Sun-Kee Hong · Jan Bogaert
Qingwen Min *Editors*

Biocultural Landscapes

Diversity, Functions and Values

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Foreword

Humanity is living in a new and peculiar era, often called “the Anthropocene”, characterized by a global and unprecedented human intrusion into most of the Earth’s ecosystems (Crutzen and Stoermer 2000), and in which recent technological advances have posed serious questions about the resilience and survival capacity of fragile ecosystems such as coral reefs, mangrove forests, mountain tropical forests, or tall grass prairies. These years starting the new millennium have been crucial for landscape sciences and their applications, certifying the ripeness of the research concepts and hypotheses in these disciplines, and, at the same time, marking the start of a significant and widespread public awareness of the landscape concept itself and of its relevance to sustainability. A key date from the aforementioned period is October 20, 2000, with the adoption in Europe of “The European Landscape Convention”, an international milestone treaty, presented in Florence (Italy) and based on a proposal of the Council of Europe’s Congress of Local and Regional Authorities. This treaty has the objective of promoting European landscape protection, management and planning, and aims to encourage efficient European partnerships in this regard. The principles of this Convention are universal and applicable in other fields as well; in it, the landscape is conceptualized as “. . . an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”. Landscape ontogenesis can therefore be summarized as follows: a geographical space, i.e. a landscape, is shaped by human actions which are determined themselves by the social, economic and cultural context, and which transform this space from a pure natural entity into a (semi-)cultural complex around which local human societies aggregate, find values and evolve. Anthropogenic effects and cultural references should therefore not be ignored from ecological landscape studies.

The identification of (landscape) elements which are recognized as important resources of evolving societies are essential to develop an epistemological approach in which several (landscape) processes act and interact. The landscape as a platform on which physical (food, water, shelter, etc.) and non-physical (cultural values, local identity, a sense of place, etc.) resources are integrated is considered an appropriate approach to translate landscape concepts into an ecosystem framework.

The distribution in space and time of resources, such as (open) space, and the cognitive mechanisms and strategies for their interception are the main components that contribute significantly to landscape epistemology, a vision which validates the "pattern/process paradigm", a central hypothesis of landscape ecology. The landscape consequently represents an epistemic domain in which it is possible to observe a synthesis of the interactions between natural systems and human culture, and in which information is conveyed by biosemiotic processes and biological codes. Definitively, the landscape is to be considered a cognitive entity in which perception is adopted by each organism to compete for resources and to maintain its population. This recognition that landscapes are not simply abiotic, cartographic or geomorphologic entities, but on the contrary represent complex and dynamic systems in which many concurrent ecological and cognitive patterns and processes meet and evolve, poses important challenges to stakeholders and policy-makers, and creates benchmarks and constraints for long-term sustainable development.

Land transformation does today not only correspond to habitat degradation and the concomitant extinction of species, but also reflects a tendency towards a different form of configuration of the open space which is preferably reserved for energy-consuming, non-sustainable intensive agriculture and for urban sprawl with logistic infrastructure expansion of which the continuously increasing areal impacts are hardly to slow down. This oversimplification of landscapes represents the major threat to the preservation of organisms, processes and values formerly accumulated in open spaces (rural landscapes) through an (inter)active, long-term co-evolution between nature and humanity. The aforementioned development model is in evident contradiction with the cultural systems and values of the recent past, when human activities were closely connected and adapted to the local characteristics of natural components, and where (natural) resources were preserved for their long-term use. In this way, different cultural models have produced a variety of "cultural landscapes" that are also recognized by UNESCO as valuable aspects of the Earth, and which have been characterized as the expression of the long and intimate relationship between peoples and their natural environment (von Droste et al. 1995). The integration between cultural landscapes and human societies is evidenced by several ecological services, which include well-being, a sense of place and social identity, and for which biodiversity is not a secondary system component but a first-order condition. Consequently, each landscape is the mirror of the resident society that shapes its lands, may introduce alien species, and uses local resources. The structure and shape of such landscapes will be different according to the dynamics of the society involved. For this reason, it is not possible to maintain the *status quo* of a "cultural landscape" when the resident population modifies its lifestyle or when the society is undergoing compositional changes with regard to its cultural values or perceptions. The speed of the dynamics that take place in modern societies is often considered higher than the speed at which the subjected landscape could eventually recover, hence producing a clear gap between human structures and landscape patterns, and thereby accumulating an "ecological debt" (*sensu* Tilman et al. 1994). The rural societies that initially produced these cultural landscapes rapidly disappeared after the industrial revolution, and were intensively transformed by a more uniform industrial society that shaped the diverse landscapes in a distinct way, leading to a simplification of the elements that are expected to support biodiversity. This process, which was initiated in Western countries at least two centuries ago, is now also spreading at great speed in the rest of the World, degrading and even destroying unique landscapes from the arctic regions to tropical and remote mountain areas. Therefore, the "cry of pain" that arises when observing the irreversible destruction of vast tropical forests must be completed with an awareness of the concomitant destruction of cultural values that preserve a relevant part of often neglected (biological) diversity that contributes to the maintenance of the well-being of rural societies.

The current volume, devoted to the cultural and biological dimensions and values of landscapes, contributes to the aforementioned awareness and tries to link the concepts of the biodiversity-landscape-culture paradigm, which constitutes an essential approach for landscape analysis, interpretation and sustainable dynamics. It confirms the interest which the landscape concept evokes in different fields of natural and human sciences and emphasizes the trans-disciplinary nature of the landscape concept and its bio-cultural values through its diversity in geographical scopes, methodological approaches, or even conceptual assumptions. It contributes therefore significantly to our common mission to defend the world heritage of cultural landscapes.

Urbino, Italy Almo Farina

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Preface

Since its early developments in the 1980s, landscape ecology has consistently considered anthropogenic elements in landscapes, as well as their significance for the ecosystems composing them. This human impact was often seen as a negative factor, and associated with terms such as habitat loss, biodiversity decline or degradation. Nevertheless, the key role of Man in landscape status and development has systematically been recognized by landscape ecologists, a point of view sometimes referred to when singularizing landscape ecology from other disciplines in ecology, which are often (but not always) oriented towards particular species or functional groups, or aiming to unravel fundamental ecological concepts, hereby commonly excluding the impact of anthropogenic factors on the ecological mechanisms at study.

Since the last decennium of the twentieth century and even more clearly after entering the new millennium, landscape ecology is directing to systems shaped by a symbiosis of cultural influences and natural values, presenting a variety of anthropogenic effects, a combination not to be considered as negative. This cross-fertilization between human society (cultural values) and its environment (nature) is not surprising, since society development was only possible through resource use, such as space or biodiversity; for example, agricultural development was only possible through domestication of wild plant species. Unique correspondences have been observed of natural and cultural values, suggesting that processes and underlying patterns should be linked, a hypothesis which merits further investigation, to which this book is contributing.

The current book is the outcome of a symposium on “Biodiversity in cultural landscapes”, organized in the framework of the 8th IALE World Congress, held in Beijing, from August 18 till August 23, 2011. As stated rightfully in the conference program by the congress chairpersons, Bruce Jones and Bojie Fu, the location of the congress was very well chosen, since China, an ancient country with a rich cultural legacy, beautiful natural areas and an impressive cultural landscape diversity, formed the ideal background to study the relationships between humanity and nature, and natural and cultural landscapes. A statement which implicitly confirms that these links between cultural and biological diversity are to be considered more

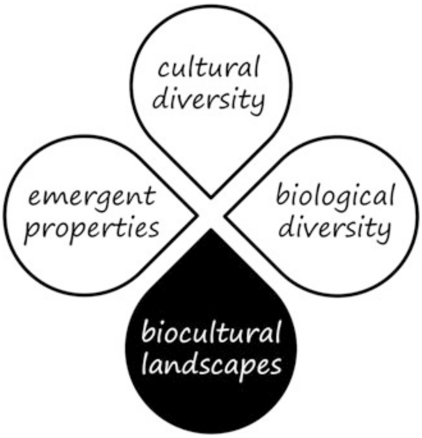

Fig. 1 Illustration of the integrative character of biocultural landscapes. Landscapes can be defined through a hierarchical approach, in which they are composed of interacting (eco)systems. This systemic view on landscapes is crucial to recognize their emergent properties. Anthropogenic action, frequently associated with agriculture, industry or urbanization, influences natural values present in the landscape, often expressed by means of biodiversity, likewise a multi-scalar concept, since assessable from small ecological systems to broad regions, and from genes to ecosystems. The interactions of cultural diversity, biological diversity and emergent properties generate a unique combination, of which the integrated nature is considered vital for sustainable landscape development, nature conservation, and cultural heritage management

often by landscape ecologists. Consequently, these interactions between human activities and biological diversity and their expression at the landscape scale form the cornerstone of this volume, as conceptualized by Fig. 1.

This book contains 14 chapters, each of which can be read on its own, conceived by authors from Asia (Japan, Philippines, P.R. China, Republic of Korea), Europe (Belgium, Italy, Slovakia, Switzerland) or North-America (Canada) willing to share their research experiences and views on biocultural landscapes, their pattern, conservation, and management.

No interesting book is without the challenge to obtain a high quality scientific input from the contributors, and without a confrontation of divergent ideas, concepts, and styles. Consequently, the editors thank all authors for their contributions of which the original character enabled to cover an appropriate geographical and conceptual range and to present a good trade-off between rather specific or local case studies and theoretical papers.

The editors likewise acknowledge the editorial staff of Springer Science+Business Media, especially Ria Kanters and Catherine Cotton, for their advice, support and patience, and also Professor Almo Farina, for having accepted to introduce this book.

Mokpo, Republic of Korea — Sun-Kee Hong
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Chapter 1
Philosophy and Background of Biocultural Landscapes

Sun-Kee Hong

Abstract Distribution of biological organisms and human's utilization is significantly related and its interaction between nature and human creates culture. However, ecosystems and habitats will disappear by reckless development and climate change. Unique biological creatures that had been contributed to maintain the traditional ecological culture are drastically disappearing. Although interesting in biodiversity is focused on species, habitat and ecosystem levels, human scale should be considered to understand recent global change and environmental issues on biodiversity loss. Therefore, it is necessary to strength and expands new paradigm on biocultural diversity beyond biological concept on biodiversity. Diversity of landscape (land or island) that had created biological and cultural diversity, however, is influencing both human tradition and life. Through the landscape, biological diversity can be structured, developed and changed.

Keywords Bioculture • Biodiversity • Biocultural diversity • Biocultural landscape • Ecosystem • CBD • UNESCO

1.1 Background

Ecologists request that recognition of economic professionals and politicians in advanced countries should be changed to solve the problems of serious climate change and indiscreet overdevelopment. Various cases have been cited to explain how much mankind has been dependent upon creatures and the ecosystem, how culture has been connected with biodiversity, and how culture has been generated. 2010 is the International Year of Biodiversity and the International Year of Rapprochement of Cultures designated by the UN. It is very significant to designate

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2010 as the year of bio-diversity and cultural rapprochement, at a time when the global ecosystem is being destroyed and the value of biocultural diversity is decreased due to climate change, thoughtless overdevelopment, our original ecosystem being destroyed for the sake of the appropriation of resources, environment pollution, and others. Various commemorative programs were implemented across the world and an international academic meeting (Convention on Biological Diversity, CBD) was held in Montreal, Canada between June 8 and 10, 2010 (International Conference on Biological and Cultural Diversity 2010a). The convention is an agreement among UNEP member countries made in 1993 in order to ensure that biodiversity is preserved, various species of creatures are used in a sustainable manner, and profits from commercial and other uses of genetic resources are divided and shared. In particular, it is very meaningful that the international meeting was held by both economic professionals and UNESCO on the topic of "*Biological and Cultural Diversity for Development*." A conference on "*Diversity for Development*" was attended by North America-based environmental development companies, energy-related international organizations, politicians, and others who discussed how to improve world economic professionals' recognition about global environment change and biodiversity crisis, with a focus on the role and cooperation of economic professionals and environmental policy makers in connection with diversity, green economy, and new models of growth. Many people's concern was drawn more than anything else to UNESCO, UNDP, and politicians' discussion about" energy, sustainable development, and diversity" and "biological and cultural diversity for sustainable development." Thus, the importance of biodiversity and cultural diversity is already internationally recognized and concerned, as an index necessary to discuss the sustainability of global environment and society. The 5th World Natural World Conservation Congress held in Jeju, in September 2012, discussed the preservation of biodiversity and sustainable utilization of cultural resources on islands and coastal regions, which are an ecosystem very vulnerable to climate change and the development process; they suggested and adopted a proposal on "*Strengthening Biocultural Diversity and Traditional Ecological Knowledge in Asia-Pacific Island Regions*." Moreover, *Island Biocultural Diversity Initiative* was formed through a workshop during the period of WCC.

1.2 Bioculture and Biocultural Diversity

Culture describes how creatures use their environment, a peculiar manner of adaptation of each race in each region, how to use resources derived from an ecosystem, a life style including how to dress, survive, dwell and communicate. UNESCO and IUCN utilize the term bioculture based on the characteristics of creatures, cultures, and languages in order to conceptualize the features of the life of men adapted to their various biological environments from ecologic, cultural, and anthropologic standpoints (Pretty et al. 2009). The academic circles use the term in a wider sense (Table 1.1). Thus, such a system of '*bioculture*' is defined as

Table 1.1 Possible cooperation of interdisciplinary research fields concerned with the intersection of nature and culture (Pretty et al. 2009)

Biological diversity	Ethnobotany
Cognitive anthropology	Ethnoecology
Commons studies	Enthnolinguistics
Cultural anthropology	Ethnoscience
Cultural geography	Historical ecology
Cultural (landscape) ecology	Human ecology
Deep ecology	Human geography
Descriptive historical particularism	Indigenous knowledge
Development studies	Intercultural education
Ecofeminism	Landscape ecology
Ecological anthropology	Nature society theory
Ecological design	Political ecology
Ecological economics	Resilience sciences (ecological and cultural)
Ecosystem health	Science and technology studies
Environmental anthropology	Social-ecological systems
Environmental education	Sustainability science
Environmental ethics	Symbolic ecology
Environmental history	System ecology

'*biocultural diversity*' of an overall meaning, which comprises the characteristics and attributes of creatures supporting the system, cultural spectrum, co-existence of biological diversity and cultural diversity, and interactions between traditional knowledge (International Conference on Biological and Cultural Diversity 2010b). Bioculture and biocultural diversity are already defined by UNESCO, IUCN, and CBD and being spreading to each corner of the world by Luisa Maffi and many researchers (Maffi 2001; Pretty et al. 2009; Maffi and Woodley 2010). In particular, value and importance of biological and cultural diversity had been known since Declaration of Belém 1988 (http://ethnobiology.net/what-we-do/core-programs/global-coalition/declaration-of-belem/).

Since a proposal for bioculture diversity and traditional knowledge on islands in Asia and pacific regions prepared by the present author and others was submitted to and adopted by IUCN World Conservation Congress convened in Jeju in September 2012, the importance of biocultural diversity (especially on island) shall be internationally recognized and various projects developed. Table 2.2 summarized important keywords relating biocultural landscape.

