.27% in state's assembly. (Elections in India 2020). However, when it comes to the urban local-level politics, half of the urban local bodies across the districts of the state have about 50% share of women representation. One of them is the Purulia district, which, though is less developed in terms of socio-economic parameters, has an appreciable share of the women representation in one of its urban local bodies (ULBs), i.e. Purulia Municipality.[1] Though this is a small municipality of India, the share of women representatives in this municipality has always been more than the stipulated share of 33%. Hence, it can be said that this is a classy example of the true representation of the innumerable smaller municipalities across West Bengal as well as India. The methodology which has been adopted in this case will be equally

[1]The Census of India spelling is Puruliya Municipality, while it is popularly known as Purulia Municipality.

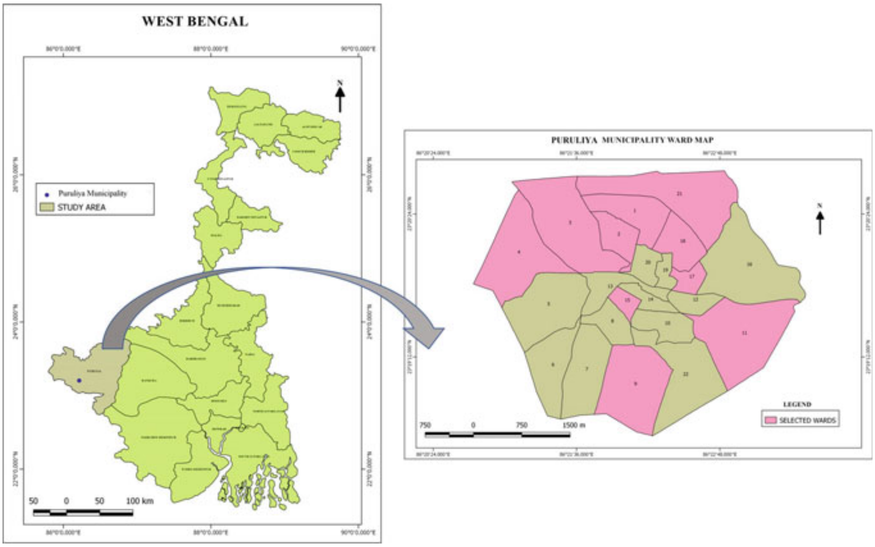


Fig. 1 Locating Purulia Municipality with special reference to wards having women representatives. *Source* Purulia Municipality, 2019

effective to gauge how much power truly a women representative wields in grass-roots democratic politics.

Purulia district (Fig. 1) is located in the state of West Bengal, eastern India having a population density of 470 persons/km^2. Demographically, the district is not well sound as the male literacy rate is 78.85%, while the female literacy rate is only 51.29% and the sex ratio is 957 females per 1000 males (2011 Census). It has ranked in the lower rung of the human development ladder (16th out of 17, HDR, 2008). Maximum people (87.25%) of the district reside in rural areas with only three statutory towns (Purulia, Raghunathpur, and Jhalda) and 25 census towns. The male work participation rate is 53.52%, while the female work participation is 31.29%. After the enactment of the 74th CAA, especially after the 2000s, the city council structure got changed. This change in the law accommodates women to come in the contender list of municipal elections and is expected to have their rightful role in the delivery of municipal services.

Inspite of huge socio-economic gender gap, the local level political participation in urban areas is quite appreciable. Purulia is the main city of the district, and local-level women's participation in the city is quite high. The local governing process has been done by Purulia Municipality, which has 23 smallest units for governing, i.e. municipal wards, out of which 11 municipal wards (ward numbers 1, 2, 3, 4, 6, 9, 11, 15, 17, 18, and 21) are represented by women councillors in the latest term, i.e. 2015-2020 term. Among the 11 councillors, 4 (ward numbers 1, 4, 11, and 17) have contested from unreserved seats, and they got re-elected by competing with the male representatives. Even in the municipal apex body, i.e.

chairman-in-council (CIC) is also represented by the 3 women councillors (ward numbers 6, 11, and 17). Hence, the women's entrance is ensured by the act of reservation, but they have a substantial role in maintaining or running the city governance.

4 Database and Methods Involved

This section discusses in detail the data and methods which have been used to know the nature of political participation of the women in the local-level politics a glimpse from the Purulia Municipality.

4.1 Database

The study discusses the condition of women representatives in the urban local governing institutions of Purulia city. Hence, only women representatives of Purulia municipality have been taken into account. Ten women councillors have been interviewed with the semi-structured schedule to trace their level of political empowerment and awareness.

4.2 Methodology

The study is largely based on primary data collected from the councillors. An attempt has been made to analyse the political empowerment and participation of women representatives. The primary data collected has been summarized and depicted through statistical analysis and cartograms. A couple of composite indices have been constructed—Women Political Awareness Index (WPAI) and Women Political Empowerment Index (WPEI) for scrutinizing the condition of women in local governance. The 18 indicators which have been used for the construction of the indices are associated with the awareness about the local urban governance and empowerment in terms of the political sphere (Table 6).

The weights in the computation of WPAI and WPEI are determined by using factor loadings and eigenvalues from principal component analysis (PCA). The principal component analysis has been used to reduce the dimensionality of the variables but at the same time retaining the originality of the variables. The following formula is used to determine the indices.

Table 6 Selected indicators of Women Political Awareness and Empowerment Indices

Women Political Awareness Index	V1	Previous political experience
	V2	Awareness regarding ward office
	V3	Nomination criteria of ward committee members
	V4	Cognizance about ward committee meeting
	V5	Mindfulness about minute
	V6	Responsiveness towards board of councillor's meeting
	V7	Accountability with the local people
	V8	Consciousness about constitutional provision of urban governance
Women Political Empowerment Index	V9	Responsibility of the representatives
	V10	Involvement and engagement in the ward's activities
	V11	Interaction in the board of council meeting
	V12	Involvement in the overcoming of the difficulties
	V13	Dependency while executing municipal work
	V14	Participation in training programme
	V15	Change in awareness level
	V16	Transformation in self-confidence
	V17	Willingness of re-contesting from unreserved seat
	V18	Political aspiration

Source Computed by authors on the basis of Primary Survey, 2019

$$= \frac{\sum_{i=1}^{n} x_i \left(\sum_{j=1}^{n} \left| L_{ij} \right| \cdot Ej \right)}{\sum_{i=1}^{n} \left(\sum_{j=1}^{n} \left| L_{ij} \right| \cdot Ej \right)} \tag{1}$$

where I is the WPAI and WPEI, X_i is the ith indicator, L_{ij} is the factor loading value of the ith variable on the jth factor, and E_j is the eigenvalue of the jth factor.

The study has also adopted a regression model where the WPEI is considered as the dependent variable, social and economic factors are considered as independent variables, and their association has been estimated. As a qualitative method, case studies have been used to analyse the state of women representatives in urban local governance.

5 Findings

Reservation has been seen as the key responsible factor which enables women to enter into politics and participate in the welfare of society. In Purulia Municipality, the women representation in the four terms (from 2000 to 2020) has always been more than one-third of the total seats and has shown an increasing trend. From the last term (2010–2015), the representation has been increased by about 9.72% because 4 women representatives contested from unreserved seats and got re-elected. Reservations might be the main entrant factor for women in politics. However, in the present situation, it cannot be determined that it is the only factor which enables women to come into the sphere of the governing process. There is a variation with respect to the caste, age, and political view among the representatives. The middle-aged women are mainly engaged as councillor in the study area, followed by the young-age cohort. Eight women councillors are from general, while two are from the Scheduled Caste (SC) category. Maximum councillors are Hindu. Most of the women councillors are from the present ruling party—All India Trinamool Congress followed by Indian National Congress and CPIM. All the representatives are married, barring one who is a widow. Except for one councillor, all have exposure to formal education of varying extent, but most of them are economically dependent on their families. Only one councillor is involved in the teaching profession.

5.1 Women Political Awareness Index (WPAI)

Candidature is an important factor in assessing political participation as it opens up possible entry for women in politics, decision-making, and leadership. The reservation also boasts up the political participation of the women. But how efficiently one would be able to utilize the position of political power is dependent on the representative's knowledge about local governance, experience, and inherent interests towards the responsibility. Political awareness is a multidimensional concept that encompasses political representation, accountability, awareness about various types of meetings, and subordinate bodies, which can increase interaction with electorates and make the representatives aware of.

Women Political Awareness Index (WPAI) has been calculated to quantify the characteristics associated with the awareness level about the local governance. It is applied to estimate the proportion of the differences among the women councillors as they represent different socio-economic as well as political background. For that, some variables related to the awareness of the political sphere of local governance have been taken. Those are previous political experience, awareness about ward office, the nomination of ward committee members, cognizance about ward committee meeting, minutes and board of council meeting, accountability with the local people, and mindfulness about the constitutional provision of urban governance, e.g. 74th CAA, women reservation and state municipal act.

It is found that the political awareness of the female representatives is not very high in general. Maximum representatives belong to lower-rung clusters—medium to low groups (Table 7 and Fig. 2). Only one representative is highly aware of the existing rules of the local governments as the composite score is 4.43; she is more politically experienced as she is a re-elected representative from a mature age cohort and has a professional engagement as a teacher. Three representatives are

Table 7 Women Political Awareness Index (2015–2020), Purulia Municipality

Composite scores of WPAI	Status of WPAI	Ward number
>4.00	High	1
3.00–4.00	Medium	11, 17, 18
2.00–3.00	Low	2, 3, 4, 9
<2.00	Very low	15, 21

Source Computed by authors on the basis of Primary Survey, 2019

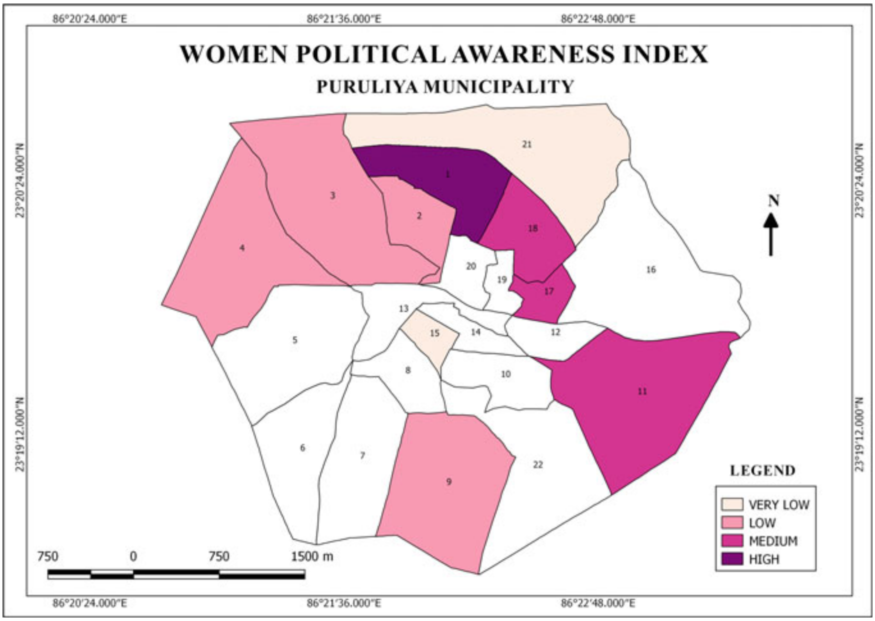


Fig. 2 Women Political Awareness Index Map of Purulia Municipality, 2015–20. *Source* Compiled by authors from Primary Survey, 2019

moderately aware of the existing rules of the community governance as the composite score is more than 3.0 but less than 4.0. Two of them are re-elected representatives, and one was town 'Mahila' (women) president and politically active much before coming to formal seat of power. They represent middle-aged cohorts and are actively engaged in the chairman-in-council (two of them), one of the urban local bodies' apex body. The four representatives who are totally inexperienced, from the young to the middle-aged cohort, are less aware of the rules and regulations of the local governance. All of them are housewives; household responsibility and recurrent personal health issues are the major responsible factors for their inability to increase their awareness about the local governance. Hence, it can be said that experience is the utmost important factor to become politically aware.

5.2 Women Political Empowerment Index (WPEI)

Reservations in the urban local bodies allow the women to enter another sphere from their cozy comfort corner. Women start participating in mainstream politics, public offices, and city-level development processes. But reservation only gives power into the hands of women; but it totally depends on them how to utilize and create their own spaces in the governing system. Few studies have found that this reservation only gives birth to the token participation; women are not truly empowered with the stipulated provision; instead, they became the voice of their counterpart or any political leader who is actually working behind the reserved seat—'the puppet and puppeteer'.

To identify the issue, Women Political Empowerment Index has been calculated with the help of principal component analysis. It has also been figured out the proportion of differences of the women empowerment within the city. It is a composite score of the parameters other than the stipulated responsibility to the representatives—involvement and engagement of the ward activities, interaction during the board of council meeting, overcoming the difficulties faced, degree of dependency in doing municipal works, participating in training programmes, changing awareness level, self-confidence, and willingness of re-contesting from unreserved and political aspiration.

It is found that only one representative (Table 8) is truly politically empowered, having a composite score of 3.08, even though she does not enjoy important posts in the municipality because of opposition party affiliation. But she has carved her own niche through the welfare of the ward residents in particular and city development in general. The rate of empowerment of the other four councillors who are not very active has a composite score of more than 2.0 but less than 3.0 (Table 8 and Fig. 3). They are experienced but still slightly dependent on the others for discharging their duties. One representative, who is in power for consecutive two terms but still has low awareness as well as a low political empowerment rate, is a classic case of token participation where the female representative is only the face for the reserved seat, but others do the work. It is also found that in a family, mostly husbands give permission to the women candidate to participate in the governing process for the sake of holding the seat for the time being, which does not satisfy the actual aim of the reservation. Hence, political empowerment of the councillor is not directly dependent on party affiliation. Prior experience, greater devoted time ward activities, regular interaction with locals, and higher political aspiration can translate into political empowerment. The rate of empowerment of four councillors is low as they are less active, with a composite score of more than 1.0 but less than 2.0. One representative is politically inactive, reflected through the composite score of 0.57. She is very ignorant about her duties, hardly attends board of council meetings, interacts with the local people, and is completely remote-controlled by her husband. This is a case of token participation, and the representative is a proxy member.

Table 8 Women Political Empowerment Index (2015–20), Purulia Municipality

Composite score of WPEI	Status of WPEI	Ward number
>3.00	High	1
2.00–3.00	Medium	3, 11, 17, 18
1.00–2.00	Low	2, 4, 9, 21
<1.00	Very low	15

Source Computed by authors on the basis of Primary Survey, 2019

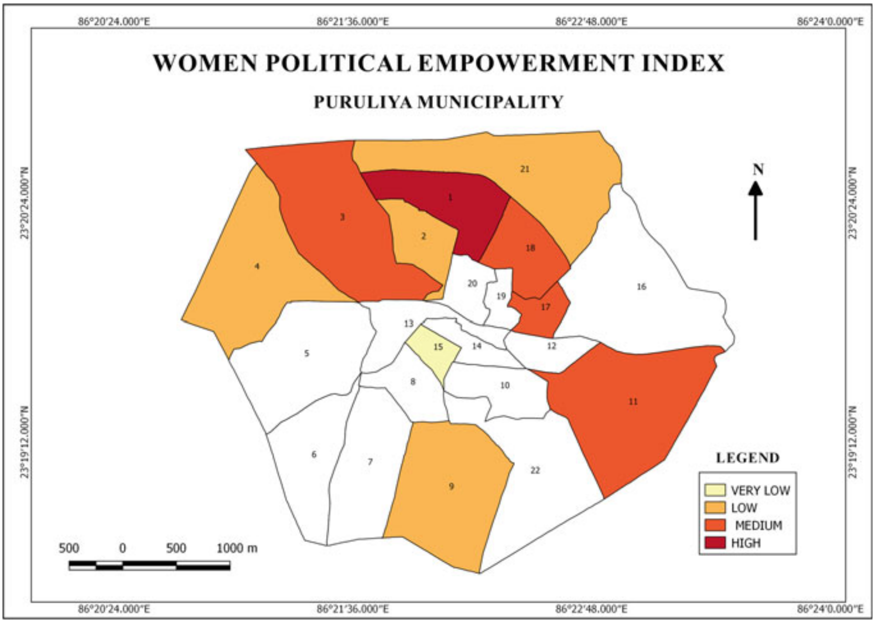


Fig. 3 Women Political Empowerment Index Map of Purulia Municipality, 2015–20. *Source* Compiled by authors from Primary Survey, 2019

5.3 Hypothesis Testing: Applying Regression Model

To evaluate the impact of social and economic factors on the rate of political empowerment, the focus here is on two sets of regression models in which the relationship between WPEI and socio-economic factors is shown. The former model estimates the impact of social characteristics (e.g. age, social group, religion, level of education, and marital status) on the nature of political empowerment, and the latter estimates the impact of economic characteristics (e.g. occupation and monthly income) on the degree of political empowerment. For the particular model, the null hypotheses are

Table 9 Relationship between WPEI and social and economic factors

WPEI	Coefficient	Standard error	Adjusted R^2	t	$P > \| t \|$	95% confidence interval	
Social factors	0.3610	0.1031	0.5556	3.50	0.0081	0.1231	0.5988
Economic factors	0.3266	0.0964	0.5377	3.39	0.010	0.1041	0.5489

Source Calculated by the authors

- H_0: WPEI is not influenced by social factors.
- H_0: WPEI is not influenced by economic factors.

The coefficient is calculated with the help of the following equation:

$$Y = \beta_0 + \beta_1 X_1 \tag{2}$$

The value of p is 0.0081 (Table 9), which is less than 0.05. So, the null hypothesis is rejected at 95% confidence interval (as, $p \leq 0.05$). Hence, WPEI is dependent on social factors. The aggregates of seniority, social group, religion, level of education, and marital status have a positive relationship with the WPEI though the coefficient is quite less, i.e. 0.36 (Table 9), and the adjusted R^2 is 0.5556 (Table 9), which indicates 55.56% variability of WPEI is explained by all social factors.

The economic factors also have a positive relationship with the WPEI as the coefficient value is 0.33 (Table 9). This model is also statistically significant as the p-value is 0.0010 at 95% confidence interval. Hence, the null hypothesis is also rejected, which indicates that the WPEI is influenced by economic factors, e.g. occupation and monthly family income. The economic factors explain only 53.77% variability of WPEI as the adjusted R^2 is 0.5377 (Table 9). Socio-economic factors aggregately explain 77% variability of the WPEI.

5.4 Empowerment Condition: A Qualitative Study

The qualitative techniques will add to the detailed study on the political empowerment of women in governance. The authors undertook detailed personal interviews to uncover the reality of women's empowerment in Purulia Municipality. The study explains that there are few honest, confident, and diligent representatives who have brought out changes in their area, while there are many representatives who are just namesake representatives because the seats were reserved for the women they were merely occupying the seats for their husband or family on their wish for the time being. Two cases are cited below.

5.4.1 Case Study 1

Rita Paramanik (name changed) is a re-elected councillor from an unreserved seat in Purulia Municipality. The graduate councillor is from a middle-aged cohort and a teacher by profession belonging to a joint family with a retired government employee husband. She is famous in the town as ‘Aunty’. She has chosen the party as her ancestors were members of the same. She narrates –‘in the changing political circumstances, I have been re-elected that too from the unreserved seat as a candidate of a party which is not even in power, only because of the people for whom my door is always open’. She entered into politics in 2010 from the reserved seat for the sake of local area development; later, she contested the election from unreserved seat competing with male candidates and still won by a huge margin. She followed the provision of the ward committee formation and is comfortable working from home. The respondent is very active with regular ward visits, tries to resolve local issues, attends frequent board of council meetings, raises questions, places her demands, and implements welfare projects as per the local needs. She attended the training workshop organized by the state government in 2015, which, admittingly, has increased her level of confidence. Though she is very active, she does not harbour any higher political aspirations as she is not very optimistic about the general anti-incumbency trend and is not eager to switch loyalties for that. Her case is an example of true political empowerment.

5.4.2 Case Study 2

Roma Saha (name changed) is a councillor from a reserved seat in Purulia Municipality. She is from a middle-aged cohort and a widow. She does not have any formal education and knows only to sign. She lives in a nuclear family with her two sons. She has been suffering from some health issues. She was not involved in politics prior to the municipal election, but when the ward was declared as reserved for woman representation, being with a good connection with an affluent political leader was persuaded to contest and won by a narrow margin. She narrates, ‘I contested the election as ‘he’ asked me to do that’. She does not know anything about the urban local bodies’ provisions though she used to attend the board of council meeting and inactively participate in the discussion. But still, she has been given an important responsibility in the municipality as Accounts Convener too whose duty is mostly discharged by her son acting on the order of the ‘godfather’. But she asserted that she listens to local people’s demands, tries to solve them, and implements welfare projects accordingly without much problem. Though she did not attend the training workshop, her self-confidence has increased with the four years of experience as a councillor. However, still, she is not confident about working independently. Even she does not want to contest from an unreserved seat in the following term, and her son is slated to contest. Her case is an example of token participation.

6 Conclusion

Women's representation in national politics across the world is quite low; it has failed to reach the total population's first quartile. Though developed countries in general have performed better than the developing countries, some developing countries are performing commendably, whereas few are in the lower rung of the ladder. In South Asian countries, there are several provisions to strengthen women's representation in politics. Political socialization is an essential factor to be a representative in national-level politics, while local-level politics does not demand it where constitutional provisions enable them to enter into the arena of politics.

In India, the national representation of women is also very low, while at the local level, it is quite high. The main reason behind it is the support from reservation policy. For local urban governance, there is the reservation of one-third of seats for women according to the 74th CAA, unlike national-level politics.

From the case of Purulia Municipality, it becomes clear that due to constitutional provisions, the number of women entrants in politics has increased, but the number is not sufficient enough to make an impact on the policies and decision-making in the urban governing process. Women Political Awareness Index (WPAI) indicates that the awareness about the state's rules and regulations among the local representatives is deficient. There are very few representatives who enter into politics by choice. Maximum representatives entered to hold power for the time being as the seats were reserved. However, after coming into power, most of them are still ignorant about the rules and regulations. In the case of the Women Political Empowerment Index (WPEI), there is only one representative who is truly and highly empowered. Few are empowered, but their awareness level is deficient. It was also found that being experienced does not ensure active participation as it can be a proxy representation. Social background, especially education, seemed to have a stronger influence than economic factors for political empowerment. If the situation continues, the future trend of the participants will stay the same. Political awareness and empowerment will be ignored continuously. The only way out of the situation is to sensitize them about the local government's provisions through different training programmes; workshops and the governing process should be transparent and well monitored.

Hence in the case of other smaller ULBs across the state or India as well as the world, the number will not ensure the actual goal of the true democracy or the broader aspect of political empowerment of the women. For wielding true political power, political awareness and active participation are the need of the hour, which determine the space of activities of the representative and enable them to tackle any situations at the grass-roots level with elan.

References

Alsop R, Heinsohn N (2005) Measuring empowerment in practice: structuring analysis and framing indicators. World Bank Policy Research Working Paper 3510. https://openknowledge.worldbank.org/bitstream/handle/10986/8856/wps3510.pdf?sequence=1&isAllowed=y. Accessed 26 June 2020

Araujo JFFE, Tejedo-Romero F (2016) Women's political representation and transparency in local governance. Local Gov Stud 42(6):885–906

Baud ISA, Wit JD (2008) New forms of urban governance in India: shifts, models, networks and contestations. Sage, New Delhi

Beall J (1996). Urban governance: why gender matters. In: Gender in development, monograph series No. 1. UNDP, New York

Bovaird T, Loffler E (2002) Moving from excellence models of local services delivery to benchmarking "Good Local Governance". Int Rev Adm Sci 68(1):9–24

Chakraborty B, Pandey RK (2019) Local governance in India. Sage, New Delhi

Drage J (2001) Women in local government in Asia & the Pacific: a comparative analysis of thirteen countries. In: UN. Economic and Social Commission for Asia and the Pacific (UN. ESCAP)

Elections in India (2020) West Bengal Assembly Election Results in 2016. https://www.elections.in/west-bengal/assembly-constituencies/2016-election-results.html. Accessed 8 May 2020

EC (European Commission) (2013) Women and men in leadership positions in the European Union, 2013: a review of the situation and recent progress. European Commission—Directorate-General for Justice, Brussels. https://web.ua.es/es/unidad-igualdad/observatorio-igualdad/documentos/informe-women-men.pdf. Accessed 8 May 2020

Equal Opportunities Commission (2003) United nations targets for proportion of women leadership and decision-making positions, 2003. https://www.legco.gov.hk/yr02-03/english/panels/ha/papers/ha0314cb2-1636-1e.pdf. Accessed 20 Mar 2021

Federation of Canadian Municipalities (2009) Promoting women's leadership in local government: local government associations help women meet the challenge, 2009. https://www.yumpu.com/en/document/read/34589847/promoting-womens-leadership-in-local-government-fcm. Accessed 20 Mar 2021

Ghosh A (2010) Role of women councillors in urban local bodies: a case study of the Kolkata and the Howrah Municipal Corporation. Pragatishil Prokashak, Kolkata

Ghosh A, Lama-Rewal ST (2005) Democratization in progress: women and local politics in urban India. Tulika Books, New Delhi

Government of India (1992) The Constitution (Seventy-fourth Amendment) Act, 1992. https://www.india.gov.in/my-government/constitution-india/amendments/constitution-india-seventy-fourth-amendment-act-1992. Accessed 8 May 2020

Government of West Bengal (1993) West Bengal Municipal Act, 1993. Department of Urban Development and Municipal Affairs. https://www.sudawb.org/wbdma_oldversion/PDF/MunicipalAffairs_MunicipalAct.pdf. Accessed 26 June 2020

Government of West Bengal (2001) West Bengal Municipal (Ward Committee) Rules, 2001. http://www.ndita.org/Download/Act_Rule/Ward_Committee_Rules_2001.pdf. Accessed 26 June 2020

Harpham T, Boateng KA (1997) Urban governance in relation to the operation of urban services in developing countries. Habitat Int 21(1):65–77

Inter-Parliamentary Union (2019) Women in National Parliaments. http://archive.ipu.org/wmn-e/world.htm. Accessed 6 June 2020

Inter-Parliamentary Union (2020) Monthly Ranking of Women in National Parliament. https://data.ipu.org/women-ranking?month=5&year=2020. Accessed 6 June 2020

Islam F (2002) State of women in urban local government Bangladesh. Bangladesh Report. http://www.capwip.org/readingroom/bangladesh.pdf. Accessed 8 May 2020

John ME (2007) Women in power? gender, caste and the politics of local urban governance. Econ Political Wkly:3986–3993

Kumari LR (2006) Women in politics: participation & governance. Authors Press, New Delhi

Mahmood A (2004) Political empowerment of women: a comparative study of South Asian countries. Pakistan Vis 10(1):151–152

Narayanan U (1999) Women's political empowerment: imperatives & challenges, mainstream, April 10

OECD (Organisation for Economic Co-operation and Development) (2014) Women, government & policy making in OECD countries: fostering diversity for inclusive growth. OECD Publishing. http://dx.doi.org/10.1787/9789264210745-en. Accessed 8 May 2020

Paproski P (1993) Urban governance systems—another unanalysed abstraction? Development Planning Unit No. 28. University College, London

Parliament of India (2020) State-wise Members of the Lok Sabha, Seventeenth Lok Sabha. http://loksabhaph.nic.in/Members/StatewiseList.aspx. Accessed 8 May 2020

Pierre JE (1998) Partnership in urban governance: European and American experience. MacMillan, London

Prasad DR (2014) Women empowerment in urban governance in India. Indian J Public Adm 60 (3):426–442

Purulia Municipality (2020) Purulia Municipality. http://puruliamunicipality.org/Default.aspx?PageId=104. Accessed 8 May 2020

Rao KSVR (2014) Emergence of women political leadership in Narsapur Municipal Council, Andhra Pradesh. Doctoral Thesis. Vishakhapatnam: Department of Politics & Public Administration, Andhra University

Sharma S (2016) Creating spaces for women: inclusion through reservation in urban local governance. J Polit Gov 5(1):29–37

Slack E, Cote A (2014) Comparative urban governance (working paper). Foresight, Government Office for Science, London

United Cities and Local Governments (2020) Gender equality. https://www.uclg.org/en/issues/gender-equality. Accessed 9 Dec 2020

Women UN (2013) A transformative stand-alone goal on achieving gender equality, women's rights and women's empowerment: imperatives and key components. UN Women, New York

Zaman F (2012) Bangladeshi women's political empowerment in urban local governance. South Asia Res 32(2):81–101

Dr. Anindya Basu is working as Assistant Professor in the Department of Geography, Diamond Harbour Women's University, since 2017. Previously, from 2011 she served as Assistant Professor in Women's Christian College, Kolkata. She has been a rank-holder in bachelor's and master's degree programme in geography from the University of Calcutta and UGC-Junior Research Fellow recipient. She has also received PG Diploma in RS-GIS from Jadavpur University. She has keen interest in sociopolitical geography, urban environmental issues, and tourism geography. She presented a number of papers in national and international conferences and seminars, apart from publishing several research papers and chapters.

Asha Bauri is working as Assistant Professor in the Department of Geography, Kashipur Michael Madhusudan Mahavidyalaya, since 2017 and also a research scholar in Diamond Harbour Women's University. She did her master's degree from The University of Burdwan and M.Phil. from Jawaharlal Nehru University. She has been a recipient of UGC-Junior Research Fellowship. Her field of interest is urban geography and planning, population studies, and political geography. She presented few papers in national and international conferences and seminars.

Spatial Analysis of the Intra-urban Quality of Life: A Study in the Darjeeling Town in India

Bishal Chhetri and Kabita Lepcha

1 Introduction

The term wellbeing is in itself a very ambiguous term and is devoid of any concrete definition, as the idea of the concept may vary from one individual to another and is very multidimensional in aspect (Fleurbaey and Blanchet 2013; Das et al. 2019). However, the concept of wellbeing in economics and development studies is usually seen from the perspective of the quality of life (QOL). Quality of life has been defined by the World Health Organisation (WHO) as "an individual's perception of his or her position in life taken in the context of culture and value systems in which he or she lives in relation to his or her goals, expectations, standards and concerns" (WHO 1999).

There has always been a general tendency among the scholars to measure and analyze the quality of life (QOL) although there is no single model or a comprehensive set of measures to do so (Stimson and Marans 2011). Yet, two main approaches, i.e., of the objective dimension and of the subjective dimension have been developed over the last few decades to define the QOL (Diener and Suh 1997). Objective wellbeing refers to the material and social circumstances which are believed to cultivate individual's or community's sense of wellbeing (SDRN 2005),

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

B. Chhetri (✉)
Department of Geography, Southfield College, Darjeeling, West Bengal, India

K. Lepcha
Department of Geography, University of Gour Banga, Malda, West Bengal, India

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_15

and it is based on the analysis of secondary sources of data like the census data. On the other hand, subjective wellbeing implies individual's self assessment of their own wellbeing (SDRN 2005) and is based on primary data collected through sample surveys (Stimson and Marans 2011).

The measurement of objective QOL involves a set of social indicators pertaining to the GDP, housing conditions, education levels, income, etc. The main functions of these social indicators are to measure the state of QOL and the changes over time; to understand the major aspects and dimensions; to find out social conditions which could be judged normatively; to be embedded in a social model and to be used for public policy goals (Smith 1973). Therefore, objective measures of QOL should include those factors that can be objectified, quantified and be translated into policies. The use of different social indicators to study QOL started in USA during the 1960s with the publication of HEW indicators and HEW trends (Smith 1973; Pacione 1982; Stimson and Marans 2011). Many scholars like Bauer (1967), Gross (1966), Sheldon and Moore (1968), etc. started taking interest in this field. Parallelly, this kind of study was being undertaken across the Atlantic in UK by group of researchers like Moser (1970), Shonfield and Shaw (1972) to name among the few, but most of the published works of early 1970s were non spatial, and it was only after the entry of geographers into the field that new dimension of space was added (Pacione 1982). Perle (1970), Smith (1973), Harvey (1972) were the first geographers among the many to contribute in this field. During the last decades, some significant studies have been conducted both by the agencies and as well as by the individuals; some international agencies like UN-HABITAT (2003) and World Bank (2003) had started focusing on the issues related to wellbeing of the urban dwellers, and scholars like Bohnke (2005), Nussbaum (2006), Haq and Zia (2012) have used objective indicators to measure QOL. In India, Parry et al. (2012), Haque (2016), Das et al. (2019), etc. have written articles related to wellbeing and quality of life.

This study measures the objective QOL in terms of material factors like housing, services and amenities of the urban households of Darjeeling town. The material dimensions of the QOL that emphasizes on individual material resources are important as they represent economic conditions of individual's material ownership which can be transformed into wealth, according to each individual's preferences and capabilities (Sen 2004; Cambir and Vasile 2015). These individual material factors that have been selected can be regarded as various component indices (indexes) by themselves and have been used to develop the composite index for measuring the QOL of the different households of Darjeeling town; the individual component indexes along with the composite index have been mapped in the town, and the areas have been identified which are lagging behind in terms of material aspects of QOL. Clusters of high QOL and low QOL have been, identified and further, those clusters can be treated as target areas, where the public policies related to the material aspects of QOL can be implemented and their progress can be monitored.