Table 2.2 Definitions of major terminology concerned with biocultural landscape (Cited from International Conference on Biological and Cultural Diversity 2010b)

Biological diversity The Convention on Biological Diversity (CBD) defines biological diversity as: "The variability among living organisms from all sources, including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." The Ecosystem approach of the Convention makes it clear that biological diversity has to be seen in the context of peoples relations with nature, and that people are part of biodiversity.
Cultural diversity According to the UNESCO Declaration on Cultural Diversity (2001) "Cultural diversity is considered to encompass "all communities in the world, each of them with their own identity determined by ethnicity, history, language, religion and art". It "widens the range of options open to everyone; it is one of the roots of development, understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence." Cultural diversity may be understood as, but not limited to, diversity in: (1) practices (rituals, production systems and knowledge transmission systems); (2) ways of living together (social systems including institutions, legal systems, leadership and tenure systems); (3) value systems (religion, ethics, spirituality, beliefs and worldviews); (4) knowledge (know-how and skills); (5) languages; and (6) artistic expressions (art, architecture, literature and music).
Local, Indigenous or Traditional Knowledge Local, indigenous or traditional knowledge systems bridge the gap between biological and cultural diversities. These complex and dynamic arrays of knowledge, know-how, practices and representations guide human societies in their innumerable interactions with the natural milieu (Nakashima and Roué 2002). Article 8(j) of the Convention on Biological Diversity gives particular recognition to this cultural dimension of biodiversity, as do all of UNESCO's cultural conventions.
Landscape The landscape concept recognizes the constant interplay between people and their natural surroundings, and more specifically the manner in which human societies shape the land and are in turn, shaped by it. The concept of *cultural landscapes* as recognized within the framework of the World Heritage Convention, underlines the significance of this encounter between biological and cultural diversities.
Biocultural diversity The inextricable link between biological diversity and cultural diversity received international recognition through the Declaration of Belem (1988). Loh and Harmon (2005) define Biocultural diversity as the total sum of the world's differences, no matter what their origin. This concept encompasses biological diversity at all its levels and cultural diversity in all its manifestations. Biocultural diversity is derived from the myriad ways in which humans have interacted with their natural surroundings. Their co-evolution has generated local ecological knowledge and practices: a vital reservoir of experience, methods and skills that help different societies to manage their resources. Diverse worldviews and ethical approaches to life have emerged in tandem with this co-evolution of nature and culture. The biocultural concept is critical to making progress on building mutual understanding and support between these two diversities.

1.3 Spreading the Biodiversity Concept to Biocultural Landscapes: The Case of the Archipelago in Southwestern Korea

The Southwestern Sea, which is a representative island-coastal region in Korea, was designated as the 3rd Biosphere Reserve in Korea in 2009 by UNESCO because the region has a unique ecosystem, superior bio-diversity, and peculiar ecologic and cultural values (Hong 2010, 2011a). The archipelago region, which has been continuously preserved for scores of years, maintains a peculiar ecosystem and an ample amount of traditional ecologic knowledge of local residents adapted to their ecosystem. In recent days, when the extent of environmental development has widened, not only biodiversity, which has been an index to the evaluation of the soundness of an ecosystem, but also cultural diversity need be considered to understand the soundness of an ecosystem network or a landscape system. For a long time, men have utilized adjacent landscape and creatures as life resources and, if necessary, cultivated and developed new species. Utilizing biodiversity has been a basis for promoting cultural diversity, which comprises food culture and residence culture; such ecologic knowledge is spreading beyond neighboring regions to counties (Huntington 2000). In recent days, the climate has changed on archipelago, changing fishing grounds due to excessive human intervention and oceanic pollution, which result in rapid change of the island ecosystem that has been maintained soundly for a long time. This environmental incident warrants significant concern from humans, and simply shows that the imbalance of man and nature is affecting biodiversity, landscape diversity, and cultural diversity.

Not only the values of landscape but also the languages and dialects of minority races are very vulnerable to westernization and quickly disappearing. Native knowledge on the use of natural resources is endangered in the same manner as biodiversity is driven out by thoughtless overdevelopment of energy and indiscreet use of land (Hunn 2001). A major concern is about how to preserve disappearing native knowledge as historic materials. As was in the past, the survival of mankind will be greatly dependent upon biodiversity in the future as well; ecologic and cultural flexibility and sustainability, which are revealed in an interactive relationship between biodiversity and cultural diversity, are used as a model for harmonious coexistence of man with their ecosystem, since the co-existence will support the existence of man in the future (Hong 2011b). Therefore, '*biocultural landscape*' may be defined as the overall and cyclic characteristics of: a space that acts as a buffer so that biocultural diversity (which is rapidly diminishing but deserves to be preserved) may be developed in a sustainable manner, ecological knowledge utilizing diversity and dynamics of the space, mechanisms to maintain the landscape development process, and an ecosystem which has an influence on the space (Hong 2007, 2011b).

1.4 Necessities and Goals of the Concept of Biocultural Landscape

Creatures and cultures have different attributes, but it seems that the term biocultural landscape was coined to stand for a space where natural and human systems coexist, since men have developed depending on nature and cannot exist without utilizing natural resources. Thus, it is undeniable that men and nature have interactively depended upon, contacted, and complemented each other in their ecologic system. Yet, it is necessary for government officials, researchers, citizens, and professionals to deeply understand that, recently, the connection between men and nature is gradually dwindling due to rapid change of the globe environment, overdevelopment, decreased biodiversity, and others. As is attested in the history of mankind, the survival of men greatly relies upon biodiversity, and ecologic and cultural flexibility and sustainability based on such an interactive relationship between biodiversity and cultural diversity will be used as a model for mankind's harmonious co-existence with its ecosystem, which can support the future of mankind.

International organizations like IUCN, UNEP, UNESCO, and CBD deeply recognize the interactive relationship between biodiversity and cultural diversity. From the standpoint of anthropology, the organizations have utilized the term bioculture so as to conceptualize the characteristics of the life of men who adapted to various biological environments, and academic circles use the term in a wider sense. UNEP GEO-4 (2007) defines that the concept of biodiversity should include human cultural diversity, which has an influence on an ecosystem and species diversity; UNESCO has summoned an expert conference on Main Line of Action on Biodiversity and Cultural Diversity in Aichi, Japan (April 2004) and Paris, France (September 2007). Article 8j of CBD clearly describes the importance of traditional knowledge for sustainable use and preservation of biodiversity. IUCN's 4th World Conservation Congress held in Barcelona had a conference on "biodiversity and native peoples" and, after the conference, the 2009–2012 IUCN program was approved so as to recognize the importance of cultural diversity and cultural values connected to nature and of native residents and native knowledge of the connection. IUCN's Commission on Environmental, Economic and Social Policy (CEESP) is promoting related projects, recognizing that the world is intertwined with biodiversity and cultural diversity.

The importance of biodiversity and cultural diversity is already internationally recognized and concerned as an index necessary to discuss the sustainability of global environment and society, since CBD, in collaboration with economic professionals and UNESCO, hosted a meeting on the topic of "Biological and Cultural Diversity for Development" in June 2010, which was the Year of World Biodiversity. The 5th World Conservation Congress organized by IUCN held in Jeju, Korea in September 2012 discussed the preservation of biodiversity and sustainable utilization of cultural resources on islands and coastal regions, which are an ecosystem very vulnerable to climate change and the development process, and suggested and adopted a proposal on "*Strengthening Biocultural Diversity and Traditional Ecological Knowledge in Asia-Pacific Island Regions*." It demonstrates that governments and civic groups across the world understand ecologic and cultural characteristics of mechanisms for developing and maintaining biocultural diversity on the basis of ecologic knowledge utilizing biodiversity on islands and coastal regions, which are an ecosystem very vulnerable to climate change and the development process.

IUCN is concerned about various problems of islands and oceans, including climate change, population on islands, poor fishing villages, and ecosystems threatened by commercial fishery. IUCN has established and operated THE GLOBAL ISLAND PARTNERSHIP (GLISPA), which educates and trains such leaders that can tackle and resolve various environmental and resource problems. Also, a number of programs are operated so that people may be adapted to climate change on islands, and long-term programs for restoring, preserving and managing islands, which are ecologically very important, are operated so that islands may be developed in a sustainable manner (Ex.: a project entitled Mangrove Ecosystem Climate Change Adaptation and Livelihood (MESCAL)). Furthermore, IUCN in cooperation with UNESCO, is involved in the designation and management of world natural heritages. Besides, CBD-COP11 already recognizes the importance of biocultural diversity and traditional ecologic knowledge, which may be considered the core of the proposal in question, and SCBD-UNESCO Programme helps conduct various activities.

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Chapter 2
Agro-cultural Landscapes in China: Types and Significances

Qingwen Min and Lu He

Abstract In many countries, specific agricultural systems and landscapes have been created, shaped and maintained by generations of farmers and herders based on diverse species and their interactions and using locally adapted, distinctive and often ingenious combinations of management practices and techniques. These Agro-cultural landscapes are all integrated bio-cultural systems with plenty of biodiversity and cultural diversity. Many traditional agro-cultural landscapes, liking rice terraces and vineyards, were listed in the World Heritage List. FAO launched an initiative in 2002 and defined Globally Important Agricultural Heritage Systems (GIAHS) as "Remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development." In this paper, the authors summarized main agro-cultural landscapes, such as (rice and dry crop) terraces, integrated farming systems (rice-fish system, dike-pond system, agro-forestry), soil and water management, multi-layered home gardens, nomadic pastoral systems, inter-cropping, and so on. Their significances were analyzed viewing from biodiversity conservation, cultural heritage, food and livelihood security, adaptation to climate change, and aesthetic value.

Keywords Agro-cultural landscapes • China • Types • Value • Agro-cultural heritage systems

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2.1 Introduction

Cultural landscapes have been defined by the World Heritage Committee as distinct geographical areas or properties uniquely, which represent the combined work of nature and of man. In December 1962, UNESCO issued the recommendation on landscape concerning the Safeguarding of Beauty and Character of Landscapes and Sites. In 1992, World Heritage Convention became the first legal instrument on cultural landscape. Until 2012, there are 82 properties with 4 transboundary properties (1 delisted property) on the World Heritage List have been included as cultural landscapes as being of outstanding universal value (UNESCO 2012).

Agriculture is one of the most important human activities with closed association with nature. Agro-cultural landscapes play an important part in cultural landscapes. There are about 26 properties included as cultural landscapes (Table 2.1), near to one third of the whole. And there are some other world cultural heritages related to agriculture, such as Mill Network at Kinderdijk-Elshout in Netherlands, and so on. These unique agro-cultural landscapes are combined works of nature and humankind, which express a long and intimate relationship between peoples and their natural environment.

FAO launched an initiative in 2002 and defined Globally Important Agricultural Heritage Systems (GIAHS) as "Remarkable land use systems and landscapes which are rich in globally significant biological diversity evolving from the co-adaptation of a community with its environment and its needs and aspirations for sustainable development". GIAHS are selected on the basis of their importance for the provision of local food security, high levels of agricultural biodiversity and associated biological diversity, store of indigenous knowledge and ingenuity of management systems. They could fall into the following categories: mountain rice terraces agroecosystems; Multiple cropping/polyculture farming systems; Understory farming systems; Nomadic and semi-nomadic pastoral systems; Ancient irrigation and soil and water management systems; Complex multi-layered home gardens; Below sea level systems; Tribal agricultural heritage systems; High-value crop and spice systems; Hunting-gathering systems. Until now, there are 25 GIAHS pilot sites all over the world, and 8 of them are in China (FAO 2014).

Compared to cultural landscapes defined by UNESCO, GIAHS are more concerned with the composite ecological system of society, economy and human based on the agriculture. They are involving and sustainable systems which are related to the livelihood of local residents. In this study, we propose the concept "Agro-cultural Landscapes" to generalize a series of specific agricultural systems and landscapes that created, shaped and maintained by generations of farmers and herders based on diverse species and their interactions and using locally adapted, distinctive and often ingenious combinations of management practices and techniques. They are all integrated bio-cultural systems with plenty of biodiversity and cultural diversity. Comparatively, agro-cultural landscapes emphasize on the living, evolving and productive systems. Agro-cultural Landscapes, one kind of GIAHS, are from the view of the landscapes.

Table 2.1 Agro-cultural landscapes in the Cultural Landscape List

Type	Name	Country
Vineyard	Wachau cultural landscape	Austria
	Alto Douro Wine Region	Portugal
	Landscape of the Pico Island vineyard culture	Portugal
	Tokaj Wine Region historic cultural landscape	Hungary
	Jurisdiction of Saint-Emilion	France
	Upper Middle Rhine Valley	German
	Lavaux, vineyard terraces	Switzerland
	The Loire valley between Sully-sur-Loire and Chalonnes	France
Food crop or cash crop	Rice terraces of the Philippine cordilleras	Philippines
	Cultural landscape of Bali Province: the Subak system as a manifestation of the Tri Hita Karana philosophy	Indonesia
	Viñales Valley	Cuba
	Agave landscape and ancient industrial facilities of Tequila	Mexico
	Coffee cultural landscape of Colombia	Colombia
Pastoral	Madriu-Perafita-Claror Valley	Andorra
	Hortobágy National Park – the Puszta	Hungary
	Richtersveld cultural and botanical landscape	South Africa
	The Causses and the Cévennes, Mediterra-nean agro-pastoral cultural landscape	France
Archaeological landscape	Ecosystem and relict cultural landscape of Lopé-Okanda	Gabon
	St Kilda	United Kingdom of Great Britain and Northern Ireland
	Archaeological landscape of the first coffee plantations in the south-east of Cuba	Cuba
	Kuk early agricultural site	Papua New Guinea
Aesthetic landscape created by agricul-tural practices	Val d'Orcia	Italy
	Costiera Amalfitana	Italy
	Agricultural landscape of Southern Öland	Sweden
Rural construction	Koutammakou, the land of the Batammariba	Togo

Source: http://whc.unesco.org/en/list/, sorted by author

Agriculture has flourished in China from time immemorial and formed varied farming practices that adapt well to different natural conditions. For thousands of years, the holistic concept of ancient Chinese philosophy, theory of harmony between man and the nature, and the allelopathy theory have been fully reflected and applied in the traditional agricultural development. Chinese philosophers have pondered on the harmonious relationship between humans, nature and environment. The *Tian Ren He Yi* theory (heaven/nature and human/society are merged into one unit) had great influence among Chinese people and formed the roots of China's traditional agriculture. Agro-cultural Landscapes also well present this point. There exist a great variety of agro-cultural landscapes in China that are representative of the different regions and agricultural practices. We try to summarize the main types of agro-cultural landscapes in China and discuss their significances from the aspects of food and livelihood security, adaptation to climate change, biodiversity conservation, cultural heritage and aesthetic value.

2.2 Types of Agro-cultural Landscapes in China

Through a very long history, China has accumulated a wealth of knowledge and theories on farming systems and agricultural techniques. There is a great diversity of agro-cultural landscapes in China. In general, these landscapes could be classified into four main types: compound systems, integrated farming systems, soil and water management and nomadic pastoral systems.

2.2.1 Compound Systems

This type contains several different agro-ecosystems in vertical space and shows great harmony between various components. Terraces and multi-layer home garden are main subtypes.

2.2.1.1 Terraces

Terraces farming is an ancient agricultural practice used to grow crops on the steep sides of mountains and hills. This process grows crops requiring large amounts of water. Terraces could collect and distribute water while reducing soil erosion. Terraces carved into slopes prevent flooding and excessive runoff after heavy rains. China is an agrarian country in which mountainous regions cover roughly two thirds of the total terrestrial area. Mountains, in China as well as in many developing countries of Asia, are characterized by inaccessibility, fragility, marginality, diversity and are backward in economic development. With increasing pressure of population growth, more slope lands are being cultivated to meet the demands for food.

According to the existence time, there are main types of terraces in China, historical terraces and modern terraces. Table 2.2 shows the differences between them. The historical terraces are terraced paddy fields adjacent to forest-fringed villages form part of the traditional agricultural landscapes in Asia. The mosaic composition of woodland, grasslands, wetlands (ponds and wet rice fields), upland swidden fields and human settlements helps sustain biological and cultural diversity

Table 2.2 Two main types of terraces in China

	Historical terraces	Modern terraces
Distribution	Mountain areas of South China, mainly in Guangxi, Yunnan, Guizhou, Fujian, Hunan and other province	Serious soil erosion areas and arid regions, mainly in Northwest of China
Crop	Paddy rice	Dry crop
Formation time	Hundreds of years or more	Tens of years
Objective	Long-term way of life	Ecological engineering

in the mountainous areas of South and Southeast Asia (Gu et al. 2012). It is chronic adaptation to farm on hilly or mountainous terrain hilly or mountainous terrain with abundant rainfall and mild climate. The other is a so-called ecological engineering since terraced fields are one of the important measures to intercept surface runoff, to increase soil infiltration rate, to reduce water and soil erosion, and to maintain soil moisture. Especially in Loess Plateau, hectares of terraces have been built, broad flat terraces for crops and narrow terraces for trees and shrubs.

Historical Terraces are distributed in South and Southeast China, such as Yunnan, Guizhou, Guangxi, Hunan, Jiangxi, Fujian and Zhejiang. And modern terraces are concentrated in Northwest China, especially in Loess Plateau. In 2010, Honghe Hani Rice Terraces System in Yunnan province was listed as GIAHS by FAO. In 2012, Honghe Hani Rice terraces, Xinhua Ziquejie Rice Terraces in Hunan province and Youxi Lianhe Rice Terraces in Fujian province all approved by Ministry of Agriculture of China as China Nationally Important Agricultural Heritage Systems (China-NIAHS).