2 Dealing with One Among the Oldest Municipalities in India

The Darjeeling Municipality is one of the oldest municipal towns in India and was first constituted on July 1, 1850, with 10 wards (Dash 1947). Darjeeling was developed as a sanitarium and under the capable administration of Dr Campbell, who was appointed in 1839 as the first superintendent of the area, around 70 European houses along with the bazaar, jail and boarding house for the sick was constructed in the town (Malley 1907). He is credited for developing the hill station, for introducing tea and coffee and for encouraging immigration in the area. Darjeeling town developed as a typical hill station, where the European section was located on the higher ridge with all magnificent buildings like Gothic churches, town hall building, bungalows and hotels overlooking the market square (bazaar) and native quarters situated down below. The 1881 maps of the town, which are all depicted in Aditi Chatterji's book "Contested Landscape: The Story of Darjeeling," clearly shows that the town was divided into two sections, i.e., the White town or the European section on the upper ridges and the Native Quarters situated on the lower reaches. The European section received all the facilities, whereas the native quarters received the bare minimum.

Till 1916, the Municipality was governed by nominated commissioners under the Bengal Municipal Act (Act III of 1884) and the Special Act (Act I of 1900). After 1916, the commissioners were elected, and again in 1932, the Bengal Municipal Act (XV of 1932) was introduced which continued till the time of independence (Dash 1947). After independence, the first election on the basis of universal adult suffrage was held in the year 1964, but the newly elected board could not take charge due to an injunction; fresh elections were held in 1966 but were soon superseded by the state government, this frequent interference by the state government in the functioning of the Darjeeling Municipality became a recurring affair thereafter. On October 12, 1988, the West Bengal Government upgraded the Darjeeling Municipality from category "D" to category "A" and the number of wards was increased from 26 to 32 (Khawas 2003). The Bengal Municipal Act of 1993 introduced the Chairman in Council system of governance, whereby the Municipality is run by the Chairman along with the Vice-Chairman and a Board of Councilors (Department of Urban Development and Municipal Affairs 2020). In year 2001, the area of Darjeeling Municipality was 10.75 km^2 but after the reorganization and bifurcation of wards in 2011, the town now covers an area of 7.43 km^2 (Darjeeling Municipality 2011) only; the town has around 22,000 households, 116 "samaj" (traditional community based organization), over 350 hotels and restaurants, 25 vegetable markets, 10 fish and meat markets and 89 institutional holdings (Chhetri and Lepcha 2012). The density of population in Darjeeling town is 15,990 persons per sq.km as per 2011 census report. The high density of population within the town exerts immense pressure on the existing infrastructure which was actually designed for 1000 persons only (Chhetri and Tamang 2013) (Fig. 1).

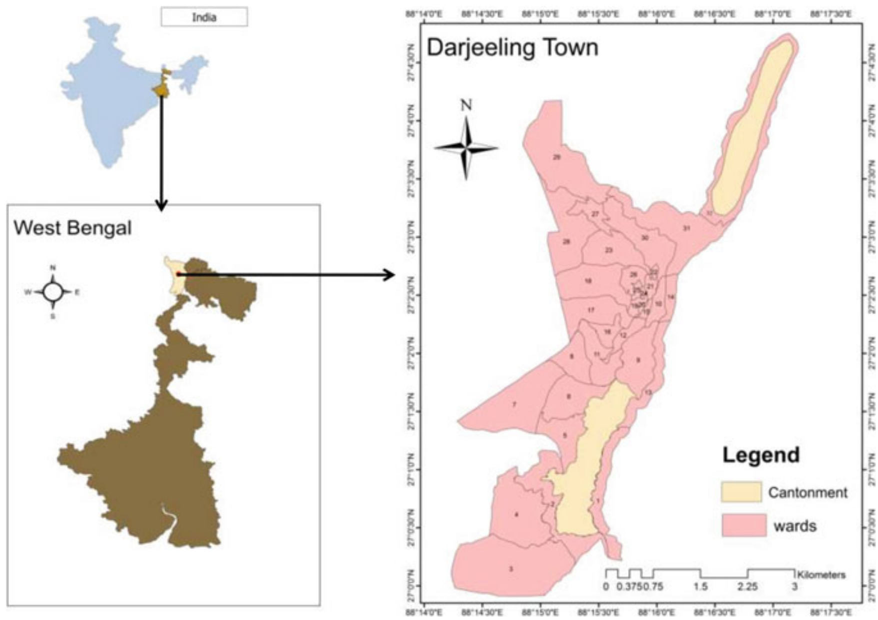


Fig. 1 Location map of Darjeeling town

3 On Calculating the QOL

Secondary data from the Municipality records and Census of India Reports have been used to identify intra-urban variations of the QOL of the households. The data have been analyzed by SPSS 17 software, and ArcGIS 10.2.1 has been employed to prepare maps and also for the spatial autocorrelation statistics. All the base maps which have been used to prepare the different figures in the study have been obtained from the Municipality of Darjeeling as hardcopies, these were subsequently digitised in ArcGIS software for further analysis. The details regarding the materials and methods section have been explained in the following paragraphs.

3.1 Acquiring and Managing the Datasets

The study has been conducted on the basis of secondary data collected from Primary Census Abstract (PCA 2011), House Level Primary Census Abstract (HLPCA 2011) and Darjeeling Municipality Records (2011). The information related to socio-economic data like Female working Population and Literates was derived from PCA and Municipality Records, whereas the data regarding housing conditions, basic services and amenities were derived from HLPCA (Table 1).

Table 1 Important indicators and their sources

Notation	Indicator	Source
X_1	% of households having TV	House Level Primary Census Abstract (HLPCA 2011)
X_2	% of households having phone (landline and mobile)	Do
X_3	% of households having LPG connection	Do
X_4	% of households having good housing condition	Do
X_5	% of households having water (within the compound)	Do
X_6	% of households accessing banking service	Do
X_7	% of households having motorcycle	Do
X_8	% of households having computer with Internet	Do
X_9	% of households having computer	Do
X_{10}	% of households having motorcar	Do
X_{11}	% of households having permanent shelter	Do
X_{12}	% of households having cement roof	Do
X_{13}	% of households having toilet present	Do
X_{14}	% of households having electricity	Do
X_{15}	% of female literates	Darjeeling Municipality Records (2011)
X_{16}	% of female workers	Primary Census Abstract (PCA 2011)
X_{17}	% of households having kitchen	House Level Primary Census Abstract (HLPCA 2011)
X_{18}	% of households having own house	Do

Thus, all the three secondary data sources were referred for analyzing the material QOL of the urban dwellers of Darjeeling Town for developing the Composite Index map and the hotspot map (Fig. 2).

Firstly, the data was normalized within the range of 0–1 with the help of Min-Max normalizer. The most desired value achieved after the normalization process is 1 and the least being 0. Data normalization technique helps to compact the data of different sizes into a common scale so that the larger values may not influence the results; this is most helpful in those situations where the data present are in different magnitudes or in different units. The following formula was used for the normalization process.

$$X_n = \frac{X_0 - X_{\min}}{X_{\max} - X_{\min}} \tag{15.1}$$

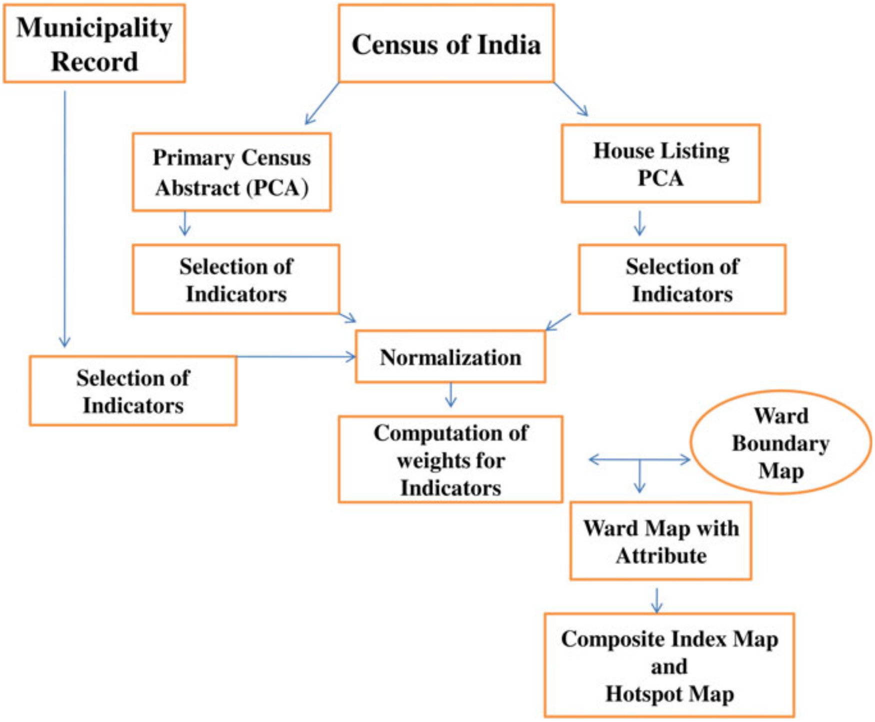


Fig. 2 Flowchart of the mapping methodology

where

X_n new value for variable X,
X_0 actual value of variable X,
$X_{\min}$ minimum value in the data set,
$X_{\max}$ maximum value in the data set.

3.2 *Fetching the Principal Components*

Principal component analysis (PCA) is the method of data reduction; it is the mathematical process that uses orthogonal transformation to convert a set of observations of correlated variables into a set of values of linearly uncorrelated variables called components (Haq and Zia 2013). The numbers of principal components are less or equal to the number of the original variables. All the principal components having eigenvalue of 1 and more are selected, and the first principal component has the largest possible variance, the second greatest variance by the second principal component and so on. These principal components have been used as component indexes and later been used to construct the Composite Score Index for measuring the QOL. The PCA has been calculated with the help of following formula (After Haq and Zia 2013).

$$X_i = \lambda_{i1}F_1 + \lambda_{i2}F_2 \ldots. + \lambda_{ij}F_j \tag{15.2}$$

where

X_i ith indicator,
λ_{ij} Factor loading which represents the proportion of the variation in X_i which is accounted for by the jth factor.
$\sum\lambda_{ij}$ is called the communality, and it is equivalent to the multiple regression coefficients in regression analysis.
F_j symbolizes jth factor or component.

3.3 *Construction of a Composite Score Index*

In order to analyze the intra-urban variations in QOL, Composite Score Index has been constructed and mapped. Composite Score Index is very comprehensive and multidimensional in nature and can represent multiple indicators by one aggregate value (Kararach et al. 2017). In this method, the ward-wise component scores were extracted by using varimax rotation. Thereafter, all the five component scores were added to get the total component score, and this total component score, was further divided by the number of components to construct the composite index.

$$\mathrm{CS_{index}} = \frac{\mathrm{TCS}}{N} \tag{15.3}$$

where

$\mathrm{CS_{index}}$ Composite Score Index,
TCS Total component score,
N Number of components.

3.4 *Spatial Autocorrelation Analysis*

This study uses Global Moran's I as a first measure of spatial autocorrelation. Moran's I ranges from −1 to 1, where the value of 1 means perfect positive spatial autocorrelation, the value of −1 indicates perfect negative spatial autocorrelation and the value of 0 signifies perfect spatial randomness (Tu and Xia 2008; Fu et al. 2014). It also calculates Z-scores, the high Z-score indicates occurrence of spatial clustering of the phenomenon, and on the other hand, low Z-score indicates dispersion.

Calculations for Moran's I are based on a weighted matrix, with units i and j. Similarities between units are calculated as the product of the differences between Y_i and Y_j with the overall mean.

$$I = \frac{N}{W} + \frac{\sum i \sum j\left(Yi - \overline{\Upsilon}\right)\left(Yj - \overline{\Upsilon}\right)}{\sum i \sum j W_{i,j}} \tag{15.4}$$

where

- N is the number of spatial units indexed by I and j,
- Y_{i} is the variable, $\overline{\Upsilon}$ is the mean of Y,
- $W_{i,j}$ is the matrix of spatial weights with zeros on the diagonal and W is the sum of all W_{ij}

Spatial autocorrelation statistics like Moran's I are global in nature as they estimate the overall degree of spatial autocorrelation for the given dataset. Sometimes the estimated degree of autocorrelation may vary significantly across geographic space. Local spatial autocorrelation statistics are used in this conjunction to provide estimates disaggregated to the level of the spatial analysis across space. Getis-OrdGi* statistics has been used as the second measure of spatial autocorrelation. The Getis-OrdGi* functions as the local spatial autocorrelation statistics and uses hotspot analysis to seek out clusters. The hotspot analysis with the help of Z-scores and P-values identifies areas where the features with high or low values cluster spatially. A feature with a high value may not be a statistically significant hotspot, to be a statistically significant hotspot; the feature with high value should be surrounded by other features with that have high values as well (Essri 2020). Composite scores have been analyzed by Global Moran's I statistics to ascertain whether the spatial autocorrelation of the dataset has occurred or not, and then Getis-OrdGi* statistics is used as the local spatial autocorrelation statistics to identify the clusters of high material QOL and the clusters of low material QOL.

The Getis-OrdGi* local statistics is expressed as;

$$Gi^* = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \overline{X} \sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \tag{15.5}$$

where

x_j is the attribute value for feature j,
$w_{i,j}$ is the spatial weight between the feature I and j,
n is the total number of features; and

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n} \tag{15.6}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2} \tag{15.7}$$

4 An Excerpt of the Empirical Findings

The findings are based on the results obtained from PCA. The main objective for conducting the PCA is to reduce the original number of explanatory variables to a smaller number of independent factors; these independent factors can explain the whole set of variables. This study tries to find out the spatial variations in the QOL of the urban dwellers of Darjeeling town with the help of 18 objective indicators (Table 1). These 18 indicators have been classified into five components by PCA, and the variables within the component are strongly correlated with each other but not with the variables of the other components. The five principal components explain 73% of the total variance (Table 3).

4.1 KMO and Barlett's Test of Sphericity

KMO and Barlett's test of sphericity is a measure of sampling adequacy that is recommended to check the case to variable ratio for the analysis being conducted. The result of KMO is 0.616 which implies that the factor analysis can be performed for the dataset, and Barlett's test of sphericity is less than 0.05, which means that the result is significant indicating that some correlation exists among the variables (Table 2).

Table 2 Statistic of Kaiser–Meyer–Olkin measure of sampling (KMO) and the results of Bartlett's test. *Source* Computed by the authors

Adequacy value of sampling Kaiser–Meyer–Olkin (KMO)	0.616	
Barlett's test of sphericity	Chi-square	323.655
	Degree of freedom	153
	Significance level	0.000

4.2 Explaining the Principal Components

The first principal component has the eigenvalue of 3.996 and explains 22% of the variance (Table 3). The first principal component includes six indicators of QOL out of the total 18. The indicators included in the first principal component are presence of TV, presence of phone (landline and mobile), LPG connection, good housing condition, presence of water within the compound and access to the banking service. This component tends to have most of the indicators related to the amenities along with the housing condition (Table 4). The positive signs of the PC1 indicate higher QOL on the basis of the above-mentioned indicators, and the negative sign signifies lower QOL. The highest component score can be seen in ward no 9 and the lowest in ward no 4 (Table 5), which means that the % of amenities with good housing condition is highest in ward no 9 and lowest in ward no 4. When the PC1 is spatially mapped, then it can be noticed that those wards like 1, 9, 10, 21, 24 and 26 which were historically part of the white town during the British Period have higher QOL and the outskirts like ward no 32, 29, 28, 27, 23, 18, 17 and 4 which were later extensions or part of the native town have lower QOL and are lagging behind in terms of amenities and good housing condition. The posh areas of the bygone era exhibit higher values (Fig. 3a).

The second principal component has an eigenvalue of 15.721 and explains 15% of the variance (Table 3). The second principal component includes presence of motorcycles, presence of computers with Internet services, presence of computers and presence of motorcars (Table 4). The second component has the indicators related to transport along with computers and Internet connections. Ward no 30 has the highest score in terms of PC2 and ward no 3 the lowest (Table 5). When spatial distribution of PC3 is examined, then it is found that ward no 30 and its peripheral wards with exceptions of ward no 5 and ward no 32 show higher levels of QOL (Fig. 3b).

The third principal component has an eigenvalue of 15.600 and explains 14.445 of the variance (Table 3). It includes indicators related to housing infrastructures like permanent shelter, cement roof, presence of latrines and presence of electricity (Table 4). The housing infrastructure of ward number 16 is the highest and that of the ward no 3 is the lowest (Table 5). The business and tourist districts located in ward numbers 9, 10, 11, 12, 15, 16, 19, 25 which are the parts of Jalapahar ridge, Toongsong area, the areas surrounding the Mall, Judge Bazaar area and Ghoom area (ward no 4) have better housing infrastructure as compared to those areas located at the outskirts of the town (Fig. 3c).

The fourth principal component explains 12.277% of the variance and has an eigenvalue of 15.210 (Table 3). Indicators related to gender like female literates and female main workers along with housing-related indicator like presence of kitchen falls under this component (Table 4). Ward number 27 has the highest score in terms of % of female literates and female working population (Main worker category), whereas ward no 5 has a very poor score (Table 5). A group of adjacent

Table 3 Total variance explained. *Source* Computed by the authors

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.778	32.101	32.101	5.778	32.101	32.101	3.996	22.200	22.200
2	2.381	13.228	45.329	2.381	13.228	45.329	2.721	15.116	37.316
3	1.953	10.851	56.180	1.953	10.851	56.180	2.600	14.445	51.761
4	1.702	9.457	65.637	1.702	9.457	65.637	2.210	12.277	64.038
5	1.329	7.385	73.022	1.329	7.385	73.022	1.617	8.984	73.022
6	0.980	5.442	78.464						
7	0.846	4.698	83.162						
8	0.726	4.034	87.196						
9	0.509	2.829	90.026						
10	0.388	2.154	92.180						
11	0.350	1.947	94.126						
12	0.310	1.722	95.848						
13	0.211	1.173	97.022						
14	0.181	1.008	98.029						
15	0.119	0.659	98.689						
16	0.109	0.604	99.293						
17	0.074	0.413	99.706						
18	0.053	0.294	100.000						

Table 4 Rotated component loadings matrix with communalities. *Source* Computed by the authors

Notation	Components					Communalities
	1	2	3	4	5	
X_1	0.875					0.840
X_2	0.783					0.780
X_3	0.770					0.813
X_4	0.686					0.588
X_5	0.658					0.687
X_6	0.652					0.787
X_7		0.840				0.777
X_8		0.790				0.740
X_9		0.783				0.784
X_{10}		0.630				0.713
X_{11}			0.892			0.867
X_{12}			0.781			0.756
X_{13}			0.631			0.723
X_{14}			0.600			0.634
X_{15}				0.795		0.681
X_{16}				0.753		0.581
X_{17}				0.538		0.556
X_{18}					0.799	0.834

wards of 10, 23, 26, 27, 30 and two outlying wards of 1 and 13 have higher scores of in terms of PC4 (Fig. 3d).

The fifth principal component with an eigenvalue of 1.617 explains 8.984% of the variance (Table 3). This component is correlated with ownership of the house (Table 4). The spatial distribution of PC5 reveals a very surprising picture, except ward no 10 all the other wards that are located within the town have low house ownership scores and those areas which are located at the outskirts have higher ownership scores (Fig. 3e). This might be due to tourism boom and migration from the surrounding tea gardens and rural areas during the late 1980s to early 1990s; in the early 90s, many residential properties were converted to commercial ones. This increased population pressure led to the buildings being converted into hotels and rental properties to house the migrants and tourists alike (Chhetri and Tamang 2013). Ward no 32 that includes Lebong and Ging area which are situated on the outskirts of the town and has not experienced development of hotels and other tourism-related structures has the highest housing ownership score, while ward no 18 covering Pragati gram, Shiva Gram, Fulbari area which are very close to the CBD and have many low-income rent houses scores the lowest in terms of ownership (Table 5).

Table 5 Factor scores with ranking of the wards on the basis of Composite Score Index. *Source* Computed by the authors

Wards	PC1	PC2	PC3	PC4	PC5	Composite Score Index	Ranks
1	0.81	−0.10	−0.35	−0.93	1.26	−0.32	19
2	−0.59	−0.04	0.55	−0.58	0.30	−0.59	22
3	0.69	−1.27	−2.05	0.51	1.80	−1.75	27
4	−3.56	−0.53	1.55	0.46	1.13	−1.85	28
5	0.72	1.30	-0.50	−2.72	1.56	−0.89	24
6	0.16	0.31	−0.26	0.53	−0.46	0.64	10
7	0.14	−0.26	0.29	1.14	0.40	1.40	7
8	−0.36	−0.06	0.09	0.81	0.03	0.49	12
9	1.06	−0.98	0.79	0.63	0.18	1.54	5
10	1.04	0.71	0.89	1.57	1.05	4.42	1
11	−0.01	−0.15	0.98	−0.22	−0.04	0.60	11
12	0.77	−0.99	1.12	0.55	−0.16	1.42	6
13	0.70	−0.80	0.15	0.92	0.23	1.01	9
14	0.43	−0.77	−0.94	0.45	−0.72	−0.97	25
15	0.68	1.37	1.43	0.15	0.60	3.74	2
16	−0.32	−0.68	1.86	−0.99	−0.56	−0.24	18
17	−0.97	−0.67	−0.67	−0.64	−1.06	−3.17	30
18	−1.08	−0.63	−1.25	−1.08	−2.77	−4.59	32
19	0.12	1.06	1.14	0.09	−0.46	2.31	4
20	0.37	0.74	−0.13	−0.54	−1.91	0.07	15
21	0.86	0.15	0.11	−1.02	−0.20	0.06	16
22	0.71	0.14	0.50	−0.91	−0.60	0.32	14
23	−1.14	0.49	0.16	1.01	−0.30	0.47	13
24	0.85	−0.06	−0.33	−0.87	−1.04	−0.61	23
25	0.75	−0.40	1.23	−0.30	0.05	1.28	8
26	0.82	−1.08	−0.64	1.03	−0.42	0.06	17
27	−1.24	0.63	−1.57	1.85	−0.09	−0.36	21
28	−0.79	−0.72	0.06	−0.40	−0.63	−1.94	29
29	−1.05	0.98	−0.218	−0.20	0.79	−0.32	20
30	0.12	3.71	−1.21	0.96	−0.52	3.47	3
31	0.61	−1.19	−1.51	0.46	0.53	−1.52	26
32	0.81	−0.28	−1.29	−1.74	1.96	−4.18	31

5 Assessing Quality of Life

Composite Score Index (simple average) has been used to determine the overall QOL (material). On the basis of this index, the different wards of the town have been ranked, and it can be seen that the highest level of material QOL is present

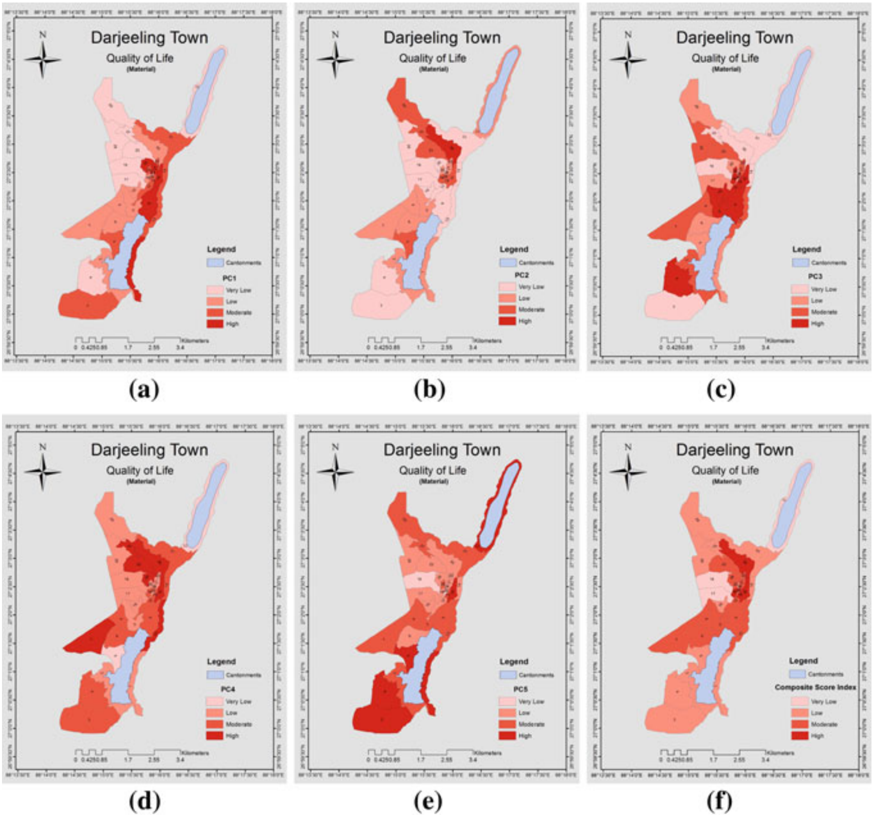


Fig. 3 **a** PC1 (amenities and good housing); **b** PC2 (transport); **c** PC3 (housing condition); **d** PC4 (gender); **e** PC5 (house ownership) and **f** quality of life in Darjeeling town

among the residents of ward no 10 followed by ward no 15 and 30. The lowest level of QOL can be observed among the households of ward no 18 (Table 5). The households of ward no 10 relatively have higher scores across all the principal components. Ward no 15 has moderate scores in most of the principal components except principal component 3 (PC3), where it got high score, whereas ward no 30 has got very mixed performance. It has performed well in principal components 2 (PC2) and 4 (PC4) while performing poorly in principal component 3 (PC3). The high QOL among the households in ward no 10 which is very close to the main promenade of the town, i.e., the mall is evident because it is the posh area of town; it is a high-class residential area where high-end hotels, restaurants and shops are located. Ward no 15 is an upper middle-class neighborhood, this area also has the presence of mid range hotels, shopping complex, restaurants, buildings and apartments; therefore, it has performed well in terms of housing infrastructure component (PC3) and has high QOL. The other ward having high QOL is ward no 30, it is a mixed neighborhood, where the houses of the upper middle class, lower middle class and the lower class are present and this area is recently undergoing transformations in terms of its functions due to the construction of hotels especially near the mall road area. The Composite Score Index of ward no 18 is the lowest which indicates a very low QOL. It has performed very poorly because it is situated on the steep slopes of the lower reaches of the town just below the botanical garden and is a low-class residential area where the housing infrastructure (PC3), basic amenities and good housing conditions (PC1), transport (PC2) and ownership (PC5) scores are very dismal. It being a poor neighborhood has performed moderately well in gender-related component (PC4) as more womenfolk are engaged in work to supplement the income of the households.

The different wards of the Darjeeling town have been categorized to spatially analyze the intra-urban variations of material QOL of the households. These wards have been classified into four categories of QOL according to their Composite Score Index. Ward numbers 10, 15, 19 and 30 are those wards which have been classified in the category which has high level of QOL and ward numbers 17, 18 and 32 are in the very low category of QOL (Table 6). When examined spatially, the areas having high QOL are those areas which are situated on the upper ridges of the town and were once a part of the white European section of the pre-colonial times; these areas had efficient municipal services since the early times and as of today mostly perform tourism-related services. There are numerous hotels and restaurants along with high-class and upper middle-class residential buildings in these areas. The areas which have very low levels of QOL are those areas which are either situated on steep slopes on the lower reaches of the town like ward no 17 and 18 or are situated far away from the main C.B.D. like ward no 32, and these areas are not properly served by the municipality in terms of various services like water supply and has the concentration of low class residential areas, whereas rest of the areas have either moderate or low QOL (Fig. 3f) and if the average and the median composite score of QOL (Table 7) for all the households of Darjeeling town is examined, then the material QOL of the majority of the households falls under the moderate category (i.e., mean value and median value falling between −0.139 and 1.54).

Table 6 Categorization of municipal wards on the basis of Composite Score Index. *Source* Computed by the authors

Composite Score Index (QOL)	Ward numbers
High (>1.54)	10, 15, 19 and 30
Moderate (−0.239 to 1.54)	6, 7, 8, 9, 11, 12, 13, 20, 21, 22, 23, 25 and 26
Low (−3.169 to −0.239)	1, 2, 3, 4, 5, 14,16, 24, 27, 28, 29 and 31
Very low (<−3.169)	17, 18 and 32

Table 7 Descriptive statistics of Composite Score Index for Darjeeling town. *Source* Computed by the authors

N	Min	Max	Mean	Median	S.D	Variance	Kurtosis
32	−4.59	4.42	−0.14	0.06	2.00	4.04	0.67

6 Identification of Clusters

To find out the spatial variation of the material QOL in Darjeeling town, Global Moran's *I* autocorrelation test was conducted. After the spatial autocorrelation test, the calculated value of Global Moran's Index was 0.182 (Table 8), which is positive, above 0 and closer to 1, indicating clustering. Further, the *Z*-score of 15.04 and the *P*-value of 0.04 which is located at the orange zone confirms the presence of clusters on the basis of QOL (Fig. 4a).

As already stated in the preceding paragraphs, the Global Moran's I gives only an estimate of the overall degree of spatial autocorrelation. In order to examine the local nature of the spatial distribution of the QOL of the households, Getis-Ord GI* was employed. The Getis-Ord GI* uses hotspots and coldspots to identify clustering of high values and low values. For all statistically significant positive and negative *Z*-scores, the larger *Z*-scores will give more intense clustering of high values (hotspots) and smaller *Z*-scores will result in more intense clustering of low values (coldspots) respectively.

The hotspots and coldspots can be used to spatially locate areas having high and low material QOL on the map, the areas having high QOL will be represented by hotspots and those areas where the QOL is low will be represented by coldspots. It can be observed that ward no 10 and ward no 21 are the areas which have exceptionally high levels of QOL with 99% confidence level (Fig. 4b) and are surrounded by those wards like 12, 15, 9, 14 and 20 which also have higher QOL values; this indicates that the hotspots that have been identified by the Getis-Ord GI* are significant as it is surrounded by other areas exhibiting higher values. The spatial distribution of the QOL of the households as per the Getis-Ord GI* statistics shows that the Posh tourist areas of the ward numbers 10 and 21 with their high end hotels, restaurants and high-class and upper middle-class residential areas have emerged as a cluster where the material QOL of the residents is exceptionally high, while ward no 32 which is on the northern outskirts of the town has emerged as a cluster where the QOL is very low (Fig. 4b). This highlights the point that there is a wide spatial variation of QOL among the households of Darjeeling town.

Table 8 Global Moran's Index. *Source* Computed by the authors

Moran's index	0.181872
Expected index	−0.032258
Variance	0.010989
z-score	2.042688
P-value	0.041083

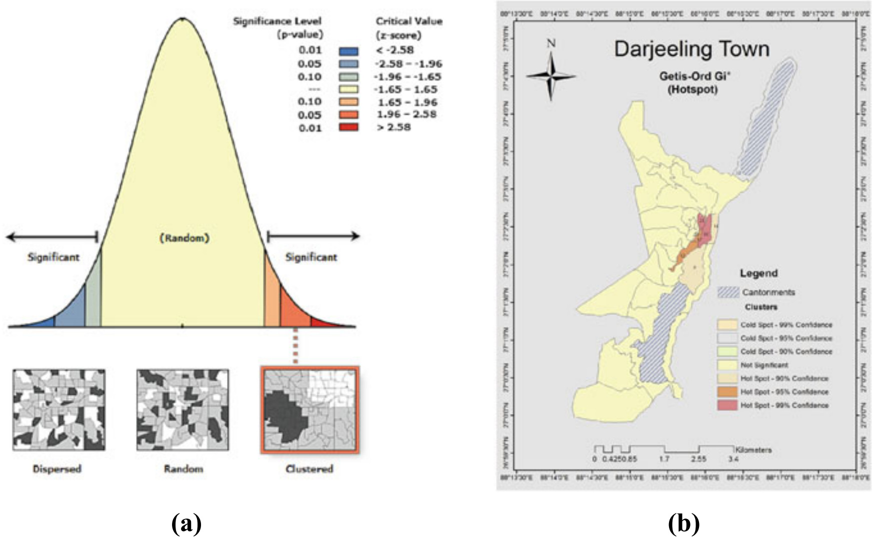


Fig. 4 **a** *Z*-Score for Global Moran's *I* and **b** hotspots for QOL (Getis-OrdGi*)

7 Conclusions

The main objective of this study was to spatially analyze the intra-urban variations in the QOL of the different households in Darjeeling town through the principal component analyses and Getis-Ord GI* statistics. Darjeeling town since the time it was conceived and developed by the Britishers was developed as an urban space where high levels of disparity, in terms of access to urban services and housing conditions between the colonizers and the colonized would exist. The town was a divided space, with the present day wards of 10, 11, 9, 12, 14, 21 and 24 were part of the White Town while, the rest of the wards were either part of erstwhile Native Town or were later extensions. It was a space, where the Europeans would host dramas, parties, balls, picnics and would spend time with mirth and laughter (Chatterji 2007) and the life of the natives would drag on with misery, labor and sweat (Pradhan 1982). Unfortunately, the levels of disparity in terms of QOL which existed in the town during the colonial period are still present up to this day as it is evident from this study. Decolonization of the urban space has to assume paramount importance as the identified hotspots shows that high QOL is restricted only to few households of the above mentioned wards while the majority of the urban dwellers seem to be devoid of it. Therefore, a more concerted and collective effort is needed from the Urban Local Body (ULB), the Gorkhaland Territorial Administration (GTA) and the State Government to remedy such disparities which exist even after 73 years of independence. The macro-level plans developed by the Central Government have to be implemented at the micro-level by the ULB and GTA, and the two bodies need to frame target oriented local-level plans and policies which can be evaluated by the monitoring cells. The Twelfth Five Year Plan (2012–2017) had highlighted the fact that the ULBs were not getting enough funds from the State Governments due to the absence of robust legal and intuitional frameworks as the States were not following the 74th Constitutional Amendment Act of 1992, which through Article 243W of the 12th Schedule grants constitutional status to the municipalities of India. The penetration of e-governance in the ULBs was found to be weak and very sporadic as there was lack of public participation in urban governance (GOI, 12th FYP 2012). Therefore, the Municipality of Darjeeling and the GTA should play a proactive role by maintaining very cordial relations with the State Government for the release of adequate funds for the proper implementation of major projects and programs to enhance the QOL of the households, they need to efficiently communicate with the Central Government in regard to various national level polices available for the urban development and have to setup policy mechanisms that ensures public participation and transparency for the academic and other scrutiny.