2.2.1.2 Multi-layer Home Garden

China has a long history in the development of multi-layered home gardens. The farmers plant trees, crops, vegetables, and raise livestock or fish in their yards mainly for their daily sustenance. House construction, agriculture and humans together form an integrated holistic system with high economic, ecological and social benefits. It is an integrated unit in which the solar energy is channeled through the plants to animals and man, and matter is cycled and recycled. This cycling and recycling process, together with the layered plant cover, protects the soil of the home garden from exhaustion, leaching, and soil erosion. The structure of the home garden varies from place to place and is influenced by both ecological factors, such as climate and soil, and cultural factors.

2.2.2 *Integrated Farming Systems*

Integrated farming systems are system-oriented multi-component agricultural models. It views farming in a holistic manner, emphasizing the interactions between components, and having the multi-biological components as its central part, thus creating a complex biological-social-economic system (Li 2001). According to the different combination, this type of agro-cultural landscapes could be divided into four categories.

2.2.2.1 Integrated Phyto-animal Coexisting Systems

China has a long history in developing integrated phyto-animal systems. In ancient times, Chinese people utilized the commensal relationship between plants and animals to meet the requirements of daily life. Typical examples of this are raising fish or ducks in rice paddies, called rice-fish system or rice-duck system. In the period of the Three Kingdoms (around AD 220), there was documentation of fish culture in paddy Fields (Wu et al. 1992). Nowadays, the regions carrying out rice-fish system are no longer limited to hilly provinces like Sichuan and Guizhou, but have extended to over 20 provinces, including north China and even to Heilongjiang province in the northwest.

More importantly, Qingtian Rice Fish Culture in Zhejiang province and Congjiang Dong's Rice-Fish-Duck System in Guizhou province were listed as GIAHS by FAO in 2005 and 2011 respectively. These traditional agro-cultural landscapes all play an important role in sustainable rural development and multi-functional agricultural development.

2.2.2.2 Integrated Farming Systems in Wetland Ecosystems

Typical examples of this category are dyke-pond system and dyke-ditch system. The dyke-pond system consists of three main subsystems: the pond with its aquaculture, the dyke with its agriculture, forestry and horticulture, and animal husbandry-silkworm production. The history of the dyke-pond system may be traces back to the middle of the ninth century in the Pearl River (Zhujiang) Delta region of China and 1,300 years ago in Taihu watershed of the Yangze River (Changjiang) Delta region. The dyke-ditch system is a form of terrestrial-aquatic integrated farming system in which low land is reconstructed to higher land, intercepted by channels. Forestry, agriculture and animal husbandry are carried out on the dykes, while fishery and aquaculture are managed in the channels with interaction from both sides. It originated from the Lixiahe region of Jiangsu province.

2.2.2.3 Intercropping

Intercropping, defined as a kind of multiple cropping system with two or more crops grown simultaneously in alternate rows in the same area (Federer 1993) while minimizing competition, is practices in China for thousands of years. Available growth resources, such as light, water and nutrients are more completely absorbed and converted to crop biomass by the intercrop as a result of differences in competitive ability for growth factors between inter crop components. Intercropping systems can make full use of solar energy and land resources, maintain a good nutrient balance, and control damage from disease, pests and weeds and, thus, they can realize the productivity increment and economic profits of an agro-ecosystem. Historically, intercropping has already been proven for the Dong Zhou and Qin dynasties (770–206 BC) as a special form of crop rotation. In China, estimations between more than 28 million hectares (Li et al. 2007) and 34 million hectares (Li 2001) of annually sown area are under intercropping. Table 2.3 concludes the main intercropping types and regions and their characteristics in China.

2.2.2.4 Agro-forestry

This is a form of integrated farming system in which woody species and agricultural crops are deliberately planted together in the same land management. As early as the New Stone Age (7,000–8,000 years B.C.), fire was commonly used to burn the forests for slash-and-burn cultivation, which is a primitive form of agroforestry. In China, major agroforestry systems are estimated to cover 45 million hectares. According to a preliminary survey, there are at least 120 tree/shrub species intercropped with agricultural crops and more than 215 combinations have been formulated. They can conveniently be grouped into four categories (Table 2.4).

2.2.3 Soil and Water Management

Farmers in China began to build agricultural water conservancy engineering to manage soil and water resources since more than 2,000 years ago. Some of these engineerings make full use of natural resources without destroying the environment and harmonize humans, land and water resources. They are major landmarks in the development of water management and technology and are still discharging its functions perfectly.

Table 2.3 Intercropping types and regions and their characteristics in China (Knörzer et al. 2009)

Type	Agricultural region	Intercropped species
Single cropping with great intercropping potential	Northeast (NE) and North (N): Liaoning, Jilin, Heilongjiang, parts of Inner Mongolia, Beijing, Tianjin, parts of Hebei, parts of Shanxi	Maize/soybean; maize/peanut; maize/potato; wheat/broomcorn millet
Single cropping for cold climate and semi-arid crops to double cropping for irrigation farming	Northwest: Gansu, Qinghai, Ningxia, Xinjiang, parts of Inner Mongolia, parts of Shaanxi	Maize/potato; maize/bean; wheat/maize; heat/buckwheat; wheat/millet; wheat/tobacco; wheat/soybean
Double cropping with potential for relay intercropping	Yellow-Huai River Valley: parts of Hebei, parts of Shanxi, Shandong, Henan, parts of Shaanxi, parts of Anhui, parts of Jiangsu	Wheat/maize; wheat/cotton; maize/soybean in rotation with wheat; wheat/garlic in rotation with maize
Three cropping seasons per year with rotations replacing intercropping	Southwest: parts of Guangxi, Sichuan, Chongqing, Guizhou, Yunnan, parts of Shaanxi	Maize/beans (sorghum) in rotation with wheat; maize/potato/wheat; wheat in rotation with maize/soybean (green bean); maize/beans in rotation with wheat; maize/wheat; wheat in rotation with maize/sesame; wheat/vegetable in rotation with sweet potato/maize/soybean; maize/sorghum in rotation with wheat; maize in rotation with maize/sweet potato; maize/potato in rotation with wheat; rice/wheat or rape; potato/maize; maize/cassava in rotation with soybean; maize/soybean in rotation with sunflower; wheat in rotation with maize/sesame -maize/potato; vegetable in rotation with maize/sweet potato; maize/sweet potato in rotation with wheat/vegetable; rape/maize; wheat/vegetable in rotation with maize/vegetable

2.2.3.1 Underground Water Channels (Karez)

Karez or Kan'erjing is a conserving facility that originated in western China, especially in Xinjiang Uyghur Autonomous Region. It is a unique methodology to irrigate arid and semi-arid regions and have contributed to forming civilizations

Table 2.4 Agro-forestry types and regions and their characteristics in China (Hsiung et al. 1995)

Type	Characteristics	Region
Agroforestry with crops dominant	This model is popular in the vast agricultural plains where trees are planted as individuals, or in clusters, patches, strips and belts in crop fields	Shandong, Anhui, Henan
Agroforestry with forest dominant	In naturally or artificially forested areas such as timber stands, orchards, special tree plantations, watershed forests, scenic forests, various crops are intergrown so as to enable multiple use of the stands without disturbance of their initial condition	South and Southeast China
Agroforestry with pasture-husbandry dominant	Trees and shrubs are planted in clusters or belts on grazing land to provide protection for herds and to ensure herbage production	Inner Mongolia and the sparse forest areas in the south
Homestead and "four-side" management	Timber trees, fruit trees, vegetables and sometimes aquatic crops are grown and poultry, animals and fish are raised on a small scale around farm houses to make the best use of land and water resources	Rural areas all over the country

under these harsh conditions. Underground tunnels following an aquifer collect water from different layers of earth by relying only on gravity alone. They are used to collect underground water from snow fall in the highlands that infiltrates underground and convey it to fields for irrigation. Karez minimizes evaporation loss and ensures an efficient use of the available water resources. Farmers select diverse crops that complement each other in terms of water requirement. In order to preserve these benefits it is necessary to maintain the ancient Karez irrigation systems including their agro-biodiversity on a sustainable basis.

2.2.3.2 Check Dam or Soil-Retaining Dam

Check dam, known as silt storage dam for farmland construction, is an engineering project for soil and water conservation. It has been created by the people in Loess Plateau for hundreds of years. This engineering project can intercept sediment, conserve soil and water and increased grain output by created new lands effectively.

2.2.3.3 Dujiangyan Irrigation System

Construction of the Dujiangyan irrigation system began in the third century B.C. This system still controls the waters of the Minjiang River and distributes it to the fertile farmland of the Chengdu plains. It is World Cultural Heritage.

2.2.4 Nomadic Pastoral Systems

Farming and pastoralism are two major economic and cultural types in ancient China. Nomadic pastoralism is a form of agriculture where livestock are herded either seasonally or continuously in order to find fresh pastures on which to graze. Nomadic pastoral systems are well adapted to the environments where they exist. They can successfully support a population with the limited resources of the land. These kind of agro-cultural landscapes are located in Northern grassland area, including Inner Mongolia, Tibet, Qinghai and Gansu. Often traditional nomadic groups settle into a regular seasonal pattern. In these systems, water is at a premium and the river valleys have therefore assumed great importance, becoming the focus for settlements of various kinds.

2.3 Significance of Agro-cultural Landscapes

Agro-cultural landscapes provide scenic, economic, ecological, social, recreational, and educational functions and values, mainly concentrated in following aspects: food and livelihood security, adaptation to climate change, biodiversity conservation, cultural heritage and aesthetic value.

2.3.1 Food and Livelihood Security

The products from agro-cultural landscapes are not only food for locals, but also their livelihood foundation. On one hand, these landscapes provide diverse products which can ensure the quality nutrition and raise income. Such as Rice-fish system, except for rice, fish and ducks, beans, sweet potato, corn and various vegetables or fruits would be planted in upland nearby. In addition, there are aquatic animals, such as snail, eel, loach, and aquatic plants, such as taro, lotus root, water celery, plantain, and other wild herbs which grow in paddy field. All of them can be great food resources. Therefore, rice-fish model is a kind of multi-purpose field as an adequate source of nutrition of plant protein and animal protein within the same production process for the local residents. Meanwhile, the sale of fish can raise farmers' income. In agro-forestry landscapes, in addition to the crops harvested every year as stable income, there is income from timber from Paulownia-crop intercropping as the trees reach the required size. On the other hand, these landscapes help improve the quantity of products. Rice production is increased by 5–15 % in rice-fish system (Sun et al. 2008). A wheat-cotton intercropping system can produce 3,000 kg/ha of wheat, 10,000–15,000 kg/ha of fresh green manure and more than 1,200 kg/ha of cotton, which is obviously higher than that of sole cropping systems. Zhao and Lu (1993) reported that shelterbelt systems in the

North China Plain reduced wind speed by 20–40 % and thereby improved surface soil moisture by 13 %. As a result of agroforestry practices, the crop yields in the agro-forestry systems were increased by 2.5–30 % for wheat (*Triticumaestium*) and by 9.6–21 % for maize (*Zea mays*).

Beside, these landscapes are good for food quality security. With little contamination of chemical fertilizers, and pesticides and pollution, rice-fish system ensures food safety and human health, which is of particular significance in terms of local residents who haven't yet shaken off poverty. Ancient tea plantations, as one kind of agro-forestry, are special systems in which tea trees grow in the forests. They are organic and pollution-free plantations for there are no artificial fertilizers and pesticide. They are low-cost, compared to plantation bushes that demand heavy applying of fertilizers and pesticide. In addition, the tea produced by tea forests tastes better than that produced by tableland tea plantations. One reason is that the former contains higher concentration of alcohol, tea polyphenol, tea catechin, total sugar, and trace elements like Fe, Mn, and Cu. Another reason is that shading trees in tea forests form a microclimate with more favorable moisture and temperature for the growth of tea trees (Chen et al. 2011).

2.3.2 Adaptation to Climate Change

2.3.2.1 Carbon and Nutrient Cycles

In rice-fish system, fish reduces residues of plants and recycle nutrient by excrement, azolla on the surface of the water also fixes nitrogen. According to a recent study (Xie et al. 2011), although rice yield and rice-yield stability are similar in rice-fish system (RF) and rice monoculture (RM), RF requires 68 % less pesticide and 24 % less chemical fertilizer than RM. A field experiment confirmed this result. The results also indicate a complementary use of nitrogen (N) between rice and fish in RF, resulting in low N fertilizer application and low N release into the environment. These findings provide unique insights into how positive interactions and complementary use of resource between species generate emergent ecosystem properties and how modern agricultural systems might be improved by exploiting synergies between species.

Intercropping also increases N fixation. Numerous studies have indicated that intercropping is a sustainable agricultural system that has the potential to increase crop yields and crop N uptake (Vandermeer 1989). Interspecific competition and facilitation interactions are the main mechanisms involved in the advantages obtained from intercropping. Monocultures often cannot fully utilize available space and resources (soil resources and light), but two species intercropped together can use space and resources more efficiently where they occupy different niches.

2.3.2.2 Reduction of Pests, Diseases and Weed and the Emission of Methane

Establishment of species diversified to control crop diseases, pests and weeds in fields is an effective way. Fish reduce rice pests and rice favors fish by moderating the water environment. This positive relationship between rice and fish reduces the need for pesticides in RF (Xie et al. 2011). Mixed systems with diverse crops are known to encounter less pest problems than pure crops (Altieri and Liebman 1986). Rice-fish system can contribute to reduction of the emission of methane compared to the mono-culture of rice.

2.3.2.3 Remarkable Resilience and Capacity to Adapt to Climatic and Other Environmental Fluctuations

The agro-cultural landscapes always have a long history and show remarkable resilience and capacity to adapt to climatic and other environmental fluctuations. The Hani Rice Terraces have been experienced in last several centuries and a lot of measures are proved to be good adaptation to drought in a changing climate. Agro-forestry helps to protect against natural disasters such as drought, wind, sandstorm, dry and hot winds, and early and late frosts.

2.3.3 Biodiversity Conservation

Agro-cultural landscapes always have multi-components, which can conserve rich agro-biodiversity. The traditional Dong's Rice-Fish-Duck Agro-ecosystem has high species richness with more than 100 species live together in one paddy field. The species-richness and Shannon-Wiener Diversity Indices under this system increased markedly and the Pielou Community Evenness Indices rose (Zhang et al. 2010a, b).

Agro-cultural landscapes also play an important role in traditional varieties conservation. The Hani Rice Terraces are rich in agro-biodiversity and associated biodiversity. Rice planted in Hani terraced fields is extremely diverse. According to the survey, there used to be 195 varieties of local rice, and the existing ones are 48. The rice-fish-duck system in Congjiang County conserves abundant glutinous rice, called *Xianghe* locally. As shown in the survey shows, there are not less than 40 types of *Xianghe* rice.

2.3.4 Cultural Heritage

There is extensive knowledge of historical events, beliefs and traditions associated with the agro-cultural landscapes. These resources can be used as a source of historical information or can be directly experienced. They can thus be regarded as a non-renewable resource of vital importance for our historical understanding. Therefore, agro-cultural landscapes comprises tangible cultural heritages including the villages, dwellings and buildings for production, the protector woods of the villages, irrigation works and road sign steles, etc., and intangible cultural heritages such as the traditional production and life styles, traditional custom and fete activities, and knowledge systems passed down orally, etc., which can help maintain the landscapes. Taking Congjiang Dong's Rice-Fish-Duck System Guizhou province as an example, the traditional festivals there are closely related to this unique agro-cultural landscape. Most of food Dong people enjoy comes from the integrated farming system. Because of that, species have been protected accordingly, and that's the reason why the agricultural model can survive over thousands of years.

2.3.5 Aesthetic Value

Agro-cultural landscapes are always mixed and harmonized with natural landscapes, generating a unique and the scenic beauty. This beauty reflects the worship of nature, conformity to nature and utilization of nature, fully manifesting the residential environment design concept advocating the harmony between human and nature. Agro-cultural landscapes can develop tourism due to their aesthetic value.