At the macro-level, the Central Government has formed the National Institution for Transforming India (Niti Aayog) on January 1, 2015. The Prime Minister's Office had asked the Niti Aayog to prepare Fifteen Year Vision, Seven Year Strategy and Three Year Action Agenda documents in 2016 (Niti Aayog 2017). Niti Aayog has recommended some policy changes and programs for the action years 2017–18 and 2019–20 under the Three Year Action Agenda. Chapter 7 of the Agenda, deals with issues related to improving urban quality of life through creation of adequate living and office space, holding down air pollution, municipal solid and creation of swamps; provision of greenery and common spaces for outdoor activity; provision of electricity, water and sewage; and provision of a vibrant transportation system that links suburbs to the center of the city and has a dense within city transport network (Niti Aayog 2017). The Aayog has reviewed some existing urban development programs like Pradhan Mantri Awas Yojana—housing for All, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart City Mission, Swachh Bharat Mission (Urban), Public Transports, Deen Dayal Antodaya Yojana—National Urban Livelihood Mission (DAY—NULM) and National Heritage City Development and Augmentation Yojana (HRIDAY) and has suggested additional measures in its Three Year Action Agenda. Of the above-mentioned programs, Pradhan Mantri Awas Yojana—housing for All, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and Deen Dayal Antodaya Yojana—National Urban Livelihood Mission (DAY—NULM) can be of great significance in improving the QOL of the urban dwellers in Darjeeling.

Pradhan Mantri Awas Yojana—housing for All (Urban Mission) was launched in June 2015 to provide housing to all in urban areas by 2022. Under this mission, it has planned to build two crore houses for urban poor including economically weaker sections (EWS) and low-income groups (LIGs). This scheme can play an important role in improving the QOL of the households in the town, as most of the wards except wards no 10, 3, 4, 5 and 32 under Darjeeling Municipality have very low-to-moderate house ownership score (Fig. 3e). These are the wards where people suffer from extreme house ownership shortages. Other then food and clothing, shelter is the third most important component which forms the basic requirement for honorable living. Therefore, this scheme along with the State Government's Housing Schemes for Lower-Income Group and Middle-Income Group should be implemented by giving more priority to those wards where the Housing Ownership Score (Fig. 3e) is low. The main hurdle in this regard is land ownership issue as most of the residents in the town do not have land ownership rights, The Municipality along with GTA should appeal to the State Government to grant landownership to the residents of Darjeeling Hill area in general and urban dwellers in particular.

Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched with an objective to provide infrastructure for universal coverage of piped drinking water, sewage, green spaces and parks. The Municipality of Darjeeling has already started relaying the entire water distribution pipelines and construction of water tanks in all the 32 wards. The project will be implemented in three phases and will incur an expenditure of 15.05 billion rupees. In addition to this, development of Park along Nehru Road and Mall Road has been undertaken which is at its First Phase (State Mission Directorate-AMRUT 2018). If the Municipality would consider the ward numbers of 4, 17, 18, 23, 27, 28 and 32 as target areas (Fig. 3a) and increase the number of water connections and pipelines in those areas, then it would help in rectification of lopsided QOL in terms of access to basic services.

Deen Dayal Antodaya Yojana—National Urban Livelihood Mission (DAY—NULM) aims to create opportunities for skill developments for market-based employments and setting up of self employment ventures. Through these schemes, training and micro-credits could be provided to the households and more emphasis could be given to the involvement of the women by the municipality. Ward no 5 and ward no 32 (Fig. 3d) should be targeted in this regard and Self Help Groups and Female Co-operatives should be formed, Community-Based Organizations like samajs and Development Boards along with NGOs should be actively involved. Capacity building exercises of the poorer households and women should be frequently conducted for their gainful employment. Low-cost housing through this scheme should be constructed for the poor. Ward numbers 3, 14, 18, 27, 30, 31 and 32 (Fig. 3c) should be given special priority in this context.

Other than these schemes, Jan Dhan Yojana and Prime Minister Ujjwala Plan should be adopted as a measure for socio-economic welfare program. Its implementation along with the above-mentioned schemes should be evaluated and monitored in the three wards of 17, 18 and 32 where the overall all index of QOL is very low (Fig. 3f). The Municipality as per the 12th Five Year Plan recommendations should setup citizen's charters comprising of the local public, municipal authorities, planners and researchers in these three wards, it should involve different stakeholders in the identifications process of the key concerns and problems faced by the residents and for monitoring the developmental activities undertaken for that purpose. Ward no 32 should be considered as a special area as it has emerged as a coldspot where the QOL is very low (Fig. 4b). Special local-level policies and plans for the socio-economic wellbeing should be framed by the Municipality and the GTA, citizen's charter and monitoring cell should be tasked for evaluating the performance of such programs. Though few programs like Swarna Jayanti Shahari Rozgar Yojana (SJSRY) and Integrated Housing and Slum Development Program (IHSDP) were under taken by the Municipality in the past, it seems these are inadequate and have not produced the desired results (Darjeeling Municipality Records 2016). Out of numerous schemes present at the macro-level which are framed by both the Central and State Governments for poverty alleviation and infrastructure improvement, the Municipality of Darjeeling has failed to seek assistance or grants nor has been able to produce any concrete action plan on its own. Therefore, the Municipal authorities along with GTA should seek assistance from the Central as well as the State Governments; they should invite planners and experts to make roadmaps for improving the wellbeing of the households of Darjeeling town.

References

Bauer RA (1967) Social indicators. MIT Press, Cambridge

Bohnke P (2005) First European quality of life survey: life satisfaction, happiness and sense of belonging. Office for Official Publications on European Communities, Luxembourg

Cambir A, Vasile V (2015) Material dimension of quality of life and social inclusion. Procedia Econ Finan 32:932–939. https://doi.org/10.1016/S2212-5671(15)01551-8

Census of India (2011) Primary Census Abstract (PCA). Directorate of census opretations. West Bengal. https://censusindia.gov.in/2011census/dchb/1901_PART_B_DCHB_DARJILING.pdf. Accessed on 04/04/2020

Census of India (2011) House Level Primary Census Abstract (HLPCA). Office of the registrar general and census commissioner, India. https://censusindia.gov.in/2011census/HLO/HL_PCA/HH_PCA1/HLPCA-19327-2011_H14_census.xlsx. Accessed on 04/04/2020

Chatterji A (2007) Contested landscapes: the story of Darjeeling. INTACH. Calcutta Chapter

Chhetri B, Lepcha K (2012) Assessment of the solid waste management system in Darjeeling town. In: Chaudhuri S, Roy DC (eds) Resource management: human and natural perspective on north-east region. Readers Service, Kolkata, pp 48–58

Chhetri B, Tamang L (2013) Population growth and associated problems: a case study of Darjeeling town. Int J Humanit Soc Sci Invention 2(5):63–67. https://www.ijhssi.org/papers/v2(5)/version-2/J256367.pdf. Accessed on 30/06/2013

Das A, Das M, Houqe R (2019) Evaluating the quality of living (QOL) of the households in Dandakaranya region, India: a well-being approach. Spat Inf Res. https://doi.org/10.1007/s41324-019-00286-w

Dash AJ (1947) Bengal district gazetteers: Darjeeling. Bengal Government Press, Bengal

Department of Urban Development and Municipal Affairs, Government of West Bengal (2020). http://www.wburbanservices.gov.in. Accessed on 27/04/2020

Diener E, Suh E (1997) Measuring quality of life: economic, social and subjective indicators. Soc Indicat Res 40(1):189–216

Essri (2020) ArcGis Pro. https://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm

Fleurbaey M, Blanchet D (2013) Beyond GDP: measuring welfare and assessing sustainability. Oxford University Press, Oxford

Fu WJ, Jiang PK, Zhou GM, Zhao KL (2014) Using Moran's I and GIS to study the spatial pattern of forest litter carbon density in a subtropical region of southeastern China. Biogeosciences:2401–2409. https://doi.org/10.5194/bg-11-2401-2014

GOI (2012) 12th FYP. http://www.planningcommission.nic.in/aboutus/committee/strgrp12/strrep_urban0401.pdf. Accessed on 28/01/2017

Gross BM (1966) The state of the nation: social systems accounting. Tavistock Publications, London

Haq R, Zia U (2013) Multidimensional wellbeing: an index of quality of life in a developing economy. Soc Indic Res 114:337–364. https://doi.org/10.1007/s11205-012-0186-6

Haque I (2016) Infrastructure development and access to basic amenities in Class-I cities of West Bengal, India: insights from census data. J Infrastruct Dev 8(1):36–84

Harvey D (1972) Social justice in spatial systems. In: Peet (ed) Geographical perspectives on American poverty, Antipode monographs in social geography vol 1, pp 87–106

Kararach G, Nahmo G, Mubila M, Nahmo S, Nhemachena C, Babu S (2017) Reflections on the green growth index for developing countries: a focus of selected African countries. Dev Policy Rev. https://doi.org/10.1111/dpr.12265

Khawas V (2003) Urban management in Darjeeling Himalaya: a case study of Darjeeling municipality. https://web.archive.org/web/20041020031749/, http://www.mtnforum.org/resources/library/khawv03e.htm. Accessed on 26/04/2020

Malley LSSO (1907) Bengal district gazetteers: Darjeeling, Second print, 1999. Logos Press, New Delhi

Moser C (1970) Measuring quality of life. New Society 428:1042–1043

Municipality of Darjeeling (2011) Municipal Records (2001–2011), Darjeeling

Niti Aayog (2017) Three year action agenda: 2017–18 to 2019–20. Government of India, New Delhi

Nussbaum MC (2006) Poverty and human functioning: capabilities as fundamental entitlements. In: Gruskyn DB, Kanbur R (eds) Poverty and inequality. Stanford University Press, Stanford, CA, pp 47–75

Pacione M (1982) The use of objective and subjective measures of life quality in human geography. Prog Hum Geogr 6(4):495–514

Parry JA, Ganaie SA, Nengroo ZA, Bhat MS (2012) Spatial analysis on the provision of urban amenities and their deficiencies: a case study of Srinagar city, Jammu and Kashmir, India. Glob J Arts Humanit Social Sci 6(2):20–31

Perle ED (1970) Social reporting in Michigan: problems and issues. State of Michigan Office of Planning Coordination. Bureau of policies and programs. Technical report A-37

Pradhan K (1982) Pahilo Prahar. Shyam Prakashan, Lalitpur

SDRN (2005) Wellbeing: concepts and challenges. Discussion paper prepared for the sustainable development research network. Briefing Three, UK. http://www.sdresearch.org.uk/wellbeing/documents/SDRNwellbeingpaper-Final_000.pdf. Accessed on 17/04/2020

Sen A (2004) Capability and well-being. In: Nussbaum M (ed) The quality of life. Routledge, New York, pp 30–53

Sheldon EB, Moore WE (1968) Indicators of social change: concepts and measurements. Russell Sage Foundation, New York

Shonfield, A. and Shaw, S. (1972). Social indicators and social policy.London: Heinemann

Smith DM (1973) The geography of social well-being in the United States: an introduction to territorial social indicators. McGraw Hill, New York

State Mission Directorate-AMRUT (2018) State annual action plan (SAAP) 2017–18. Municipal Affairs Department, Government of West Bengal. https://www.amrut.gov.in. Accessed on 28/04/2020

Stimson R, Marans RW (2011) Objective measurement of quality of life using secondary data analysis. In Marans RW, Stimson R (ed) Investigating quality of urban life: theory, methods, and empirical research, Social indicators research series, vol 45, pp 33–51

Tu J, Xia ZG (2008) Examining spatially varying relationships between land use and water quality using geographically weighted regression I: model design and evaluation. Sci Tot Environ:358–378. https://doi.org/10.5194/bg-11-2401-2014

U.N. Habitat (2003) The challenge of slums. In: Global report on human settlements. Earth Scan Publications, London

WHO (1999) Introduction, administration, scoring and generic version of the assessment program on mental health. https://www.who.int/mentalhealth/media/en/76.pdf. Accessed on 14/04/2020
World Bank (2003) Sustainable development in dynamic world: transforming institutions, growth and quality of life. In: World development report. https://openknowledge.worldbank.org/handle/10986/. Accessed on 30/04/2020

Bishal Chhetri is Assistant Professor in Department of Geography, Southfield College, Darjeeling. He has been teaching geography since 2009. He completed his B.A. (Hons) from Darjeeling Government College and M.A. from University of North Bengal. His area of interest is in developmental studies and has conducted UGC minor research project in this field. He has published number of national and international research articles and has co-edited one book.

Kabita Lepcha is Assistant Professor in Department of Geography, University of Gour Banga, Malda. She completed her B.A (Hons) from Loreto College, Darjeeling and M.A. from University of North Bengal with Fluvial Geomorphology as specialization; her field of interest lies in fluvial geomorphology and socio-cultural studies. She has been pursuing her PhD from University of Gour Banga, Malda. She has published various research articles in both national and international journals and has published two books.

Three Decades of Urban Dynamics in India: Exemplifying Haora Sadar Subdivision

Monalisa Patra and Koel Roy Chowdhury

1 Introduction

Urbanization can be defined as the conversion of rural lands to urban or other built-up uses, representing an important type of land transformation (Chen et al. 2020). Economic development of a society and a progressive division of labours has led to the formation and expansion of towns and cities around the globe (Mandal 1998). Worldwide urbanization is steadily rising over the years and cannot be reflected by a linear curve. In 2019, 55.71% of the global population were urban residents, which was only 30% in the 1960s (Ritchie and Roser 2018). It is projected that by 2050 the percentage of urban population will be 56% and 64%, respectively, in Africa and Asia only. Between 2014 and 2050, India, China and Nigeria together are expected to have 37% of the projected growth in urban population. India is projected to contribute to around 404 million urban dwellers followed by China (292 million) and Nigeria (212 million) (UNICEF 2012).

The definition of urban varies from country to country. The criteria of defining urban area ranges from administrative criteria (e.g. area within the jurisdiction of a municipality or town committee), a threshold population size (where the minimum

Disclaimer: The presentation of material and details in maps used in this chapter does not imply the expression of any opinion whatsoever on the part of the Publisher or Author concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its borders. The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents and databases in this chapter are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the Publisher or Author.

M. Patra
Institute of Development Studies, Kolkata, India

K. R. Chowdhury (✉)
Department of Geography, Presidency University, Kolkata, India
e-mail: koel.geog@presiuniv.ac.in

R. B. Singh et al. (eds.), *Practices in Regional Science and Sustainable Regional Development*, https://doi.org/10.1007/978-981-16-2221-2_16

for an urban settlement is typically in the region of 2000 people, although this varies globally between 200 and 50,000), population density, economic function (e.g. where a significant majority of the population is not primarily engaged in agriculture, or where there is surplus employment) to the presence of urban characteristics (e.g. paved streets, electric lighting, sewerage) (Goldstein 1990). Every country has chosen its own standard for delimiting urban areas. In India, urban areas are defined by the census using administrative and demographic benchmarks. In 2011, the definition of urban area was divided into two parts. The administrative criteria were used to define all places with a municipality, corporation, cantonment board or notified town area committee as Statutory Towns. All other places which satisfy the demographic threshold such as a minimum population of 5000, at least 75% of the male main working population engaged in non-agricultural pursuits and a density of population of at least 400 persons per sq. km. was known as Census Towns (Census 2011). Different study reports also focus on social aspects of urban areas, i.e. urbaneness as a criteria for definition (UNICEF 2012).

Urban growth patterns can be of several types depending on the nature of the urbanization. It can be infilling, i.e. the shape inside the city can change, edge expansion, i.e. the extension takes place along the fringes and also spontaneous unplanned widening. In the developed world, cities mostly encounter edge expansion, whereas spontaneous growth is more prolific in the developing and underdeveloped countries (Cheng and Masser 2003). Government policy changes sometimes play a significant role in the nature of urbanization and which, in due course, results in the transformation in the form of the city. In Wuhan city in Central China, the urban growth pattern has mostly followed the transport lines and economic activities (Chen et al. 2020). Urban growth patterns are also dependent on the physical terrain in which a city is situated, where built-up areas are rarely found on high terrains and slopes (Herold et al. 2003). There are some stages of urban growth. When industrialization and urban economic activity start booming in a certain place, urban areas start expanding. It slowly reaches a stagnant point and the growth stops (Xiao et al. 2006). It is also seen in some of the global cities that not only economic activities but also the economic condition of the people of a city plays an important role in the pattern of growth of a city (Dociu and Dunarintu 2012).

Traditionally, urban settlements have been classified as compact and dispersed. The former defines very closely spaced houses and the latter means sparsely spaced ones. The conceptual ambiguity of sprawl is seen in most literature as “lost in semantic wilderness” (Angel 2007, Barnes 2015, Sudhira et al. 2004). It is observed that sprawl can alternatively or simultaneously consist of changes in land use, land development along with the land-use behaviours and their consequences (Bhatta et al. 2010). Accurate definition of sprawl is very much debated among the scholars and urban planners. However, unifying the available explanations, it can be observed that urban sprawl is an uneven and unplanned growth due to multifarious reasons ultimately leading towards inefficient utilization of resources, but the nature of sprawl and the population characteristics of sprawl varies over space and time (Bhatta 2009). Sometimes urban sprawl is defined as the uncontrolled and misappropriate expansion of an urban area into the surrounding countryside forming low density poorly planned patterns of development, and it is common in both high- and low-income countries (UNICEF 2012). Urban expansion has become unique characteristics of cities. Factors such as migration (Haregeweyn et al. 2012), decentralization of economic activities, population explosion (Bhatta 2009), topography, socio-cultural and psychology of the inhabitants determine the nature of urban sprawl.

It is evident that land covers in urban and peri-urban areas are rapidly changing with the change in economic activities. The environmental degradation, increasing population, growing land prices on one hand and expanding transport network and developing economic activity, decentralization of the public sectors lead towards the increasing built-up density of the suburban or urban fringe areas. Hence, analysis of the pattern of city growth needs attention for the planners and geographers. Measuring urban built-up area with the help census or surveyed data is generally biased because the data are mostly residential. The pattern of uses of lands is not taken into consideration, whereas remote sensing data offers a way of generating reasonable proxy variables of the built environment. Mapping built-up area using remotely sensed data is a useful tool for planners to analyse the temporal changes in the urban land-cover change with the nature of urban built-up area (Zha et al. 2003). The modification of physical environment, i.e. characteristics of urban places can be inferred from the classification of multispectral satellite images. A place that is distinctly urban can be determined from the imagery regardless of the characteristics of the residents (Weeks 2010). Temporal remote sensing data analysis can easily depict the growth pattern of any city. The historical imagery analysis gives a temporal dimension upon the growth of the cities. However, remote sensing data does not provide the perception and the reasons behind the rapid pace of urbanization. The uniqueness of the spatial dimension and perception of urban built-up area has been ignored in the research arena of urban study (Herold et al. 2005).

The current research uses satellite images for temporally mapping the growth of urban built-up areas. The classified areas have been analysed using statistical indices. Finally, a questionnaire survey has been conducted using a stratified random sampling to introspect into the causes behind the change in urban land use, which gives the uniqueness to this work. Therefore, the objectives of the study include:

- Analysing the nature of urban sprawl in Haora Sadar subdivision, Haora district of West Bengal in India from 1990 to 2016
- Assessing the factors affecting the nature of urban expansion in Haora Sadar subdivision, Haora district West Bengal, India

The two objectives of this study have provided a systematic pathway for conducting both quantitative and qualitative researches.

2 Study Area

In this research, Haora Sadar subdivision of Haora district in West Bengal, India, has been chosen as the study area (Fig. 1). Haora district is located between 22° 48′ N and 22° 12′ N latitudes and 88° 23′ E and 87° 50′ E longitudes and bounded by Hooghly river, North and South 24 Parganas on east, Hooghly district in the south, Midnapur in east and west Midnapur in the west. Haora district has a prolonged history which dates back much before the initiation of the colonial rules of Bengal. The ancient texts of Bengal such as "Mansamangal" written by Biprodas Pipilai (1495) has a mention of this place and the petition sent to the Mughal emperor Aurangazeb by the British East India Company has an inclusion of some places of Haora district such as Salkia, Ramkrishnapur, Kasundia, etc. Haora was initially under the zamindari of Burdwan and Muhammad Aminpur, but after the Battle of Plassey, the fate of Bengal altered and a treaty was signed between the then Nawab of Bengal, Mir Quasim and British East India Company and by 1760 Haora came under the sphere of British East India Company. In 1787, Hooghly district was formed and also the entire Haora district. In 1843, Haora appeared as a separate district. Looking at the large historical lineage indicating an interesting urban dynamic, Haora district has been chosen as the study region of the urban dynamics. Haora is also important in demographic terms as it is the second most densely populated district of West Bengal after Kolkata, and its expanding nature provided the opportunity to be chosen as an area of research.

Haora is the second smallest district after Kolkata, the capital of West Bengal, but in spite of its small size, it has a great importance in the map of West Bengal throughout its journey. Haora and Kolkata are adjacent and linked by four bridges, namely Haora bridge, Vidyasagar Setu, Nivedita Setu and Vivekananda Setu, and these have almost blurred the distance between Haora and Kolkata and developed a symbiotic relationship between the two twin cities. The census conducted in the British India in 1896 reported that Haora had a population record of 84,069 and which was reported to have grown up to 157,594 in 1901 and further reached a sum of population of 4,273,099 in 2001 and the last census of 2011 reported a sum of 4,850,029 as total population of the district.

Haora, which is sometimes known as the "Sheffield of East" and the hub of light engineering industries, is the house of many industries such as Burn Standard Company (since 1781) which is now a part of Bharat Bhari Udyog Nigam Limited (BBUNL), Shalimar Plants (since 1902), Jute Industries and several Iron and Steel Industries comprising both scrap iron industries and light manufacturing industries. These industrial belts have played a significant role in the increasing population as it has provided an abundant employment opportunity which attracted migrating population from the neighbouring areas. The increasing population has made a passage for the enhancement of urban built-up areas.

Haora district has two subdivisions, namely Uluberia and Haora Sadar Subdivision. Haora Sadar subdivision is composed of Haora municipal corporation

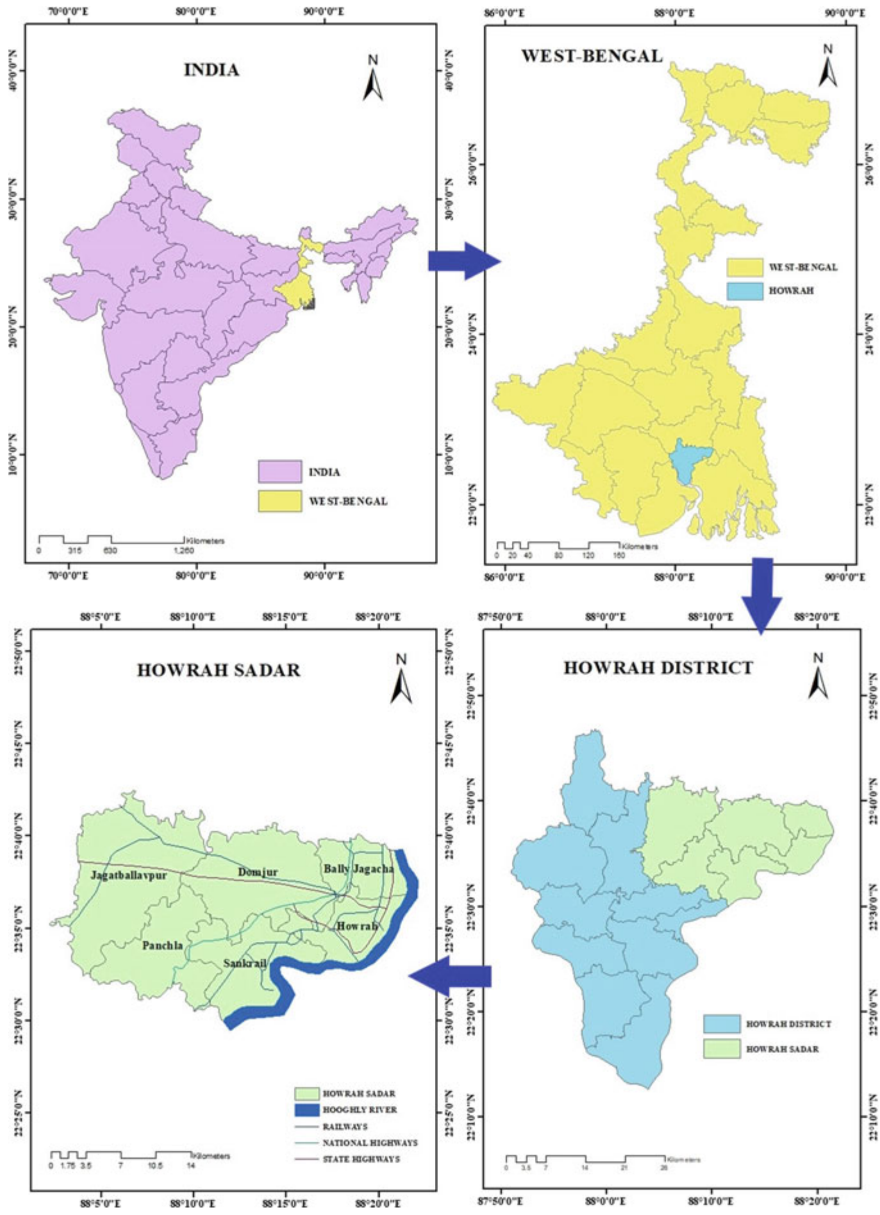


Fig. 1 Location map of Haora Sadar subdivision, Haora district, West Bengal. *Source* Authors

and five community development blocks, namely Bally Jagacha, Domjur, Panchla, Sankrail and Jagatballavpur.

3 Methods

The study has been conducted in Haora district from 1990 to 2016. Data was obtained for the years 1990, 2000, 2010 and 2016. Figure 2 shows the sequence of the methods involved in this work.

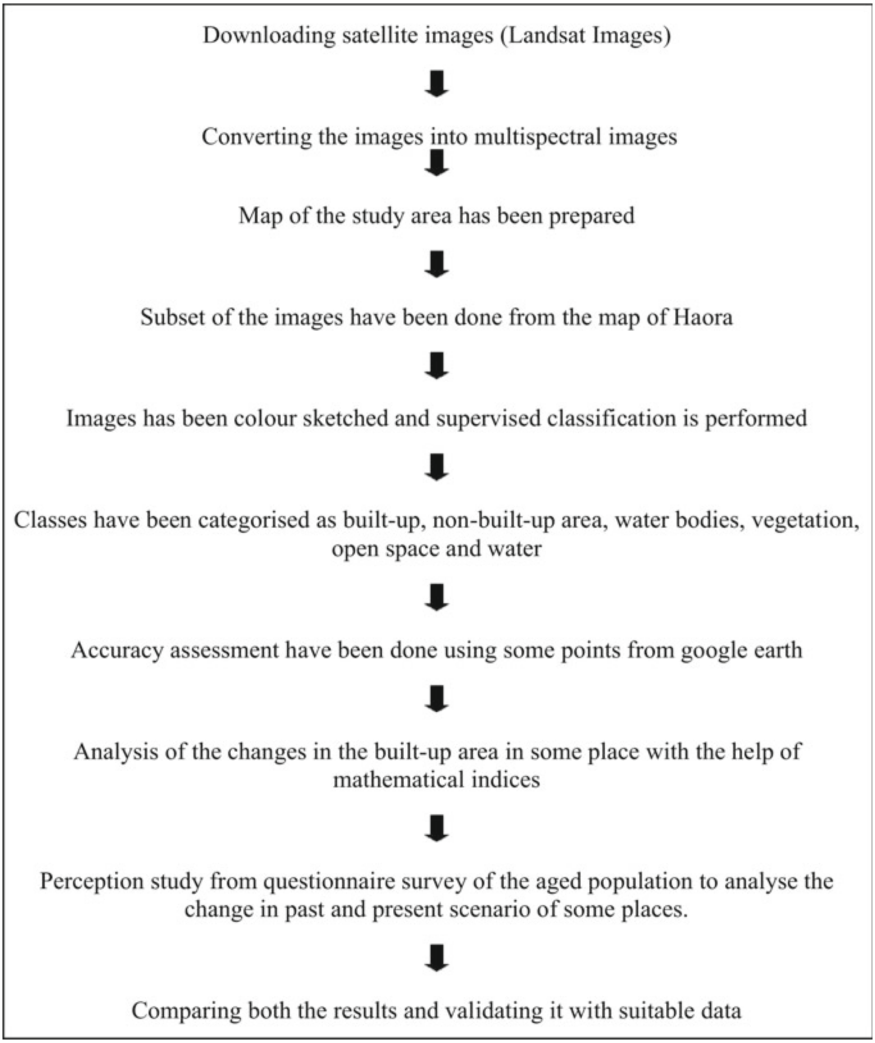


Fig. 2 Flow chart showing the sequence of methods involved in the work. *Source* Authors

4 Analysis of the Remote Sensing Images and Statistical Analysis

The gradual growth of the urban built-up area of Haora Sadar subdivision showed that there is hardly any space left for urban expansion in 2016. There is also a massive compaction of the city. The nature of the built-up area was calculated using indices like patch density, largest patch index and Shannon's entropy. Figure 4a–c shows the result of urban expansion. The comparative study of the results derived from the indices has shown a significant trend of growth from the year 1990 to 2016. It is evident from the classified maps of Haora Sadar subdivision (Fig. 3) that the built-up area is expanding and tending towards a compact kind of settlement.

The first mathematical index that has been chosen is the patch density (PD) index. The entire landscape has been chosen as the base of calculation of the built-up area. Patch density is the number of built-up patches divided by total landscape area. It has been measured as numbers per thousand hectares. The value of PD is >0 and has no upper limit. This measures landscape patterns. By measuring the PD Index of the landscape in all the years a temporal change in the landscape pattern has been measured (Fig. 4a). In 1990, the value of patch density was 15.464. In 2000, it reached up to 17.3417, and it has further increased to 22.1773 in 2010, and in 2016, it became 24.1346. The trend of this increasing density of patches leads towards compact kinds of settlement.

Largest patch index (LPI) was also calculated. Largest patch index is the percentage of total built-up area occupied by the largest built-up patch. The value ranges between 0 and 100. The temporal change in the largest patch (Fig. 4b) shows an increasing trend from 41.6251% in 1990 to 80.3146% in 2016. This is an indicator of the dominance of built-up area over the non-built-up area. The value of LPI ranges between $0 < \text{LPI} < 100$. Here in this study, the LPI value has increased significantly which is an indicator of the dominance of built-up area over non-built-up area in Haora Sadar subdivision.

Relative entropy is a globally accepted measure for analysing urban sprawl. The entropy method is widely appreciated in the field of urban study because of its simplicity and range. As determining the threshold value is considered to be a challenge that is faced by urban geographers, Shannon's entropy index which has a very clear range and threshold value is considered as one of the most reliable indices. The value of Shannon's entropy varies between 0 and 1 where the threshold value is 0.5. The value greater than 0.5 indicates a sprawled or dispersed settlement, whereas below the threshold indicates a compact type of built-up area. In Haora Sadar subdivision, the value of SEI in 1990 was 0.7716 indicating a dispersed kind of growth. In the year 2016, the value of SEI was 0.467 showing a perfect compact kind of settlement (Fig. 4c).