2.4 Conclusion

China has various agro-cultural landscapes with significant ecological, economic, cultural and aesthetic values. The maintenance of these landscapes and the inherent cultural heritage depends totally on continued agricultural activities such as farm operations, building maintenance and land management. As agriculture is an important bearer of agro-cultural landscapes, the conservation and development of such landscapes should be dynamic and bring benefits to local farmers. Greater effort should be made in the future to advance the study of agro-cultural landscapes. Firstly, we need further enrich the content of investigation. It is important to accelerate mechanistic and quantitative research on the good and typical traditional agro-ecological model, not just limited to qualitative research. Multi-disciplinary and inter-disciplinary research frameworks and teams need be established to address more complicated problems in reality. Secondly, innovative methodologies and methods need be developed to allow the cooperation between different disciplines. Thirdly, the general investigation, collection, exploration and organization of agro-cultural landscapes in China need to be accelerated. The last but not the least, protection and exploration of traditional agro-cultural landscapes need adapt to the changing social, economic and policy contexts to incorporate with the ideas like circular agriculture, low-carbon agriculture and etc.

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Chapter 3
Zonation of Biodiversity in the Forests of *Lasang* Landscapes in the Philippines

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Abstract *Lasang* landscapes in the Philippines are equivalents of the Japanese satoyama. These are mosaics of patches composed of villages, agricultural lands and forests where dependency of human and nature relationship is evident. *Lasang* is known in diverse names in various islands of the Philippines. It is known as *muyong, pinugo, lakon, gubat, guba, lasang and bungtod,* to name a few. I used the term lasang in this paper as I am more familiar with it. The zonation of biodiversity in forests of selected *lasang* landscapes in the Philippines were documented. Woody species along altitudinal zones were studied in bioculturally significant forests in the Philippines like Mt. Pulag (northern Luzon), Mt. Akiki (northern Luzon) and Mt. Mayon (southern Luzon) by analyzing altitudinal trends from available published sources. Results showed that woody species from lower elevation were encroaching in higher altitudes. A critical analysis of the observed pattern of vegetation zonation in these forest landscapes was comparatively done. Environmental issues like biodiversity loss, habitat degradation, deforestation, bioinvasion, among others were evident. Concerns for environmental rehabilitation and ecological restoration through appropriate sustainable management practices were elucidated.

Keywords Biocultural landscapes • Ecosystem • National protected areas • Satoyama • *Guba* • *Muyong*

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3.1 Introduction

A *lasang* landscape refers to subsistent farming communities with sustainable human-nature relationship (Buot and Osumi 2004; Foster 1992; Foster and Zebryk 1993; Foster et al. 1992; Fukamachi et al. 2003, Nature Conservation Bureau 2002, 2003; Rackham 1994). As such you will see a good forest adjacent to villages, farms, grasslands and water channels. These ecosystems are needed in the day to day subsistence of the community people. *Lasang* landscape is known in several names in the archipelagic Philippines having diverse cultures and regional and local dialects. In the Cordillera, northern Luzon alone, it is known in various names like, *muyong, pinugo, lakon, batangan,* etc. (Buot and Osumi 2004). In other parts of Luzon island, it is known as *gubat* or *guba* system particularly, in Palawan (Sopsop and Buot 2011a, b). In the Cebuano speaking areas of Visayas and Mindanao, it is known as *lasang* and *bungtod*. Other areas in the Visayas and Mindanao which are not Cebuano speaking certainly have their own names as well for this unique biocultural landscape and heritage. I prefer to use *lasang* in this paper for reasons of dialect and landscape familiarity.

Through the years, people live subsistently in harmony with nature in the *lasang* landscape. However, with human population pressure, there was scarcity of food and hence, poverty triggering migration of people from the lowlands to the uplands. There was severe cutting and clearing for kaingin and worse, logging for timber, resulting to biodiversity loss (Mittermeier et al. 1999; Myers et al. 2000). There has been sustained expansion of farmlands in the forests to meet the demands of the increasing population. *Lasang* has experienced a lot of problems with the loss of several unique and keystone species in the area, adversely affecting vital ecosystem processes and functions.

Assessment of biodiversity is thus, imperative. Assessment and analysis of biodiversity, particularly along altitudinal gradients in Philippine mountains in the context of sustainable agriculture were only accomplished by quite few researchers. Plain enumeration of biota were done in some specialized fields (Merrill and Merritt 1910; Pancho 1983; Pancho and Gruezo 2006; etc.). However, it is quite insufficient to solve the complex problems of the present. It has to be combined with quantitative techniques shown first by Brown (1919), Payawal and Markgraf (1981) and Buot and Osumi (2011) while working on the zonation of Mt. Makiling and the field and classification techniques as well, like cluster and ordination analyses used by more recent workers (Buot and Okitsu 1998; Belonias and Aguilar 2004; Banaticla and Buot 2004, 2005; Buot 2007, 2008).

With all of these data, it is very important now to compare results of these studies so that we can have better understanding and grasp of the scenario, hence, facilitating the formulation of the most appropriate and sustainable restoration or management strategy towards conserving the declining and deteriorating resources.

Analyses of data on plant diversity along altitudinal gradient covering various vegetation patches should be done in the light of the prevailing physical, natural and anthropogenic disturbances triggered by pressing socioeconomic conditions in the *lasang* landscape. It is only through this holistic approach that we can arrive at a sound decision regarding conservation, sustainable rehabilitation and management of mountain resources.

It is therefore the objective of this paper to (1) compare the zonation pattern of tree biodiversity in the forests of the *lasang* landscapes in the Philippines, (2) discuss the factors influencing the zonation pattern and (3) identify appropriate sustainable management practices to address the present concern.

3.2 Methods

Three important *lasang* landscapes in the Philippines were studied. These were Mt. Pulag and Mt. Akiki of the Cordillera mountain range, northern Luzon and Mt. Mayon of southern Luzon. The peak of Mt. Pulag is a sacred ground to the Igorot tribes since it is believed that their ancestors were buried there. To the west of Mt. Pulag is Mt. Akiki, a steep mountain terrain with unique biota alongside kaingin farms. Mt. Mayon, on the other hand, is a very attractive legendary volcanic mountain known for its frequent and destructive eruption. Common to the three mountains is the presence of human activities despite their present status as national protected areas.

Comparative analyses of the data published by Buot and Okitsu (1998, 1999) for Mt. Pulag, Buot (2007) for Mt. Akiki and Buot (2008) for Mt. Mayon were done. Therefore sources of data for analyses were from these three publications. The trends of the altitudinal vegetation zonation were critically analyzed to better understand the current problems in these *lasang* landscapes. Possible solutions to address the current issues and concerns were then discussed. An earlier version of the paper could be found in a simple conference proceedings (Buot 2010). However, in this paper, it has been modified to the context of the *lasang* biocultural landscape.

3.3 Results and Discussion

Result of the cluster analysis of vegetation data (RBA) of Mt. Akiki *lasang* landscape (Buot 2007) is shown in Table 3.1. It revealed three distinct altitudinal vegetation zones for Mt. Akiki, namely: Zone I – Pinus-Lithocarpus-Deutzia-Leptospermum forest with subzone IA – Pinus forest at 1,685–2,200 m above sea level (m asl) and subzone IB – Pinus-Lithocarpus-Deutzia-Leptospermum forest at 2,350 and 2,640 m asl; Zone II – Eurya-Lithocarpus forest at 2,300–2,500 m asl; and Zone III – Drimys-Eurya-Rhododendron-Leptospermum with subzone IIIA – Drimys-Eurya forest at 2,700 m asl and subzone IIIB – Rhododendron-Leptospermum forest at 2,750 m asl.

Table 3.1 Woody vegetation zones of Mt. Akiki *lasang*, Benguet, Philippines

Zones	Elevation (meters above sea level, m asl)	Dominant woody vegetation
Zone I	1,685–2,640	*Pinus-Lithocarpus-Deutzia-Leptospermum*
Sub-zone IA	1,685–2,200	*Pinus*
Sub-zone IB	2,350–2,640	*Pinus-Lithocarpus-Deutzia-Leptospermum*
Zone II	2,300–2,500	*Eurya-Lithocarpus*
Zone III	2,700–2,750	*Drimys-Eurya-Rhododendron-Leptospermum*

Physiognomically, Zone I is the pine forest, Zone II and Zone III are mossy forests of the *lasang* landscape. The only difference between Zone II and Zone III lies on the height of the vegetation. Zone II has tall and large trees while Zone III appears too short already apparently because of the very low daily temperature at the higher elevations (2,700–2,900 m asl) that impedes efficient photosynthesis. But both zones have trees with gnarled and twisted branches and twigs practically covered with lichens and bryophytes, particularly, mosses and liverworts. While the three zones are important for the people in the *lasang* landscape, Zone I and part of Zone II are the most economically significant to them. Local people have their vegetable farms in these zones. Above Zone III is a grassland plateau of cultural meaning, serving as the burial place of their ancestors. To this date, the plateau dominated by a dwarf bamboo (Sinarundinaria) is a sacred ground in the *lasang* landscape.

It is surprising that vegetation from 2,350 to 2,640 m asl of the lasang in Mt. Akiki are more related to the more disturbed Zone I having Pinus as one of the dominant elements. This shows that destructive activities are already rampant in these sites. According to Buot (2007), altitudinal zonation pattern of woody vegetation on Mt. Akiki is very similar to that of Mt. Pulag *lasang* landscape (Table 3.2). The presence of pure and mixed Pinus zone, an extensive montane forest dominated by oaks (Lithocarpus) and the presence of Sinarundinaria grassland at the summit, characterize both mountain landscapes.

More prominently, both massifs (Mt. Akiki and Mt. Pulag) do not have the characteristic dipterocarp flora of the tropics, making it different from the southern Luzon mountains and the rest of the mountains in the Philippines. The non-existence of dipterocarps on Mt. Pulag and Mt. Akiki *lasang* forests could be attributed to the separation of northern Luzon from the rest of the Philippines during the early Tertiary (54.8 million years B.P.) (Dickerson 1928). This separation of northern Luzon must have prevented the dipterocarps which characterize the lowland tropical Philippine forests from colonizing Mt. Akiki and Mt. Pulag. On another thought, however, the slopes of Mt. Akiki and Mt. Pulag are very steep (above 70 %) (Buot and Okitsu 1998, 1999), leaving the pines to be the most dominant vegetation after cutting the original forest cover.

The absence of dipterocarps on Mt. Akiki and Mt. Pulag was likewise observed in the forests of Mt. Mayon *lasang* landscape (Table 3.3). Buot (2008) has

Table 3.2 Woody vegetation zones of Mt. Pulag *lasang,* Benguet, Philippines

Zones	Elevation (meters above sea level, m asl)	Dominant woody vegetation
Zone I	2,000–2,400	*Pinus-Deutzia-Schefflera*
Sub-zone IA	2,000–2,300	*Pinus*
Sub-zone IB	2,300–2,400	*Pinus-Deutzia-Schefflera*
Zone II	2,400–2,600	*Syzygium-Leptospermum-Eurya-Dacrycarpus-Lithocarpus*
Zone III	2,600–2,700	*Rhododendron-Clethra-Eurya*

attributed this to the combined impact of intensive anthropogenic activities and natural geological processes such as frequent volcanic eruption (Buot 2008). The altitudinal vegetation zones on Mt. Mayon (Buot 2008) were: Zone I, Erythrina-Ficus-Glochidion zone (500–800 m asl) Zone II, Astronia-Cyathea-Weinmannia zone (900–1,500 m asl), and Zone III, Eurya-Clethra-Neonauclea-Fagraea-Vaccinium zone (1,600–2,200 m asl).

The development of dipterocarps is favorable on soil that retains ample amount of moisture (Richards 1996). Based on ocular field observation, however, the soil on Mt. Mayon *lasang* is sandy and very loose throughout the study area, including the lower altitudes. There were, nevertheless, few struggling dipterocarps reported on Mt. Mayon in some portions of the volcanic mountain (PAWB-DENR 1992). The general soil condition could have been possibly modified gradually through the years, by frequent eruption of Mt. Mayon, coupled with rampant and extensive clearing for agricultural activities resulting to the disappearance of dipterocarps from the study area of the Mt. Mayon *lasang* (Buot 2008).

Another feature that made Mt. Mayon different from other mountains is the absence of a well developed mossy forest (Buot 2008). Though mosses were present but they were so scanty compared with other tropical rainforests and even to that of Mt. Akiki and Mt. Pulag. According to Buot (2008) this could be due to frequent eruption of Mt. Mayon which adversely affect the full development of the typical mossy forest in the *lasang* landscape.

It therefore appears that the influencing factors for the altitudinal vegetation zonation pattern in Mt. Akiki, Mt. Pulag and Mt. Mayon are combination natural and anthropogenic processes and activities. The past geological history and the geography of the massifs, the human activities like deforestation, kaingin farming and the like shaped and dictated the pattern of biodiversity zonation in the forests of the *lasang* landscapes in the Philippines. The past subsistent and harmonious interaction between the components of the *lasang* landscape apparently had been deteriorating. This is gradually replaced by the strong drive to survive no matter what will happen to the lasang landscape.

Table 3.3 Woody vegetation zones of Mt. Mayon *lasang*, Albay, Philippines

Zones	Elevation (meters above sea level, m asl)	Dominant woody vegetation
Zone I	500–800	*Erythrina-Ficus-Astronia-Glochidion*
Zone II	900–1,500	*Astronia-Cyathea-Weinmannia*
Zone III	1,600–2,200	*Eurya-Clethra-Neonauclea-Fagraea-Vaccinium*

3.4 Implications to the Management of Mountain Forest Ecosystem

Tables 3.1 and 3.2 illustrated the continued ascent and encroachment of pine forests (up to 2,600 m asl), replacing the rich broadleaves dominated by the oaks. This is very evident at 2,350 and 2,640 m asl on Mt. Akiki (Table 3.1) and also at 2,325 m asl in Mt. Pulag *lasang* landscape (Table 3.2). This means that the trend will have to continue so long as the favorable factor for the establishment of the pines will be provided adequately.

And indeed, this is favorably enabled by the indiscriminate human activities like kaingin farming, tree harvesting and burning. Knowing the pioneering and competitive ability of pine, it will immediately colonize bare substrates ahead of the rest of the biota. And because none else will be able to survive in such steep dry slopes in the Cordillera's *lasang* landscape forests, pine can become topo-edaphic climax species (Buot and Okitsu 1998). This is also the case of the Pinus taiwanensis in Taiwan (Hsieh et al. 1994).

The same is true on Mt. Mayon *lasang* of Albay in Bicol peninsula, southern Luzon. Dominants were observed to extend the normal distribution range (Table 3.3). Astronia populations of Mt. Mayon were observed outside of their typical ranges which could possibly adversely affect other taxa originally inhabiting these zones. This is exactly what is reported in Mt. Makiling, the nearest southern mountain mass to Manila (Payawal and Markgraf 1981; Buot and Osumi 2011). Diplodiscus populations of Mt. Makiling were reported to ascend to higher elevations. According to Payawal and Markgraf (1981), logging in the Mt. Makiling forests in 1940s could be one of the causal factors of this displacement. Whether this is beneficial or destructive to the entire forest and *lasang* landscape, remains to be a subject of investigation and scientific inquiry.

There is a need to protect and conserve the unique biodiversity and natural heritage in the forests of these *lasang* landscapes. The local government should play a lead role here in community awareness program and community based biodiversity and indigenous culture education drive. Village level ordinances may be more appropriate against activities leading to forest gap formation and eventual ecosystem degradation and collapse of ecosystem services.

3.5 Conclusions

The zonation pattern of woody biodiversity in the forests of the *lasang* landscapes of Mt. Akiki, Mt. Pulag and Mt. Mayon indicated the ascent of the lower altitude elements displacing the original species in the higher altitudes. There is a need to study whether climate change play a role on this or this is simply a case of succession as a response to disturbance. Extensive human activities such as tourism, agriculture and over-collection of resources tend to be the enabling factors sustaining the scenario. It is urgent to design a concerted local community action plan such as biocultural awareness drive and legislation to reawaken the *lasang* landscape inhabitants to adopt more harmonious and sustainable farming activities, hence, minimizing or putting a stop to the current destructive activities.