There is a low gradient in the change in the SEI value between 1990 and 2000 & 2000 and 2010. The change, however, steepens between 2010 and 2016. Thus, it is observed that the urban change in Haora district is gradual but rapid.

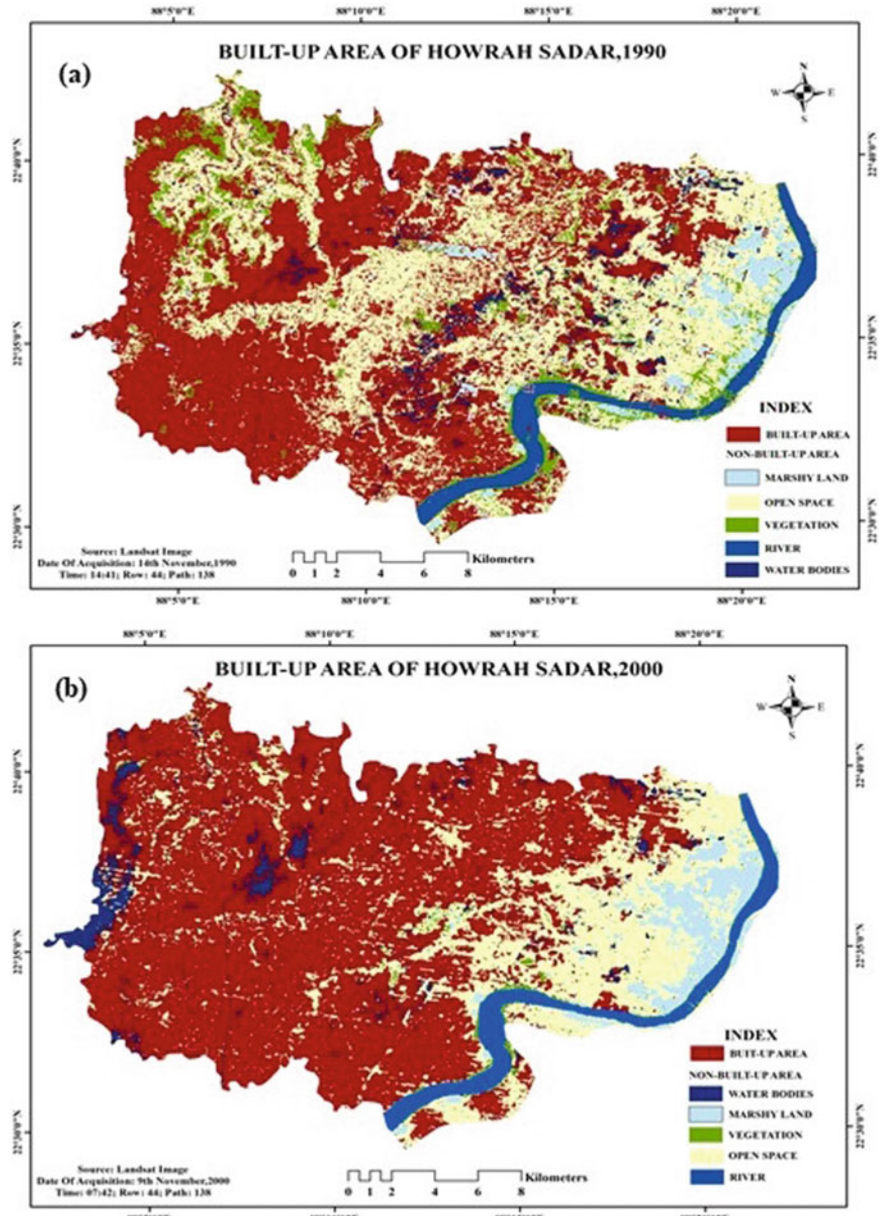


Fig. 3 Gradual expansion of built-up area of Haora district in **a** 1990, **b** 2000, **c** 2010 and **d** 2016. *Source* Landsat Data classified by Authors

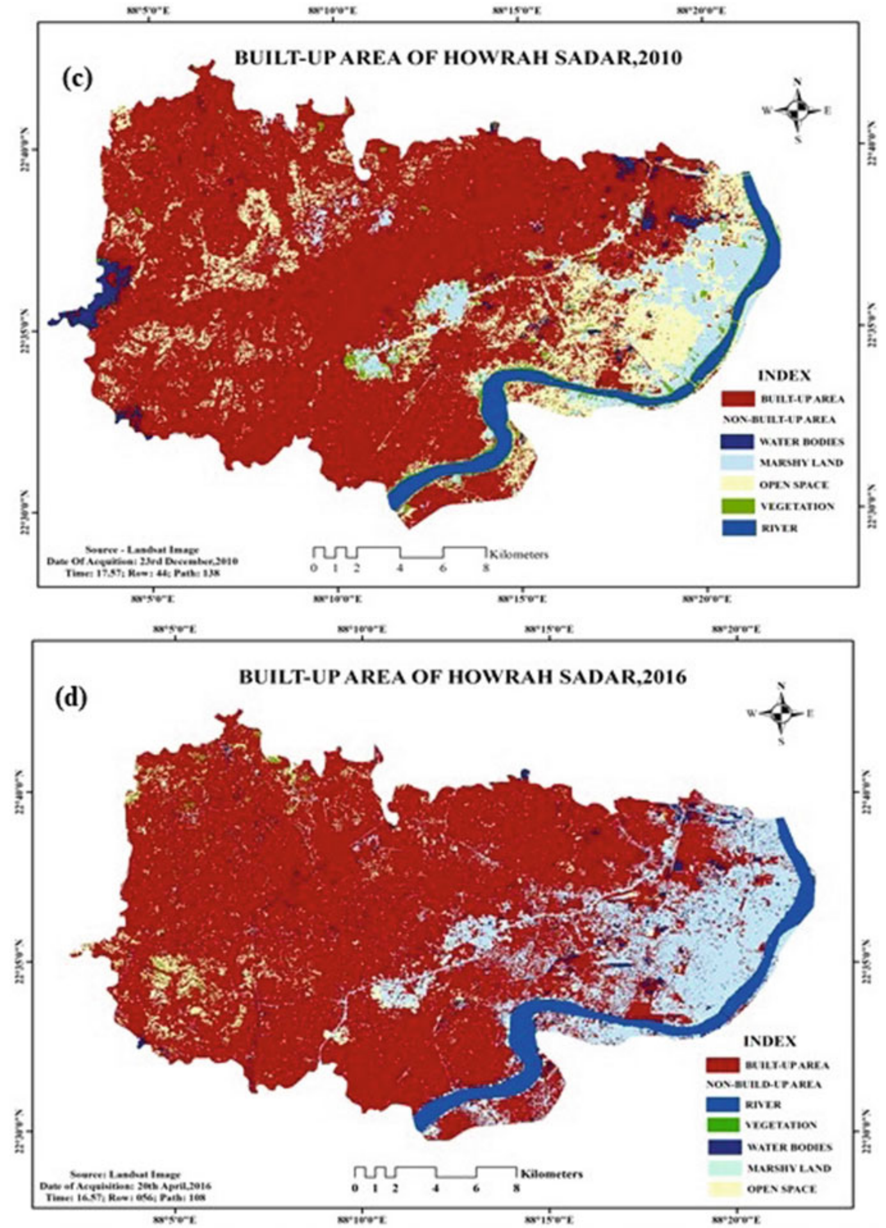
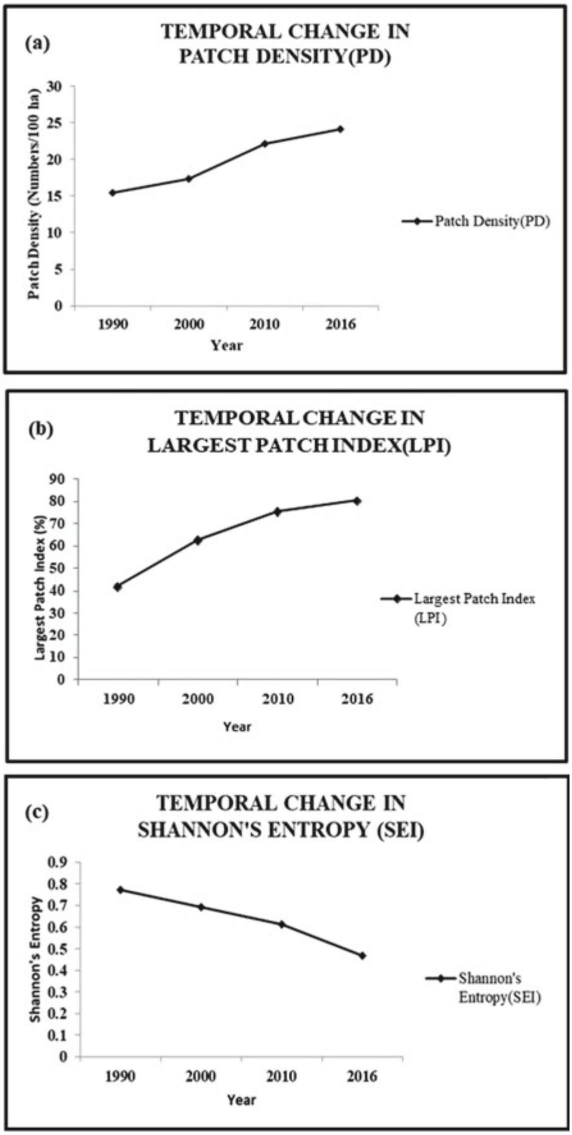


Fig. 3 (continued)

Fig. 4 Line graph showing temporal changes in **a** patch density, **b** largest patch index and **c** Shannon's entropy. *Source* Authors



5 Perception Study of Bally and Islampur of Haora District

Every city has its own history. Looking at the indices and the expansion of built-up areas from classified satellite images, it is not possible to understand the entire story of urban dynamics. Keeping that in mind a questionnaire survey was conducted to analyse the urban amenities in the study area and introspecting the causes behind

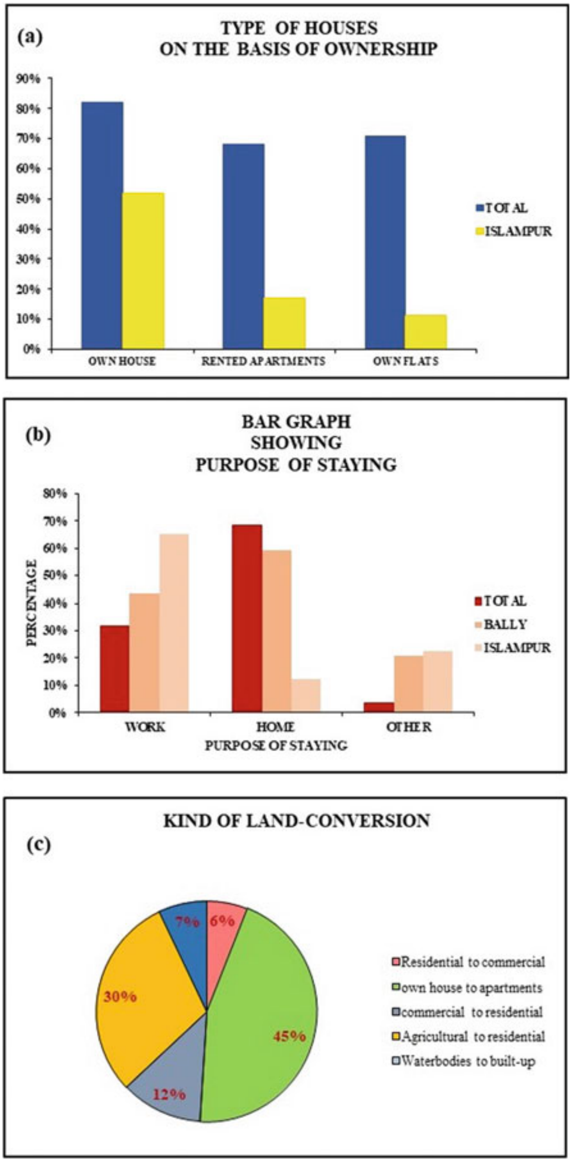


Fig. 5 Graphs showing **a** types of houses on the basis of ownership, **b** purpose of staying and **c** kind of land conversions. *Source* Authors

such rapid urbanization. The target group was chosen by a stratified random sampling method including only a population of 60 years and above. The survey was carried out in the cities of Bally and Islampur. Bally was already a built-up area in 1990, while Islampur converted to an urban centre between 2010 and 2016. As per census 2011, the percentage population above 60 years is 5% to the total population in Haora Sadar subdivision. The sample size was, therefore, chosen as the 5% of the total population of these two places. As a result, 138 people in Bally and 83 persons in Islampur were surveyed. The results have been compared with the census data of West Bengal, India, to locate the position of Haora district with respect to the entire country and the state.

Nature of houses is one of the most important indicators of urban expansion. Most of the respondents surveyed lived in self-owned houses. Around 70% of the respondents live in Islampur because of the employment of either their son or daughter in the area. The same is around 48% for Bally. The respondents being dependants to the working kins; they are often bound to live in these areas (Fig. 5a, b). Some of the people surveyed also preferred to live in these areas because of the available urban amenities. Most of them, however, were already accustomed to the area because of their previous employment in the Haora industrial belt.

The nature of urbanization was also found to be different between Bally and Islampur. As the former is a newly converted urban centre, land conversion from agricultural uses is more prominent. Bally, being an old town, is now changing to a high-rise apartment city. Most of the old houses in Bally are getting promoted to modern buildings by brokers. Most of the people said that young generations prefer to stay in apartments compared to own houses because of the huge cost of maintenance and security issues, and some of the respondents have indicated that big land brokers offer lucrative amounts to the landlord and that also sometimes play a key role in the land conversion. The conversion of residential area to commercial area, own house to apartments, water bodies to built-up indicates a strong shift from the non-built-up to the irreversible built-up.

From the survey, it is evident that there is a sharp increase in the percentage of people availing banking services (Fig. 6a). The use of banking services has shown a sharp increase, whereas the percentage of people using the post offices for financial activities has declined significantly. The use of Automated Teller Machine (ATM) has been increased because using ATM cards give people a benefit of carrying less liquid money, which is travel handy for the busy urban life. Financial services are a part and parcel of urban life, and the available banks, post offices and ATMs play a very significant role in understanding the urban way of life. Haora district consists of more than 200 branches of different banks and around 500 ATM outlets in several areas. The respondents who have been surveyed have shown a trend of using more banks and ATMs as the lifestyle of the area is changing. People use ATM cards for shopping purposes, and after the policy of demonetization, even the smallest shop also accepts ATM cards. Both the nationalized and private banks are operating as financial service providers. The respondents have mentioned that post offices were in use for the financial activities initially, but now the banks have taken the place and almost every respondent has a bank account in which they operate regularly.

Haora Municipality was established in 1862. From 1896, it started supplying filter water across the city. During 1882–83, Bally Municipality was formed separating it out from Haora. As per the Haora Municipal Corporation Act of 1980, Haora became a municipal corporation, in 1984. The corporation area is divided into fifty wards, each of which elects a councillor. The Haora Police

Commissionerate is responsible for law enforcement in the city. Water supply is one of the basic amenities provided in the urban lifestyle. A five-point Likert scale has been constructed to measure the satisfaction of the respondents temporally about the water availability (Fig. 6c) When people were asked about the scenario of water supply, they said they were quite dissatisfied with the water supply at that time, but gradually the situation has improved with the intervention of the Municipal Corporation. The people's perception regarding the availability of water has changed from 55% dissatisfaction to 70% satisfaction between 1990 and 2016.

Like water supply, electricity is also one of the basic requirements in the city. It has been reported that nowadays not only the non-renewable source of energy but also the renewable sources of energy are being used as the source of electricity. Here also the five-point Likert scales have been used to measure the people's satisfaction with the electricity available in Haora district, and it has been found that Haora Municipal Corporation has been able to make people quite satisfied with electric supply. Very less incidents of power cuts are seen in this area compared to the time of 1990s. The respondents told some stories about frequent power cut breaks while they were students, and at the time of survey, they said there are very few power cuts and the available electricity is quite satisfactory and the people have experienced a journey from unsatisfied urban amenities to quite satisfactory urban amenities. Almost 78% people are very satisfied with electricity which is a significant change compared to only 11% rate of satisfaction with electricity in the year 1990 (Fig. 6b).

Availability of street light is not only an indicator of development, but it is taken as a safety measure for the residents as well. Though there are plenty of street lights Fig. 7a, the crime rate has not declined in this area. According to a Report provided by NCRB, Haora has a highest crime rate of 240.25 compared to the national crime rate of 218.67. However, some residents were of the opinion that the shifting of the government headquarters to the district has significantly reduced the incidents of crime.