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Chapter 4
Role of the Oriental White Stork in Maintaining the Cultural Landscape in the Toyooka Basin, Japan

Kazuaki Naito, Naoki Kikuchi, and Yoshito Ohsako

Abstract To clarify the role of a reintroduced bird, which was once extinct in Japan, in the maintenance of the Japanese cultural landscape, we identified the distribution patterns of eco-friendly rice farming using the White Stork-Friendly Rice Farming Method, which was developed in the process of reintroducing the stork in the Toyooka Basin. The unique patterns reflect the biased distributions of paddy fields where the farming method is employed. In addition, some hotspots are evident in the basin. However, oriental white stork nesting sites were equitably distributed throughout the area. The role of this type of farming in maintenance of the Japanese cultural landscape is discussed from ecological and sociological viewpoints.

Keywords *Ciconia boyciana* • Ecosystem service • Paddy field • Reintroduction • Umbrella species

4.1 Introduction

The dominant landscape of Japan is the border zone between mountain foothills and arable flat land. This area, known as Satoyama, comprises paddy fields, rivers, and hills. The paddy fields not only provide food but also enhance biodiversity by providing habitat for fish, amphibians, and insects. Paddy fields are often situated in

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waterfowl flyways; they play a significant role in the conservation of waterfowl populations (Washitani 2007; Kurechi 2007). The importance of enhancing biodiversity in rice paddies was recognized in a resolution passed at the 2009 Ramsar Convention on Wetlands (Ramsar 2008).

Large and conspicuous animals are often identified as flagship or umbrella species to promote conservation of regional ecosystems (Caro and O'Doherty 1999; Roberge and Angelstam 2004). Because their habitats are usually very large, they may also include those of other, smaller species living in the same area. Umbrella species are often situated at the top of regional food webs, relying on diverse species as prey. The oriental white stork, *Ciconia boyciana* Swinhoe, originally native to China, Russia, Korea, and Japan, is an umbrella species that has been classified as endangered by the International Union for Conservation of Nature. In Japan, the native population of the oriental white stork became extinct in the wild in 1971. In this chapter, we describe the distribution pattern of a new farming method, eco-friendly rice farming, which was developed to support the reintroduction of oriental white storks in the Toyooka Basin. We clarify the role of this method in the maintenance of the cultural landscape in the area.

4.2 Conservation History of the Oriental White Stork in the Toyooka Basin

The oriental white stork, one of the largest birds in Japan, is threatened both domestically and globally. It is carnivorous and preys on various animals. At present, approximately 3,000 oriental white storks breed primarily at the boundary of China and Russia and spend the winter in southern China and Korea. Until the beginning of the Meiji Era (1868–1912), these storks could be found throughout Japan, particularly in the Toyooka Basin. Some remained in the basin year round. In the 1920s, the population of oriental white storks in and around the basin was estimated to be approximately a hundred (Ikeda 2000). Efforts were therefore made to maintain the stork population in and around the basin (Iwasa 1936a, b). However, due to a series of complex factors, the population began to decline during and after the Second World War. During the war, many trees were cut, destroying the nesting sites. After the war, the population was further threatened by the effects of agricultural chemicals, destruction of foraging habitat due to river improvement, and land consolidation for paddy fields. A continually diminishing population resulted in inbreeding depression, which further reduced the number. Despite conservation activities in the Toyooka Basin beginning in 1955, the breeding population of the basin finally died off in 1971, marking the extinction of the wild population of oriental white storks in Japan. In 1965, while the population was thinning, a captive breeding program was initiated in the Toyooka Basin. Despite long-term efforts, the program was not successful until 1989, when the first chick was hatched from a pair of storks introduced from Russia.

Fig. 4.1 Oriental white stork foraging in a paddy field where eco-friendly farming is employed in Toyooka, Hyogo Prefecture, Japan. Foraging in paddy fields is common especially in May and June when fields are flooded and the rice plants are still relatively short and uncrowded (Taken by Kazuaki Naito)

After the first successful captive breeding, the captive population steadily grew year by year and reached 100 individuals in 2002. Encouraged by this population growth, a reintroduction project was undertaken with the cooperation of various stakeholders in the local community. The first release of oriental white storks into the wild occurred in 2005, and by 2010, a total of 27 individuals had been released in the basin. Natural reproduction started in 2007 and the number of breeding pairs in the wild increased to seven in 2010. Thus, self-sustaining growth of the free-living population was established in the basin.

4.3 Paddy Fields as Habitat for the Oriental White Stork

According to the observations of the foraging behavior of wild and released storks in the Toyooka Basin, the oriental white stork forages in paddy fields, ditches, rivers, and marginal grassland (Naito and Ikeda 2007). Its characteristic foraging sites change seasonally. Storks forage in and around paddy fields in May and June when the water supply is sufficient and the rice plants are still short and uncrowded (Fig. 4.1). They feed on aquatic animals, such as dragonfly larva, diving beetles, frogs, tadpoles, and occasionally fish, if the ecological network includes them. During the summer, the storks primarily forage in the marginal grasslands adjacent to the paddy fields, where rice grasshoppers and other insects are abundant. After rice harvesting in early autumn, the storks often forage in dry paddy fields where grasshoppers and other insects can still be found. During the winter, they forage mainly in ditches along the paddy fields or in river shallows where fish or red swamp crawfish may be caught. Paddy fields and their surroundings are indispensable as foraging sites; they are heavily utilized throughout the year. Therefore, rice farming is crucial in maintaining the quality of the oriental white storks' habitat.

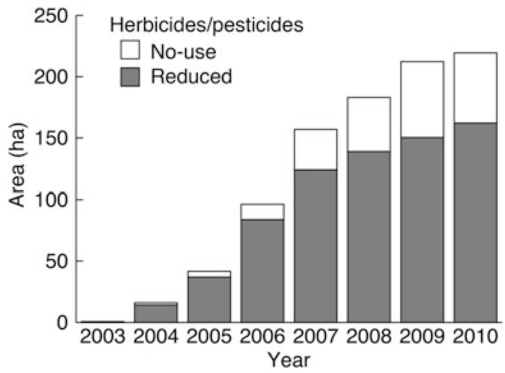

Fig. 4.2 Area of paddy fields in which the White Stork-Friendly Farming Method is employed (data from Toyooka City). This method has been employed since 2003 for eco-friendly rice farming in the Toyooka Basin to support the reintroduction of the oriental white stork while producing rice

4.4 Alternative Farming Practices for Conservation of the Paddy Ecosystem

A considerable portion of the Toyooka Basin is covered by paddy fields, mostly developed on the flood plain of the Maruyama River, which runs through the basin. From 1985 to 2010, the number of farm households in Toyooka City decreased continuously from 8,370 to 3,144 due to the aging of farmers and low price of rice. During the same period, the total area of paddy fields also decreased from 4,577 to 3,013 ha. Therefore, maintenance of paddy fields has emerged as an important aspect for the conservation of the landscape and biological diversity in this area. The same holds true for other regions in Japan.

The Toyooka Basin is located in the lower reaches of the Maruyama River and is almost at sea level. Because water from the river's tributaries concentrates at its bottom, the basin is often flooded. The risk of flooding and predominant humidity of the agricultural land prompted development of the land consolidation project, which started before the Second World War but speeded since 1960s. The project included elevating the paddy fields and separating the water supply and drainage systems, as well as enlarging the unit size of paddy field. The result was habitat degradation and a loss of aquatic animals in and around paddy fields. Previously, paddy fields were a good substitute for a natural flood plain that served as a suitable habitat for aquatic species. However, the land consolidation project resulted in drastic changes to the paddy ecosystem, and biodiversity was seriously compromised. In addition, the future of rice farming is insecure due to declining prices and retiring farmers. Thus, an alternative agricultural method is needed for both economic and ecological reasons.

To facilitate the restoration of foraging habitat for storks, an alternative organic rice cultivation system, the White Stork-Friendly Farming Method, was introduced in 2003, 2 years before the reintroduction of oriental white storks to the Toyooka Basin (Nishimura 2006; Naito and Ikeda 2007; Naito 2011). Use of this farming method has increased year by year, reaching 212 ha in 2010 (Fig. 4.2). This method, which involves both rice cultivation and provision of habitat for aquatic animals,

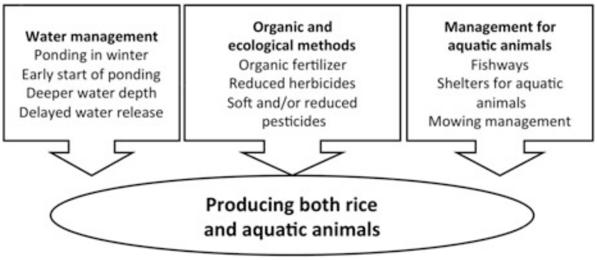

Fig. 4.3 Summarized criteria and concept of the White Stork-Friendly Farming Method (Source: Toyooka Agricultural Extension Center). The criteria were defined by the project team composed of members of the Toyooka Agricultural Extension Center and related municipal departments during 2002 and 2003

includes water management, utilization of organic materials, and wildlife conservation (Fig. 4.3). With this method, water remains in the paddy field for as long as possible. Ponding is initiated during early spring, and water release is delayed. These techniques are not employed in conventional rice farming; however, they are essential to the White Stork-Friendly Farming Method for weed control, to provide a nurturing environment for aquatic animals, and to promote biological diversity. This eco-friendly farming method reduces the application of herbicides and pesticides by 75–100 % compared with methods conventionally used for farming food rice and alternatively soft or low biological impact pesticides; organic fertilizers are selectively used. Habitat management for aquatic animals – the final step – is optional, but may include constructing fishways between paddy fields and ditches and a deep area at the corners or edges of paddy fields to provide shelter for aquatic animals during drying periods. Fishways restore the previously disconnected ecological network between paddy fields and ditches, enabling some fish species, such as catfish and crucian carp, to reproduce in paddy fields during the ponding season.

4.5 Effect of the White Stork-Friendly Farming Method

In 2010, we prepared a map of the paddy fields, in which the White Stork-Friendly Farming Method is employed, specifically where reduced chemical or chemical-free cultivation methods are being used to produce rice for human consumption or brewing sake (Japanese rice wine) in the Toyooka Basin. To emphasize the increased economic benefits of and reduced chemical load from this farming method, the map was converted to raster data with a resolution of 10 m. Subsequently, mean values for each 100-m area were calculated. The economic calculation was based on the actual selling prices of rice produced by this farming method (herbicides/pesticides-free or reduced herbicides/pesticides) and compared to those of rice produced by conventional farming. Yields for both conventional and organic

Table 4.1 The effects of eco-friendly rice farming

Rice type	Herbicides and pesticides	Price (yen/30 kg)	Yield decrease[a]	Ratio[b]	Area (ha)
Food rice	No-use	10,800	0.78	1.40	50
Food rice	Reduced	8,600	0.90	1.30	149
Rice for sake brewing	No-use	11,600	0.78	1.50	7
Rice for sake brewing	Reduced	9,100	0.90	1.37	14
Food rice	Conventional	6,000	1.00	1.00	3,013

[a]Yield decrease was estimated on the basis of the accounts of local farmers who employed the method

[b]Relative economic value of produced rice per area calculated as the price multiplied by the yield decrease

farming were estimated by farmers who employed the eco-friendly farming method (n = 30). The results are shown in Table 4.1. The reduction in herbicides/pesticides load according to the farming criteria was calculated assuming a 75 % reduction in agricultural chemicals for food rice, a 65 % reduction for sake-brewing rice, or herbicides/pesticides-free farming. A map of the decrease in chemical load was also created using the same procedures.

Unique patterns reflect the biased distributions of paddy fields where the White Stork-Friendly Farming Method is employed. In addition, some hotspots are evident in the Toyooka Basin. Areas of high economic return and low herbicides/ pesticides load are concentrated in particular regions (Figs. 4.4 and 4.5). The White Stork-Friendly Farming Method is intensively employed in particular villages, in which the decision to employ this type of farming is made. This pattern is preferable if the effect of biodiversity-friendly farming increases as the area that employs this farming method accumulates. Meanwhile, the paddy fields that employ the White Stork-Friendly Rice Farming Method are often situated near nesting sites, fostering the synergistic effects of stork conservation and rice farming. Expanding the area in which eco-friendly farming is employed will encourage regional biological diversity and allow expansion of habitat for free-living oriental white storks.

4.6 Distribution of Nesting Sites and White Stork-Friendly Paddy Fields

Before their extinction, the wild population of oriental white storks nested at the tops of large pine trees (*Pinus densiflora*). However, in recent decades, these pine trees have mostly disappeared because of pine wilt disease and successive changes in forest vegetation. Currently, natural nesting trees in the forests surrounding the Toyooka Basin are too few in number to support the reintroduced species.

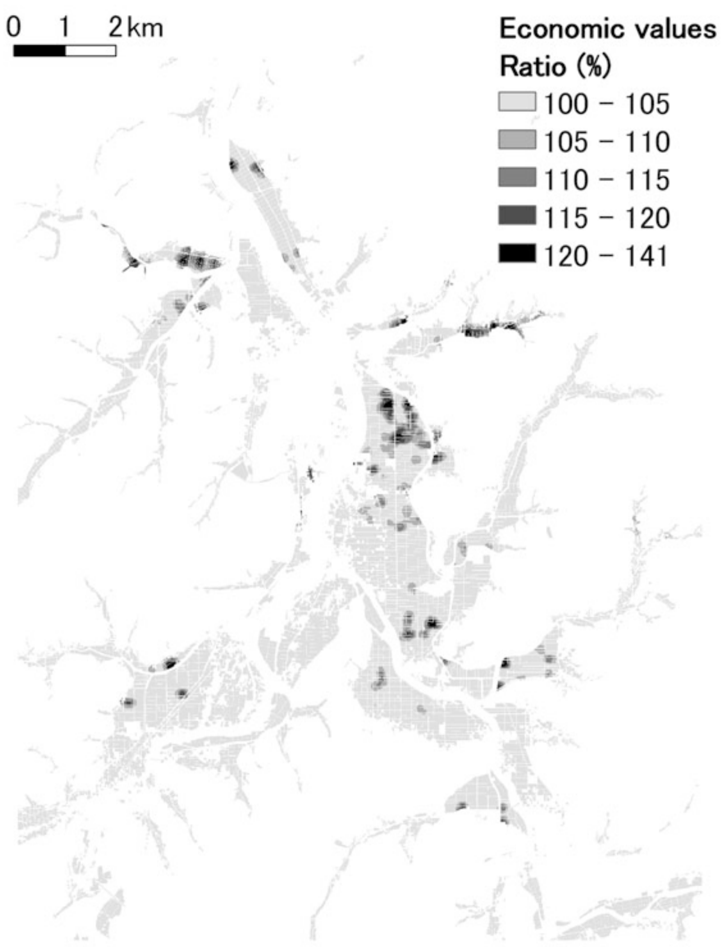

Fig. 4.4 Estimated economic benefit resulting from eco-friendly farming in the Toyooka Basin. The relative economic value compared to conventional farming is calculated on the basis of the distribution of eco-friendly/conventional farming, price of rice produced by each method, and estimated yield of rice using each method. Paddy fields with high economic value are concentrated in particular areas in the basin

Therefore, to ensure regeneration of the species, restoration of nesting sites is critical. Artificial nesting poles 10–12 m high, usually made of concrete with a mesh plate approximately 1.6 m in diameter affixed to the top, have been provided by local governments and associations (Fig. 4.6). The first artificial nesting pole was installed in 2002; additional poles were installed after 2006, and by 2010, 23 nesting poles had been placed (Naito 2011). Most are situated among paddy fields, particularly those in which the White Stork-Friendly Farming Method is employed, standing as symbolic monuments of the reintroduction project. By 2010, eight

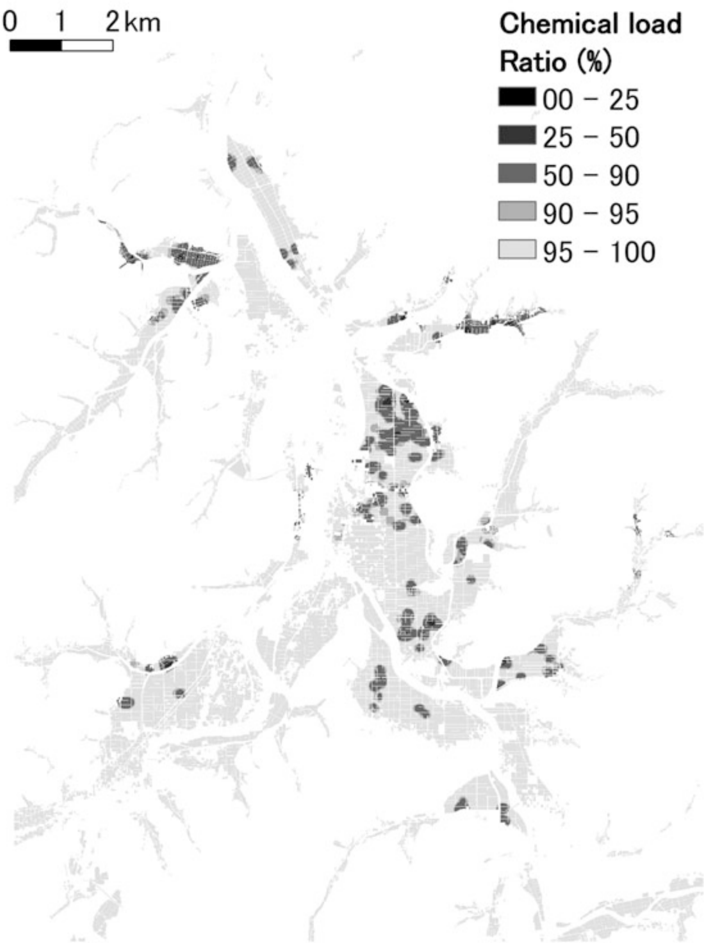

Fig. 4.5 Estimated decrease in herbicides/pesticides load resulting from eco-friendly farming in the Toyooka Basin. The relative herbicides/pesticides load compared to that of conventional farming is calculated on the basis of the distribution of eco-friendly/conventional farming. A marked reduction in herbicides and pesticides is observed due to eco-friendly farming

artificial nesting poles were in use by the released storks (Fig. 4.7). Four additional nesting sites were found: two on utility poles and two on the cages in which the captive storks were placed. At present, no natural trees are used for nesting in the reintroduced population of storks.