The total road length in Haora is approximately 300 km. Road connectivity has played a major role in the process of urbanization of Haora district. Important highways like Grand Tank Road, Kona Expressway pass through Haora and connect it with neighbouring districts. Haora station, established in 1854, connects with most of the major cities of India and is considered a lifeline for both Haora and Kolkata. Though the respondents are quite satisfied with the roadways (Fig. 7b), the survey revealed that problems like congestion, pollution and ill maintenance of roads often lead to water logging. Thus, sometimes they are quite dissatisfied with the road conditions.

Haora always was a strong base for education in India and West Bengal (Fig. 8a).

As far as the health facilities are concerned, the respondents complained about the state of the government hospitals. Therefore, they prefer private healthcare facilities. The private nursing homes provide high-end facilities to the patients, and the basic cleanliness of the nursing homes are much more than the government

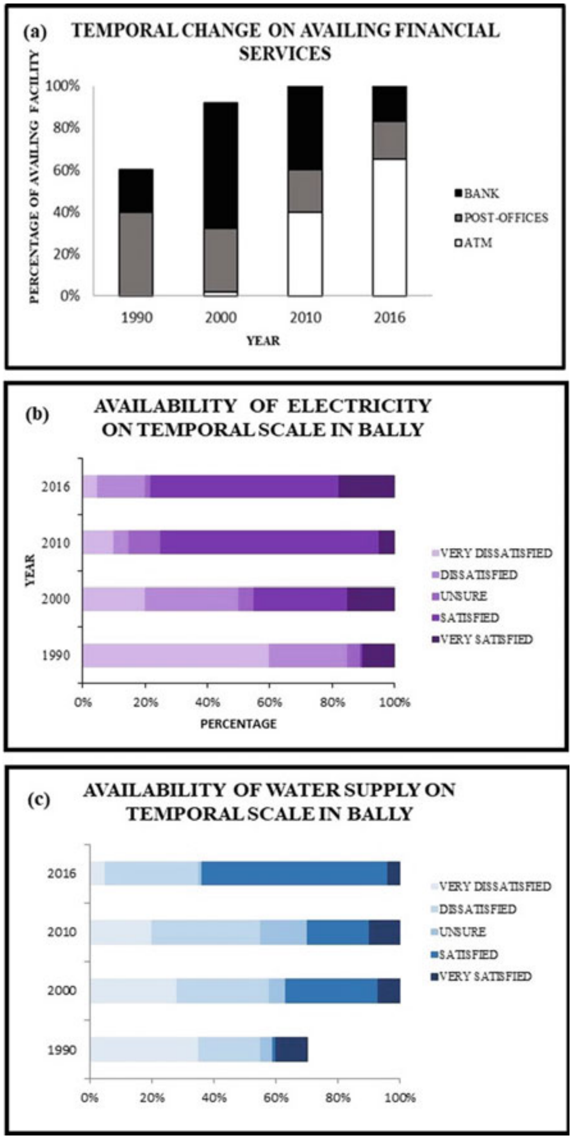


Fig. 6 Graphs showing **a** temporal change in available financial services, **b** temporal change in availability of electricity and **c** kind of land conversions. *Source* Authors

hospitals. However, the difference in the charges makes it difficult to avail the facilities by all the economic classes, and the respondents have pointed out that the medical charges are increasing by leaps and bounds and because of that sometimes they have to rely upon the government hospitals and the health centres. The dismal conditions of the OPDs and the pressure upon the hospitals have reduced the patient to bed ratio and patient doctor ratio. Hence, the above diagram shows the upsurge in the nursing homes, and they are giving tough competition to the government

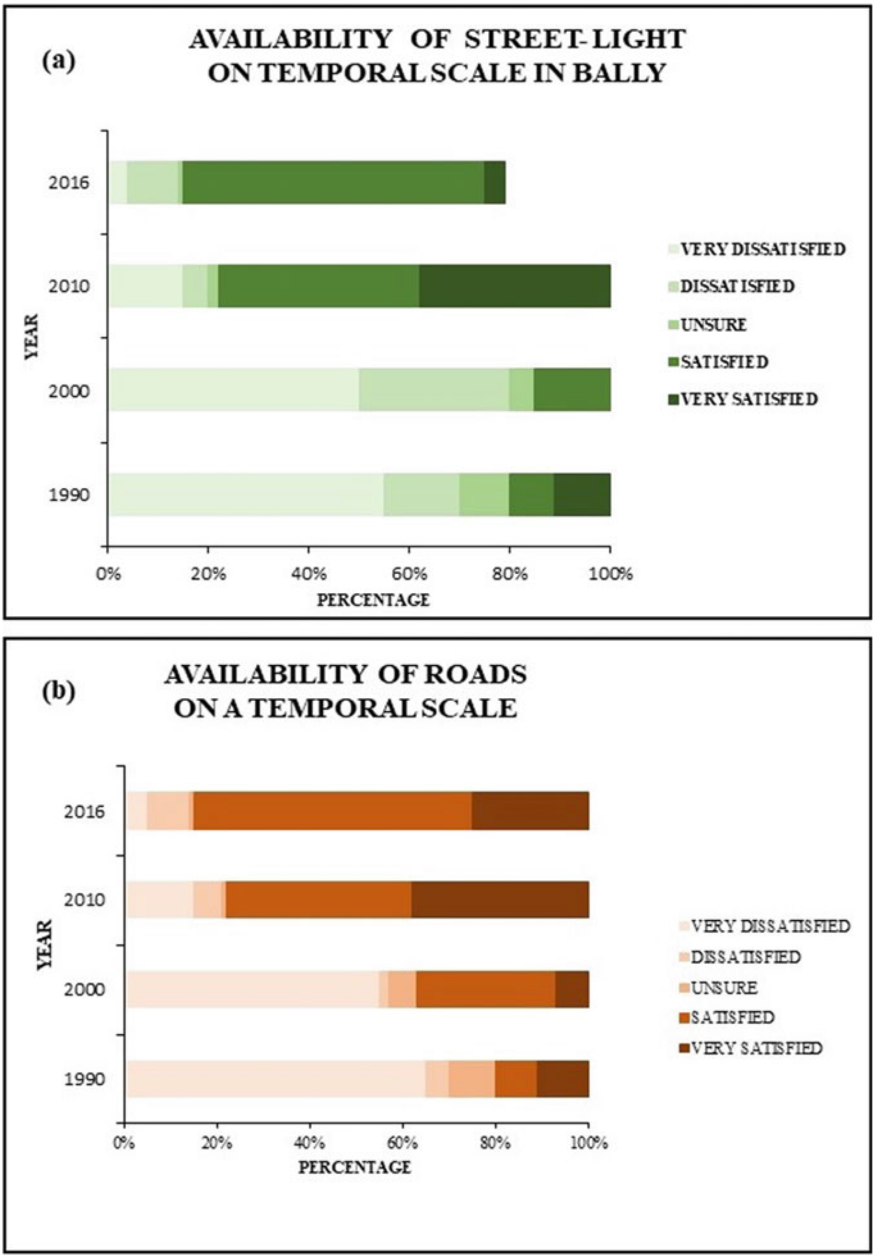


Fig. 7 Graphs showing **a** availability of street lights on a temporal scale, **b** availability of roads on a temporal scale. *Source* Authors

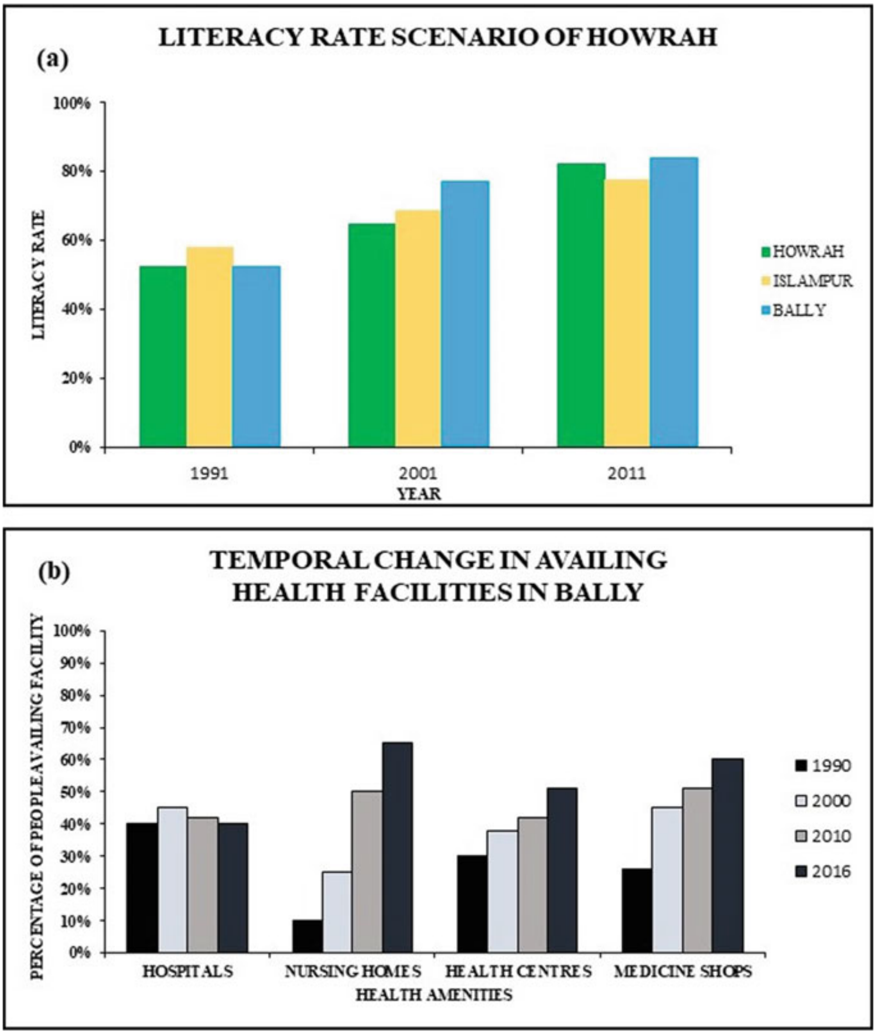


Fig. 8 Graphs showing **a** literacy rate scenario of Haora, **b** temporal change in available health facilities in Bally. *Source* Authors

hospitals. Hence, most of the people who are economically competent are moving towards private nursing homes, and medicine shops are also very much frequent in every nook and corner of Haora compared to that of 1990.

6 Conclusion

From the perception study, it is very clear that Haora's infrastructural development and employment opportunities have accelerated the urban growth of Haora. The population rise in Haora district is a combination of both natural cause and migration. The industrial belt of Haora has pulled people to this district throughout history. The railway junction and the Haora Bridge have acted as catalysts. Slums and squatters are the initial mode of residences for the migrants, which in due time have reduced the open spaces of the area. Excessive population pressure led to the dispersal of the settlements mostly along transport lines followed by the conversion of available non-built-up areas.

Repeated visits to Haora Sadar subdivision during this study have given an impression that urban land-use changes are very rampant in this area. The study has been conducted using both the primary and secondary data, and the results found are significant. It has been observed that over the period of thirty years, the urban landscape has changed from a dispersed kind of settlement in 1990 to compact settlement in 2016. The urban way of living has been infused in this area where people are getting accustomed with urban amenities available, and it is increasing regularly. The increasing value of the largest patch index and patch density of Haora Sadar Subdivision has proved the fact that built-up density is leading towards compaction. Open spaces are reducing as built-up area is increasing, and it has been noticed from the questionnaire survey of the respondents that water bodies, parks and open spaces are converting into built-up areas. India being among the top populous countries (second comprising of 1.311 billion population immediate next to China comprising of 1.371 billion population) of the world and projected to be most populous country of the world by 2022 has provided a great passage for studying urban built-up areas as the urban area of India is about 32% of the total land area, and it is increasing by leaps and bounds. Overall, it can be concluded that in micro-scale also rapid urbanization process is evident indicating India as the projected largest urban agglomeration in the coming century. Urban built-up measurement is still under a research domain of urban geographers because mathematical indices are not always sufficient because of the spatial dimension of urban growth. It is quite evident that there is a huge scope of research in urban built-up measurement.

References

Barnes GC, Hyatt JM, Angel CM, Strang H, Sherman LW (2015) Are restorative justice conferences more fair than criminal courts? comparing levels of observed procedural justice in the reintegrative shaming experiments (RISE). Crim Justice Policy Rev 26 (2):103–130

Bhatta B (2009) Analysis of urban growth pattern using remote sensing and GIS: a case study of Kolkata, India. Int J Remote Sens 30(18):4733–4746. https://doi.org/10.1080/01431160802651967

Bhatta B, Saraswati S, Bandyopadhyay D (2010) Urban sprawl measurement from remote sensing data. Appl Geogr 30(4):731–740. https://doi.org/10.1016/j.apgeog.2010.02.002
Census (2011) Primary Census Abstracts, Registrar General of India, Ministry of Home Affairs, Government of India, Available at: http://www.censusindia.gov
Chen K, Long H, Liao L, Tu S, Li T (2020) Land use transitions and urban-rural integrated development: theoretical framework and China's evidence. Land Use Policy 92:104465
Cheng J, Masser I (2003) Urban growth pattern modeling: a case study of Wuhan city, PR China. Landscape Urban Plann 62(4):199–217. https://doi.org/10.1016/s0169-2046(02)00150-0
Dociu M, Dunarintu A (2012) The socio-economic impact of urbanization. Int J Acad Res Account Finance Manag Sci 2(1):47–52
Goldstein S (1990) Urbanization in China, 1982–87: effects of migration and reclassification. Popul Dev Rev. 1990 Dec 1:673–701. https://doi.org/10.2307/1972962
Haregeweyn N, Fikadu G, Tsunekawa A, Tsubo M, Meshesha DT (2012) The dynamics of urban expansion and its impacts on land use/land cover change and small-scale farmers living near the urban fringe: a case study of Bahir Dar, Ethiopia. Landscape Urban Plann 106(2):149–157. https://doi.org/10.1016/j.landurbplan.2012.02.016
Herold M, Couclelis H, Clarke KC (2005) The role of spatial metrics in the analysis and modeling of urban land use change. Comput Environ Urban Syst 29(4):369–399. https://doi.org/10.1016/j.compenvurbsys.2003.12.001
Herold M, Goldstein NC, Clarke KC (2003) The spatiotemporal form of urban growth: measurement, analysis and modeling. Remote Sens Environ 86(3):286–302. https://doi.org/10.1016/s0034-4257(03)00075-0
Kumar JAV, Pathan SK, Bhanderi RJ (2007) Spatio-temporal analysis for monitoring urban growth—a case study of Indore City. J Ind Soc Remote Sens 35(1):11–20. https://doi.org/10.1007/bf02991829
Mandal RB (1998) Urban geography. Concept publishing company
Ritchie H, Urbanization RM (2018) Our world in data. 2018 Jun 13.Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/urbanization
Sudhira HS, Ramachandra TV, Jagadish KS (2004) Urban sprawl: metrics, dynamics and modelling using GIS. Int J Appl Earth Obs Geoinf 5(1):29–39. https://doi.org/10.1016/j.jag.2003.08.002
UNICEF (2012) The state of the world's children 2012: children in an urban world. Esocialsciences; 2012 Mar
Weeks JR (2010) Defining urban areas. Remote sensing of urban and suburban areas. Springer, Netherlands, pp 33–45
Xiao J, Shen Y, Ge J, Tateishi R, Tang C, Liang Y, Huang Z (2006) Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. Landscape Urban Plann 75(1–2):69–80. https://doi.org/10.1016/j.landurbplan.2004.12.005
Zha Y, Gao J, Ni S (2003) Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. Int J Remote Sens 24(3):583–594. https://doi.org/10.1080/01431160304987

Monalisa Patra is an M.Phil. research scholar in Institute of Development Studies, Kolkata. She has done her graduation from Presidency University with geography major. She has completed her M.Sc. from Presidency University with specialization in regional planning and development. Of late she is pursuing her M.Phil. in development studies. Her research interest lies in urban planning and demography.

Koel Roy Chowdhury is an assistant professor at the Department of Geography, Presidency University. After completing her M.Sc in geography from the University of Calcutta, she completed another M.Sc on GIS and human geography from the University of Leicester, UK. Her PhD was from the RMIT University, Melbourne. She was a Commonwealth scholar and received AusAid scholarship from the government of Australia for her PhD. She was a JSPS Postdoctoral fellow from the United Nations University, Tokyo. Her research interest lies in urban and population geography, and she mainly works in areas where these two interact.