Oriental white storks nesting on artificial poles are now a common sight in the reintroduction project area. As the territory of a breeding pair of storks may extend for approximately 2 km from its nesting site, placement of the nesting poles was made with consideration of this territorial need.

Fig. 4.6 Oriental white stork nest on an artificial nesting pole among paddy fields in the Toyooka Basin (photo by Kazuaki Naito). The first chick in the population of reintroduced storks fledged from this nest in 2007

4.7 Discussion

As rice farming dates back more than 3,000 years in Japan, thousands of species, including various taxonomical groups, have formed seminatural communities in paddy fields (Hidaka 1998; Hidaka et al. 2008). As a top predator, the oriental white stork is a conspicuous species representing biological diversity in the paddy landscape; however, many species at lower trophic levels may also benefit directly from biodiversity-friendly rice farming. In general, the White Stork-Friendly Farming Method may be expected to have a good effect on the conservation of a wide variety of species in landscapes that include rice paddies due to effective water management and the reduction or elimination of agricultural chemicals.

For farmers, the relatively high price obtained from agricultural products cultivated using this method is an indispensable incentive to commence or continue eco-friendly farming, especially given the steady decline in consumer price of conventionally-produced rice. Therefore, this type of farming has the potential to protect paddy fields from being repurposed or abandoned. In addition to providing economic advantages and an incentive to continue rice farming, the presence of these storks reinforces the historical importance of the Satoyama (Kikuchi 2010). Therefore, storks have a significant role to play in the promotion of sustainable agriculture and conservation of the cultural landscape.

Interviews with 30 farmers who employed the White Stork-Friendly Farming Method in 2012 revealed three common themes related to the introduction of this eco-friendly farming method (Kikuchi 2012): increased stability of agricultural management, strengthening of relationships between consumers and farmers, and a noticeable increase in biodiversity in and around paddy fields accompanied by an emerging awareness of the spiritual relationships between living things and ourselves. Approximately 70 % of the farmers felt that the number of living things had increased after the implementation of the new farming method. All farmers interviewed wished to continue with the new farming method because it resulted in higher prices for their rice, maintained biological diversity, and strengthened relationships among people.

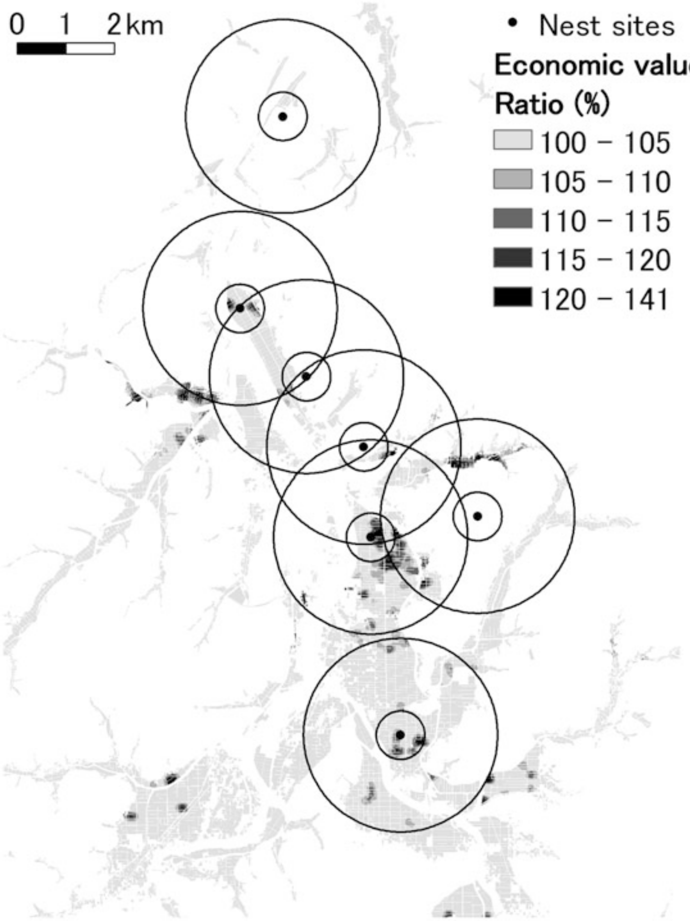

Fig. 4.7 Map of nesting sites of oriental white storks in 2010 overlaid on a map of economic benefit (see Fig. 4.4). Seven pairs of storks bred in 2010 in the Toyooka Basin. The territory of each pair is indicated by circles (minimum 500 m from the nest and maximum 2,000 m). Paddy fields with higher economic value occupy a considerable area where eco-friendly farming is employed within the territories of breeding pairs

Use of the White Stork-Friendly Farming Method, a biodiversity-friendly farming method with consistent economic benefits, has been steadily increasing and expanding to new areas. However, this situation may not be sustainable in the long term for various reasons, including the commercial price of rice, the progressive aging of farmers, and competition from other biodiversity-friendly agricultural products. In addition, some social factors make the future of this type of farming uncertain. For example, a decline in the price of rice may compromise the effects of the White Stork-Friendly Farming Method, whereas higher economic returns encourage farmers to produce organic rice. Because most farmers employing this method operate relatively large commercial enterprises, the economic benefit is more significant to them than it is to small-scale, part-time farmers. Second, considerable time and money must be invested in order to implement this method. Thus, it may be less attractive to older farmers. Finally, the expansion of organic farming may be limited to large-scale, full-time farmers. Part-time farmers tend to consume their rice within their own families. Consequently, the economic incentive is reduced because the White Stork-Friendly Farming Method requires more time and labor than conventional rice farming.

Recently, a new branding of agricultural products emphasizing peaceful coexistence between humans and other living things has attracted attention and is gradually expanding in Japan. This organic farming movement is associated with species that live in rural areas and symbolize safe food, including the bean goose, Japanese crested ibis, and oriental white stork. The associated fish and insect species include the Japanese rice fish, crucian carp, predaceous diving beetle, and giant water bug. Recently, the Ministry of Agriculture, Forestry, and Fisheries has been encouraging the activities for animal or plant friendly farming which are usually characterized by unique package designs for agricultural products using typical animals or plants living in the region (living thing marks) to promote public understanding of projects that contribute to the conservation of nature and familiar living things and to promote Japan's national biodiversity strategy.

4.8 Conclusions

Paddy fields in Japan not only provide food but also enhance biodiversity by providing habitat for fish, amphibians, and insects. They play a significant role in waterfowl flyways and the conservation of waterfowl populations. However, the sustainability of paddy farming is precarious because of the aging population of farmers and the low price of rice. In this chapter, we described the role of reintroduced oriental white storks in encouraging eco-friendly rice farming, the economic value of agricultural products obtained from use of this farming method, and the reduced load of agricultural chemicals in maintenance of the cultural landscape in the rural area of the Toyooka Basin. This umbrella species contributes to the conservation of the cultural landscape and encourages economically sustainable agriculture.

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Chapter 5
Developing Integrated Methods for Biological Conservation and Sustainable Production in Agricultural Landscapes

Yunhui Liu, Guishen Zhao, and Zhenrong Yu

Abstract As one of the most dominated landscapes in the global terrestrial area, the agricultural landscape contributes greatly to global biodiversity conservation while providing essential food products. However, in the last few decades intensive agricultural production has driven the dramatic loss of biodiversity providing various ecological services critical to sustainable food production. Land sparing and land sharing approaches, two hotly debated measures to reconcile biodiversity conservation and food security to face the challenge of feeding nine billion people, all fail to consider real world complexity and provide limited solutions. We propose that knowledge and technologies including landscape assessment and planning, sustainable intensive or ecologically intensive agricultural practices, elaborate ecological design at different scales, ecological engineering and biotechnology, should be integrated as a more robust solution. Meanwhile, more incentives and innovative policies for sustainability – with the consideration of social, economic and cultural agents in the biocultural landscape – should also be combined to ensure the efficient and proper application of the above mentioned knowledge and technology to achieve the aim of food security without compromising biodiversity and sustainability.

Keywords Biodiversity • Food security • Landscape assessment and planning • Ecological design • Ecological engineering • Biotechnology • Biocultural agents

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5.1 Introduction

The importance of biological diversity for human society and agricultural production has been widely concerned since the last century (Tilman and Downing 1994; MEA 2005; Klein et al. 2007; Tscharntke et al. 2007). Except for providing materials essential for human survival, various ecosystem services associated with biological diversity are all crucial to the sustainability of agriculture. Unfortunately, habitat loss and fragmentation combined with the application of chemicals induced by the expansion and intensification of modern agriculture have become the major driver of biodiversity loss and also have been greatly detrimental to biodiversity-associated ecological services in the agricultural landscape (Matson et al. 1997; Tilman et al. 2001; Norris 2008). Considering the increasing global demand for agricultural products in the coming decades (UN Millennium Project 2005; Godfray et al. 2010), the conflict between agricultural production and biological conservation should be reconciled to ensure the above mentioned prerequisites for both human sustenance and agricultural development. In the last decades, considerable effort has been made to explore solutions for balancing biological conservation and agricultural yield (Pain and Pienkowski 1997; Gurr et al. 2003; Kleijn and Sutherland 2003; Bengtsson et al. 2005; Harvey et al. 2008), however, these proposed measures are all segregated approaches, which consider or emphasize one or several aspects of the conflict. In this paper, we will urge that a more integrated measure combining knowledge from biological technology, farming management, ecological engineering, landscape management, etc., should be developed to promote both sustainable agricultural production and biological conservation in the intensively managed agro-landscape.

5.2 Biodiversity, Agriculture and Food Security

5.2.1 Agriculture, Biodiversity Loss and Global Food Security

Land use for agricultural production is a major driver for global endangerment (Scharlemann et al. 2005; Norris 2008). The threats of agricultural production to biodiversity come from both the local and landscape levels. At the local scale, agricultural chemicals can kill organisms directly or when the chemicals enter the environment (Richter et al. 1997). In addition, uncontrolled application of one or several high yield varieties has resulted in dramatic loss of genetic diversity (Thrupp 2000). As monoculture became increasingly common, crops became more vulnerable to pests and diseases than in traditional intercropping or rotational systems. This in turn required more use of chemicals and thus caused a further threat to organisms. Meanwhile, machine-driven practices, such as more frequent plowing, can destroy organisms either directly or by changing the physical condition of their habitats.

At the landscape level, landscape change, including habitat loss and land fragmentation, exerts important impacts on both the composition and distribution of biodiversity (Turner et al. 2001). Habitat loss caused by converting pristine and natural habitats to cropland is reported to be even more destructive than other threats such as pollution and overexploitation (Wilcove et al. 1998). Habitat fragmentation was suggested to pose an important additional threat to biodiversity as well (Piessens et al. 2005; Strantford and Robinson 2005). For instance, biodiversity, the rates of both predation and parasitism were affected by fragmentation, thus causing the release of insects from predator control (Kruess and Tscharntke 1994). Considerable evidence has also indicated that landscape fragmentation disrupts plant–pollinator mutualisms (Harris and Johnson 2004).

Ironically, biodiversity loss caused by high-yield-oriented agricultural production in turn hampers sustainable development of agriculture and results in food insecurity. In general, greater diversity relates to greater productivity in plant communities, greater nutrient recycling in ecosystems and greater ecosystem stability. The loss of biodiversity can lead to lower productivity. For example, grassland field experiments across different regions have shown that each halving of the number of plant species within a plot leads to a 10–20 % loss of productivity (Hector et al. 1999), and the average plot containing one plant species is less productive than the average plot containing 24–32 species (Tilman et al. 1996, 1997). It was estimated that global grassland is 20–35 % under degradation globally (FAO 2009a), which is detrimental to the livelihood and food security of people, especially the poor in rural areas. In addition, biodiversity loss is detrimental to biodiversity associated with ecosystem services, such as pest control, pollination, nutrient cycling, etc., which further undermines agricultural productivity. For example, it was estimated that the yields of some fruits, seeds and nut crops would decrease by more than 90 % without pollinators (Southwick and Southwick 1992).

5.2.2 *Agriculture and Biodiversity Retention*

Despite all the above mentioned agriculturally negative effects on biodiversity, agricultural use of land does not necessarily mean loss of diversity, and the role of agricultural land for biodiversity has been widely underestimated (Tscharntke et al. 2005). Accounting for more than 40 % of global terrestrial area, agricultural land is actually one of the most important habitats for much of the world's biodiversity (Pimental et al. 1992). It was estimated that more than half of all species exist principally in the agricultural landscape instead of protected areas (Blann 2006). For example, traditional rice fields in China serve as an important habitat providing food sources for Asian crested ibis (Nipponia Nippon), an International Union for Conservation of Nature (IUCN) Red List endangered species.

Meanwhile, agroforestry and low intensity agriculture were also important for biodiversity retention. As an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock, agro-forestry sustains a high diversity of species itself and/or provides diverse niches or food for organisms (Wunderle 1998). Low-intensity Tonle Sap grasslands in Cambodia support important concentrations of threatened bird species, including the largest global population of Bengal Florican (Houbaropsis bengalensis), an IUCN Red List critically endangered species (Gray et al. 2007). In addition, some traditional diverse planting systems can be thought as efficient on-farm conservation methods (Zhu et al. 2003). For instance, in the Hani ecosystem of Yunnan province in southwest China, more than 48 rice of 198 rice varieties are still preserved in the system by mixed-variety planting (FAO 2012).

5.3 Reconcile Biodiversity Conservation and Food Production

It is estimated the global population will reach about nine billion by 2050 (World Population Prospects 1999) and therefore 70–100 % more food will be required (Godfray et al. 2010). To meet this increasing food demand with current methods, another one billion hectares of natural habitat would need to be converted to agricultural production primarily in the developing world, which harbors most of diverse species in the world, indicating more threatens to biodiversity (Tilman et al. 2001). On the other hand, the increased demand for ecosystem services calls for more effective conservation of biodiversity (Jackson et al. 2005; Scherr and McNeely 2008). Therefore, it is necessary to take measures to reconcile the conflict between food production and biodiversity conservation.

5.3.1 Land Sharing and Land Sparing: Benefits and Limitations

Two approaches – land sparing and land sharing – have been widely discussed as potential strategies to reconcile biodiversity conservation and food production (Balmford et al. 2005; Green et al. 2005; Fischer et al. 2008; Norris 2008; Phalan et al. 2011).

5.3.1.1 Land Sparing

Land sparing consists of separating land for conservation from cropland, with high-yield farming facilitating the protection of remaining natural habitats from agricultural expansion (Green et al. 2005; Fischer et al. 2008; Gabriel et al. 2010; Hodgson et al. 2010; Fischer et al. 2011; Phalan et al. 2011). Biodiversity in such landscapes is largely restricted to natural reserves that are intentionally set aside from agriculture. High yield food production is achieved through high resource inputs on limited lands to prevent the negative effects of arable land expansion, while drastically reducing negative effects on the environment per unit of product.

However, land spared from farming does not mean it is spared for biodiversity conservation (Matson and Vitousekp 2006). Intensive agricultural production might affect much more land and water (e.g. regions downwind or downstream) than they actually incorporate (Matson et al. 1997; Tilman et al. 2002; Hautier et al. 2009). Also, intensive agricultural management proposed by the land sparing approach is likely to result in substantial loss of species due to its intensification especially in landscapes with naturally high species turnover (Fischer et al. 2008). In addition, industrially intensive production does not necessarily result in high yield. In the low productivity environment, industrially intensive production can cause serious environmental degradation rather than sustainable high output, and land sparing may not be desirable for both high yield and biodiversity in such areas (Dorrough et al. 2007). Finally, the land sparing approach actually ignores the crucial ecosystem services associated with biodiversity that are essential to ensure the sustainability of agricultural production (Tscharntke et al. 2012a).

5.3.1.2 Land Sharing

Land sharing, or so-called wildlife friendly farming, emphasizes integrating biodiversity conservation and food production on the same land by using wildlife-friendly farming practices (Green et al. 2005; Fischer et al. 2008; Perfecto and Vandermeer 2008; Gabriel et al. 2009). When the land sharing strategy has been applied, natural or semi-natural habitats were scattered throughout the landscape, and farmed land had a complex structure similar to native vegetation (Luck and Daily 2003; Fischer et al. 2006). Biodiversity in these agricultural systems can avoid negative environmental effects due to its much lower resource input, which fosters ecological services and may also assist in the re-assembly of ecological communities in response to climate change (Fischer et al. 2008).

However, several limitations are related to the land sharing approach. On one hand, land sharing methods always tend to produce lower yields and are rarely as biologically valuable as intact natural habitat. For example, a recent comprehensive analysis indicated that organic farming (a system producing food with minimal harm to the ecosystem) is typically less productive than conventional farming systems (Seufert et al. 2012). On the other hand, the effectiveness of wildlife friendly farming, such as conversion from conventional to organic farming or the creation of crop field boundaries, could depend on landscape complexity at larger scales (Kleijn et al. 2006; Batáry et al. 2011). Application of wildlife friendly farming could sometimes achieve limited success in either cleared or complex landscapes (Tscharntke et al. 2005). Finally, the adoption of land sharing methods requires more land to be converted in order to produce the same agricultural output and then results in additional biodiversity loss.

5.3.2 Real World Complexity Calls for Improved Strategies to Reconcile Biodiversity Conservation and Food Security

In addition to the above mentioned inherent limitations, real world complexity has shown that both land sharing and land sparing approaches have been insufficient to reconcile biodiversity conservation and food production (Brussaard et al. 2010; Godfray et al. 2010; Tscharntke et al. 2012a).

Firstly, the application of both land sharing and land sparing approaches have been all context-specific (Fischer et al. 2008). Intensified industrial production, which requires mechanism management, tends to occur in flat landscapes, while low-intensity agriculture, mainly relying on manual practices, is more likely present in rugged and mountainous landscapes where mechanism practices are limited by the landforms (Fischer et al. 2008). Secondly, food shortages are, in fact, a regional problem for developing countries. Most of the increased food for hunger elimination should be grown domestically in the developing country where biodiversity and food shortages coexist due to political or economical reasons (McCalla 2000; Scherr and McNeely 2008). In developing countries with hunger and poverty, lower-productivity lands (drylands, hillsides and rainforests) account for more than two-thirds of total agricultural land (Nelson et al. 1997), and small land holders rather than the large-sale commercial farmers produce most of the food products, and act as the actual backbone of food security in developing countries (World Bank 2008; Tscharntke et al. 2012a). Intensive agricultural production proposed by the land sparing approach is not likely to be sustainable in such areas. Even in the regions where the overall landscape conditions are favorable for intensive industrial production (such as soil fertility, topography, etc.), the high yield achieved by intensive industrial production produces high environmental costs that would not be likely to continue in the future. For example, intensified agriculture in the past decades has greatly contributed to increased food production in China but brings a series of negative environmental consequences such as water pollution, soil degradation and water shortages (Zhu and Chen 2002; Wang et al. 2009; Guo et al. 2010), which are becoming bottlenecks to food production in the region.

The land sharing approach, on the other hand, could be thought of as a developing-world conservation paradigm to a certain extent (Wright et al. 2012). Reintroducing or mimicking low-impact practices to sustain the conservation value of the heterogonous landscape mosaic is the dominant paradigm in European countries (Sutherland and Hill 1995; Bignal and McCracken 2000), by providing farmers with large amounts of financial compensation for lost production (Green et al. 2005). In developing countries, the semi-natural habitat approach has been rarely applied (Wright et al. 2012), and traditional wildlife friendly production has been experiencing a dramatic transformation to intensive industrial production to seek greater yields since the "green revolution" in the last century. Labor shortages in rural areas has accompanied the rapid urbanization in developing countries that also encourages more intensive chemical and mechanism-dependent agricultural production instead of traditional labor-dependent wildlife-friendly production (ISIS 2006).

Poor agricultural techniques, especially poor economizing and recycling techniques, have contributed to lower productivity or greater environmental costs (with higher productivity) in developing countries. In African countries, low adoption of modern agricultural production technologies amongst farmers in Ghana was one of the main reasons for low agricultural productivity in the region (Akudugu et al. 2012). In China, nitrogen application in some regions is extraordinarily high, but decreased nitrogen-use efficiency has caused a series of negative environmental impacts (Zhang et al. 1996; Zhu and Chen 2002; Ju et al. 2006; Guo et al. 2010), however the same crop yield could be actually achieved with significantly reduced amounts of nitrogen fertilizer (Ju et al. 2009).

5.4 Developing an Integrated Approach to Reconcile Biodiversity and Food Security

Both land sharing and land sparing approaches provide a partial but not perfect solution for balancing biodiversity and food production. Biodiversity conservation and increased yield should be achieved based on more robust, eco-efficient ways. Methods including landscape assessment, landscape planning, ecological design, ecological engineering, biotechnology, and intensive but resource-conserving or eco-efficient agriculture should be integrated to achieve the balance between biodiversity conservation and food security.

5.4.1 Landscape Assessment and Planning

The status of resources, suitability and ecological risks in the agricultural landscape should be well recognized before developing a sustainable strategy to improve biodiversity conservation and crop yield (Fig. 5.1). Landscape assessment is a process to identify the key areas needing protection in the landscape, the land-use suitability for agricultural production and the potential for yield increase. Landscape assessment also evaluates existing and potential threats of agricultural practices on biodiversity and associated ecological services. Based on this information, landscape planning to reconcile biodiversity conservation and yield increase can be undertaken, not only including regional land-use allocation (such as the area,

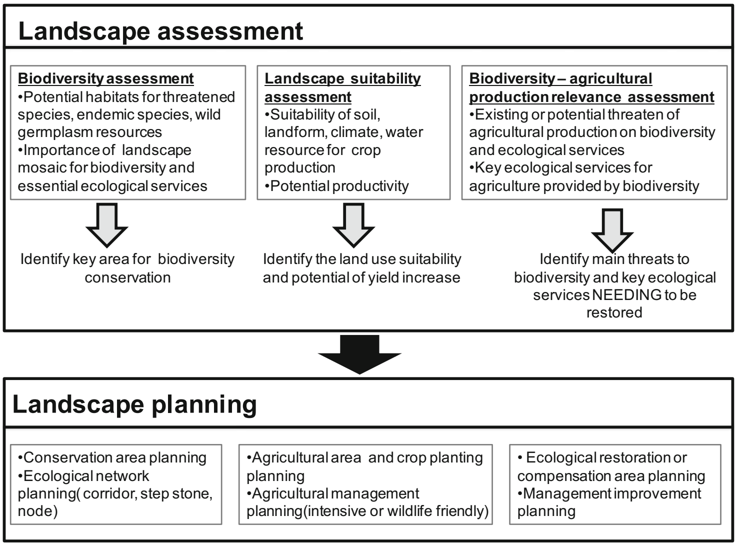

Fig. 5.1 Process and contents of landscape assessment and landscape planning for reconciling biodiversity conservation and food production in agricultural landscapes

location and spatial configuration of the conservation area, production area, ecological restoration area and ecological networks) (Smith et al. 2013), but also with planning for agricultural management and management improvement. In some circumstances, adjusting the planning of crops according to resource availability is essential. For example, wheat/maize intercropping was not encouraged in recent years in some regions of Gansu province in northwest China, due to the water shortage. Areas of cereal crops should be well planned to ensure food security, as cereal crops would be replaced by more profitable cash crops, such as biofuel crops (Dong 2007). Furthermore, agricultural management planning should provide guidelines for regional optimized crop management, including guidelines for fertilization, irrigation, tillage, etc. based on crop needs, soil nutrient availability, water resource availability, climate characteristics, topographical and geographical location (such as slope or location in the watershed), etc. (Lilburne et al. 1998; Sharpley et al. 2003; Lu et al. 2012).

5.4.2 *Developing Sustainable Intensive Agriculture or Ecological Intensive Agriculture*

Generally, as proposed by land sharing or land sparing approaches, agriculture presents two common modes, either intensive industrial management or traditional management. Intensive industrial management should be transformed to sustainable intensive agriculture (Matson et al. 1997; Tilman et al. 2002; Godfray et al. 2010) to reconcile the requirements of high yield and natural conservation. This means inputs in intensive agriculture, including water, chemical nitrogen and pesticides, must be used in more efficient ways within the agricultural landscape to prevent losses of these inputs from reducing the capacity of downwind or downstream ecosystems to support biological diversity (Tilman et al. 2002; Day et al. 2008). Research has indicated that producing more or the same foods from the same area while reducing the environmental impacts can be achieved by using existing technologies (Ju et al. 2009; Chen et al. 2010). For example, precision agriculture, which allows the application of water, nutrients and pesticides only to the places and at the times they are required (thereby optimizing the use of these inputs), could potentially reduce the negative effects of agricultural production on biodiversity (Day et al. 2008; Gebbers and Adamchuk 2010). In addition, ecological services associated with biodiversity will be considered in the sustainable intensified landscape. At least a minimum surface area of 5 % of farmlands should be kept as ecological infrastructure (Boller et al. 2004). Low intensity agriculture lands, especially those with greater economic value like orchards or agroforestry, can serve as ecological infrastructure (Boller et al. 2004) and also provide farmers with increased income. Furthermore, sustainable intensive agriculture should also be based on a careful, planned and prudent use of resources in order to enable our future generations to know and share these resources.

Traditional wildlife friendly practices, on the other hand, could be updated to become ecologically intensified agriculture. According to the recent definition by the Food and Agriculture Organization (FAO) (2009b), "ecological intensification" within the framework of organic agriculture is "maximization of primary production per unit area without compromising the ability of the system to sustain its productive capacity." Ecologically intensified agriculture does not mean the semi-natural habitat approach (Wright et al. 2012) or traditional production free of chemical input only, but includes elaborate ecological designation and ecological engineering approaches to achieve maximized output with little input per unit area. The core of ecologically intensified agriculture is to intensively harness the natural functionalities of ecosystems by using biological mechanisms to replace chemicals or using physical inputs without external costs including environmental costs in particular (Doré et al. 2011).

5.4.3 Ecological Design

Ecological design is "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes" (van der Ryn and Cowan 1996). The key points for ecological design are to meet the inherent needs of humans and their economy by sustaining the integrity of the structure and function of both natural and managed ecosystems, mimicking nature in agricultural systems; encouraging renewable resources; recycling, reusing and efficiently using materials and energy; and conserving natural ecosystems and indigenous biodiversity at viable levels (Shu-Yang and Freedman 2004). In the context of reconciling biodiversity and food production, three levels of ecological designation should be considered, including biological-relationship design at the community or sub-community level, circulation-system design at the ecosystem level and landscape design at the landscape level (Luo 2008).

5.4.3.1 Biological Relationship Design

Biological relationship design is aimed at improving efficiency of resource utilization (light, temperature, water, nutrients and land) and decreasing dependence on the use of large quantities of agrochemicals and the consumption of fossil fuel energy by elaborately selecting crops and/or animals coexisting in the agro-ecosystem. Four basic models of interspecies relationships could be designed:

1. Design of complementary ecological niches and phenology for plants to save land or utilize resources efficiently. Configuration of species according to ecological niche and phenology is an efficient way of facilitating access to complementary resources including land, soil, water and nutrients, as well as light, temperature, etc. For example, intercropping crops with tree seedlings or fruit seedlings is an efficient way to utilize land, temperature and sunlight.
2. Design of rhizosphere-process-based plant interactions. Rhizosphere processes among plant combinations may help to increase the performance of intercropped species; one or both species may facilitate access to nutrient resources that are less available to the associated cultivated species. A well known example is that legumes can provide other species with large quantities of nitrogen through their dead roots or nodules. On low-phosphorus but high-nitrogen land in northwest China, maize (*Zea mays* L.)/faba bean (*Vicia faba* L.) intercropping reported a 43 % yield increase as maize can uptake more phosphorus when mobilized by the acidification of the rhizosphere via faba-bean-root release of organic acids and protons (Li et al. 2007).
3. Design of plant – animal synergies for high production, pest control and weed control. Integrating crop planting with fish or poultry husbandry is not only a good way of saving land but also potentially encourages synergies among species for greater efficiency in nutrient utilization, pest control, etc. For example, in the rice–fish system, which has been maintained for over 1,200 years in south China and recently designated as a "globally important agricultural heritage system," fish reduce rice pests and rice favors fish by moderating the water environment. The synergy between fish and rice has enabled rice–fish cultivation to use 68 % less pesticide and 24 % less chemical fertilizer than rice monoculture because fish reduces rice pests and the complementary use of nitrogen between rice and fish in rice–fish systems results in low nitrogen fertilizer application and low nitrogen release into the environment (Xie et al. 2011). In addition, better ecosystem stability (yield) was also observed (Xie et al. 2011), and greater

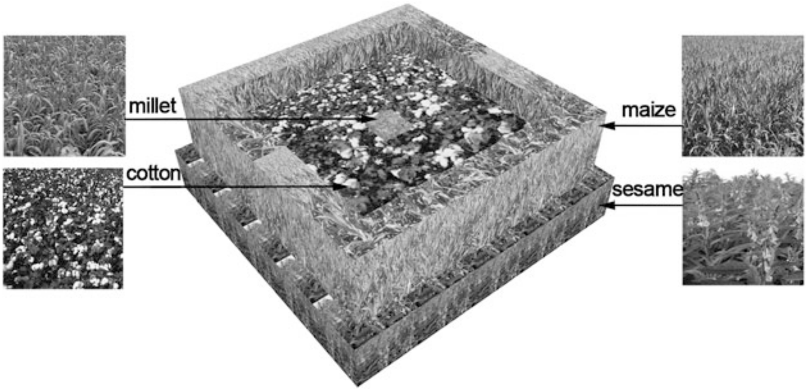

Fig. 5.2 An example of plant configuration design for pest control in cotton fields, Hebei province, China (Source: Jing Wang)

output (fish and rice) can be achieved with almost the same or less input (water, land, fertilizer) as a rice monoculture.

4. Design of spatial or temporal plant configurations for control of pests, weeds and diseases. A selective spatial or temporal plant configuration can serve as an effective way for pest and disease control in fields. Potential mechanisms include that the companion plant could (1) improve the availability of alternative foods such as nectar, pollen and honeydew; (2) provide shelter, food or a moderated microclimate favoring natural enemies or (3) provide alternative hosts or prey (Landis et al. 2000). In addition, allelopathy among organisms can be employed for managing weeds, insect pests and diseases in field crops (Farooq et al. 2011). For example, integration of smothering allelopathic crops such as pearl millet (*Pennisetum glaucum* L.), maize and sorghum in a rice–wheat cropping system, grown after harvesting wheat (*Triticum aestivum* L.) and before rice transplantation, offers effective weed control for the upcoming rice crop in Asia (Peters et al. 2003). Figure 5.2 presents a special crop configuration for cotton pest control, which has enabled constant production for 10 years without application of chemical fertilizer or pesticides even in a year of pest outbreak in Hebei province, China. In this cotton field, sesame was planted in the surrounding to draw aphids from the cotton, while maize surrounding the cotton serves as a trap crop for Lepidoptera pests; Millet in the center of the cotton field, on the other hand, attracts birds to helpful with control Lepidoptera pests.

5.4.3.2 Design of Integrated Planting/Animal-Farming Cycling System

An integrated cropping/animal-farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. Different from diversified systems, which consist of

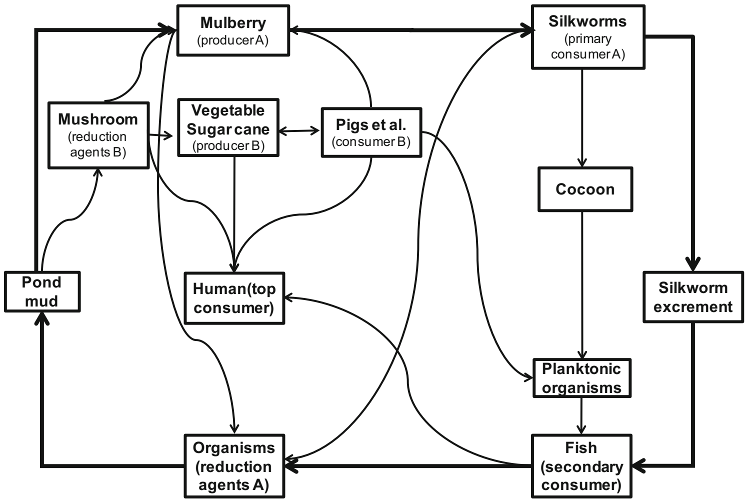

Fig. 5.3 Nutrient cycling in the dike–pond system in the Pearl River (Zhujiang) Delta, China

independently coexisting diversities of crops and livestock, integrated planting/animal systems create synergic interaction among plants (crops) and livestock, with recycling allowing the maximum use of available resources.

In an integrated planting/animal system, crop residues can be used for animal feed, while animal and animal by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, thus reducing the use of chemical fertilizers. A successful design of integrated planting/husbandry depends on sufficient knowledge input as management decisions related to any one component of the organic resources (animal/land/crop cycle) may affect the others. Specifically, technology input for improving intake and digestibility of crop residues is essential. Crop residues and manure nutrients should be applied properly and efficiently to avoid soil degradation and costs for production and transportation or even surpluses lost in the environment. A good example of the integrated cropping/animal-farming system is dike-pond system (Fig. 5.3). In this system, various species of fish living at different water depths are raised in the ponds, while mulberry, vegetables or sugar-cane was is planted on the dikes. The mulberry is used for silkworm production; while vegetables and sugarcane are used for direct human consumption. Pond mud is used as a fertilizer for both crops on the dike and for mushrooms that are cultivated on the floor of the silkworm sheds in winter when silkworm production ceases. After harvesting the mushrooms, the mud-bed is used to fertilize vegetables, crops and trees. Furthermore, pigs, chickens and ducks are reared on the dikes to provide further manure to fertilize the fish ponds and to encourage the growth of planktonic organisms as fish food. Many dyke dike crops are furthermore fed directly to the fish or livestock.

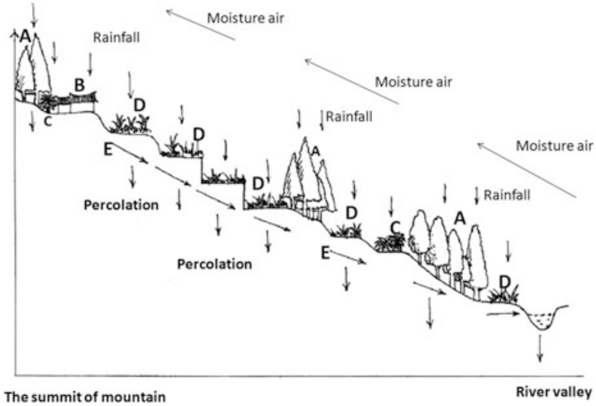

Fig. 5.4 The vertical distribution of the forest/village/terrace/river ecological landscape in Hani, Yunnan province, China. (**a**) Forest; (**b**) village; (**c**) dry land; (**d**) water terrace; (**e**) surface runoff and spring flow carrying nutrients (Adopted and modified from FAO 2012)

5.4.3.3 Landscape Design

Traditionally, landscape design mainly referred to landscape architecture and garden design. As pattern–process-relationship research developed in the landscape ecology discipline, the composition and configuration of landscape elements at larger scales have been widely recognized having significant effects on ecological processes (including organism processes) and ecological functions in the last decades. Artificial adjustment of the amount, composition and configuration of landscape components can be potential measures to improve ecological processes and ecological functions. For example, the establishment of corridors can serve as effective measures to ensure the migration and communication of populations in a landscape. Windbreaks, which provide shade and shelter, have long been used as tools to create a more benign and productive microclimate. Riparian buffers can prevent the loss of agricultural nitrogen or phosphorus from water bodies, etc. Dramstad et al. (1996) give some principles to direct the design of patches, edges, boundaries, corridors and mosaics to encourage sustainable design, which ties together land, water, wildlife and people. More guidelines of landscape design should be developed according to the site specific context.

There are many examples proving that elaborate landscape design can achieve a long-term harmonious relationship between humans and nature. A very creative landscape design is the Hani terraced paddy fields at the Honghe River, Yunnan province, China. In this special forest/village/rice terrace/river landscape, villages are built on mountain sides, with natural forests and rice terraces located just above and below the villages, respectively, with the river flowing on the valley floor. The forest has played an important role in sustaining abundant water supplies for the system over thousands of years and also supporting diverse flora and fauna (Fig. 5.4). By taking the geographical advantage, a method of "fertilization of rice fields with hydropower" has been developed, with manure, cleaned dung and humus being washed into the terraced fields through irrigation ditches or natural precipitation (FAO 2012). A complex series of rice-based agricultural systems has been developed, including combinations of rice–duckweed, rice–lotus, rice–fish and rice–duck (Yao and Cui 2006) and diverse rice varieties have been planted, with 195 varieties of local rice historically used, of which 48 varieties are currently still planted (FAO 2012). The spatial structure of the Hani terrace performs various ecological functions, including soil and water conservation, control of soil erosion, village safety, maintenance of system stability and self-purification capacity, while the diverse planting ensures sustainable production for hundreds of years with little occurrence of pests and diseases.

5.4.4 Ecological Engineering

Ecological engineering was originally attributed to "those cases in which the energy supplied by man is small relative to the natural sources, but sufficient to produce large effects in the resulting patterns and processes" (Odum 1962), and was redefined more widely as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch and Jorgensen 2004), and recently was proposed to be broadened including both "practical ecological engineering" and "scientific ecological engineering" (Gosselin 2008). Basically, ecological engineering can be thought of as an incorporation of engineering techniques with ecological knowledge to benefit both the natural environment and human society. In the context of reconciling biodiversity and food production, it is the measures and technologies that enable the above discussed landscape planning and ecological designs to be put into practice, including not only measures and technologies to restore biodiversity and ecosystem services, alleviate environmental pollution and promote effective resource utilization, but also to develop new sustainable ecosystems with both human and ecological value (Mitsch and Jørgensen 2003). Potential ecological engineering approaches to reconcile biodiversity and food production include:

1. Ecosystem construction engineering. For example, a constructed wetland can be established to treat agricultural non-point pollution (Braskerud 2002).
2. Ecosystem restoration. Ecological restoration is an important measure to reverse human-induced environmental degradation, and it is especially widely implemented to improve biodiversity restoration all over the world (Benayas et al. 2009). Ecological restoration has also been successfully applied to reform natural infertile land. For example, in the 1970s, successful engineering measures were applied to reduce the high level of soil salinity in one of the most important cereal production areas in China – the North China Plain – (Xin and Li 1990) and greatly increase wheat yield in the region (Zhang 2011) (Fig. 5.5).
3. Habitat manipulation for pest control (Gurr et al. 2004). This approach includes a series of environmental manipulations to provide natural enemies with the necessary resources (such as supplementary and complementary food,

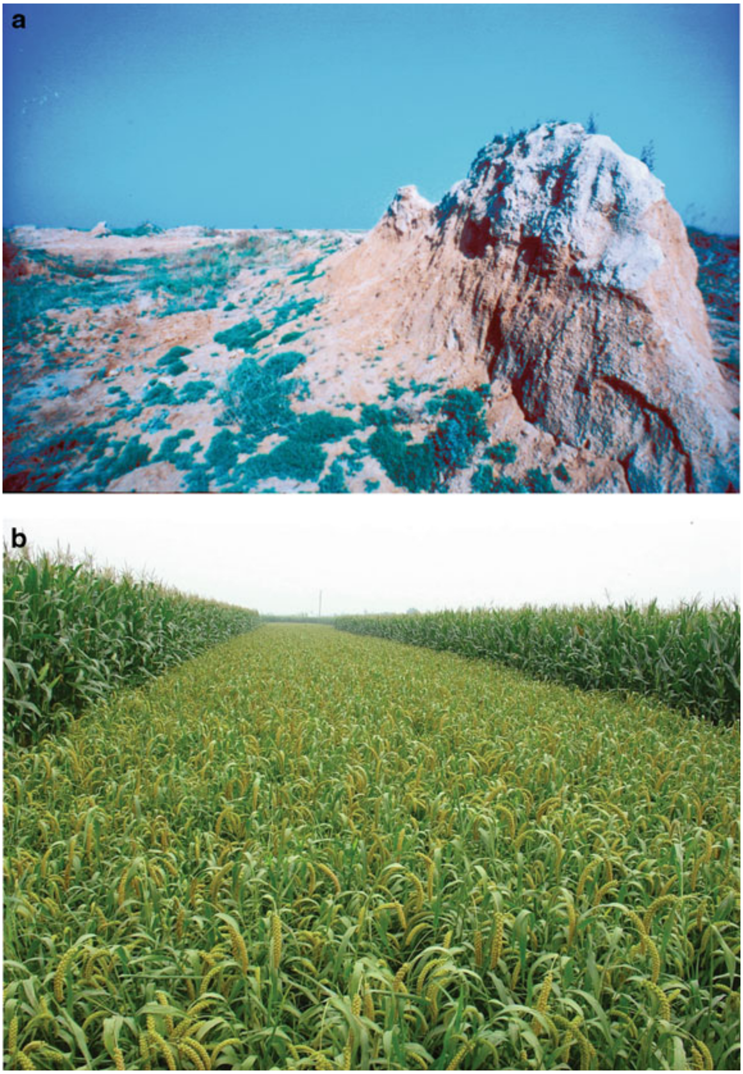

Fig. 5.5 Ecological engineering enabled great increases in yield and biodiversity in Quzhou county, Hebei province, China. (**a**) Before desalination; (**b**) after desalination (Photo by Guocai Zhang)

microclimate modification and existence of refuge habitats) to improve their effectiveness in controlling pests, or to mitigate the negative impact of agricultural practices (Landis et al. 2000).

4. Agricultural waste treatment and recycling utilization. Waste treatment and utilization are important measures to reduce pollution and improve production and economical efficiency. Recycling agricultural waste as animal fodder,

fertilizer or fuel has been practiced for centuries but needs to be strengthened with modern techniques.

5. Agricultural resource conservation and utilization. Examples of such include the conservation and utilization of forest and rangeland ecosystems, fisheries and land as well. In the case of forest management, ecological engineering uses a series of technologies to ensure the use of the forest with minimal impact to the forest ecosystem, including technologies to harvest timber from an ecosystem without diminishing the forest's ability to regenerate, provide clean water and air and provide habitats for a range of plant and animal species.

5.4.5 Agricultural Biotechnology

Agricultural biotechnology is definitely an essential part of the integrated methods to solve conflicts between food production and biodiversity conservation as it improves productivity levels per unit of land area and then allows less intensively-cultivated land to be planted (Delmer 2005; Green et al. 2005; Godfray et al. 2010). According to the FAO definition based on that contained in Article 2 of the Convention on Biological Diversity, biotechnology refers to "any technological application that uses biological systems, living organisms, or derivatives thereof to make or modify products or processes for specific use," covering a broad range of technologies, including genetic improvement of plant varieties and animal populations to increase their yields and/or efficiencies, diagnosis of plant or animal diseases and vaccine development. Biotechnology will be the main direction of development in the future because it not only increases agricultural productivity but also is more sustainable and/or environmentally friendly than traditional intensive production (Raghavan and Parida 2006). For example, biopesticides formulated with the spores of the fungus Metarhizium anisopliae var. acridum have been used successfully to control migratory locusts in countries such as Timor-Leste and Tanzania (FAO 2011a). Biotechnology also can be developed to characterize and conserve agricultural biodiversity (FAO 2011a). For instance, the use of molecular markers, cryopreservation and reproductive technologies can all play an important role in the characterization and conservation of crops, livestock, forestry and aquatic and microbial genetic resources for food and agriculture, and they are currently being used in developing countries for this purpose (FAO 2011b).

5.5 Discussion

It is not easy to keep the balance between biodiversity conservation and sustainable food production when faced with rapidly increasing population growth. Neither land sparing nor land sharing approaches, which are currently widely discussed, provide sufficient solutions to meet the demands of improving yields without compromising environmental integrity or public health. We propose more integrated methods involving wide ranges of knowledge and techniques, including landscape assessment and planning, sustainable intensive or ecologically intensive agricultural practices, elaborate ecological design at different scales, ecological engineering and biotechnology as solutions in this chapter. More efficient agricultural production must be intensively based on knowledge and technology in the future. The progress and integration of relevant knowledge and technologies will be very crucial for a win-win situation in biodiversity conservation and food security. Several aspects of knowledge and technology gaps that should be filled at different levels are:

1. At the levels of genes and individuals, better understanding is needed of crop physiology and the relationship between traits and yield (Cassman 1999; Tester and Langridge 2010). More advanced breeding technology also is urgently needed to develop select varieties that not only have increased yield but more importantly have traits of greater water- and nutrient-use efficiency, as well as tolerance of abiotic stress (Godfray et al. 2010; Tester et al. 2010; Fan et al. 2012).
2. At the scale of population and community, research is particularly needed to quantify the role of biodiversity in sustainable production associated with ecosystem function and service provision, and to develop methodologies of management and restoration.
3. At the ecosystem level, recycling technologies for agricultural waste and ecological restoration technologies should be improved.
4. At the landscape level, it is essential to quantify the effect of spatial and temporal heterogeneity of resources or land use on biodiversity, ecosystem service and crop production, and to determine how changes of these spatial and temporal heterogeneities over time affect biodiversity, ecosystem service and crop production (Bianchi et al. 2006; Veres et al. 2013; Tscharntke et al. 2012b). In addition, it is necessary to have a better understanding of the landscape-moderated biodiversity and ecological services of environmental management measures (Batáry et al. 2011), and to develop site-specific or landscape-specific biodiversity conservation and food production management strategies (Francisco et al. 2005; Rusch et al. 2013; Tscharntke et al. 2011).

However, the harmony between biodiversity conservation and sustainable production is beyond the problem of technology (Altieri and von der Weid 2000) but constrained by the biocultural landscape context as well. Aspects of society, economics and culture in human-dominated landscapes may determine whether the above mentioned knowledge and technology can be further developed, or whether developed science and technology can be acknowledged, accepted and properly or efficiently applied, and are all important determinants for biodiversity conservation and sustainable production. For example, although the importance of ecological planning and design have long been acknowledged (McHarg 1969), land management has generally been based on short-term profitability instead of sustainability in the long run. Technological, financial, trade, ethical and policy supports from developed world to developing world are also crucial to the solution of biodiversity conservation and food security. Agents of bioculture, such as ethics, religion and life styles (Takeuchi and Hamilton 1993; Bryant 2000; Yang et al. 2004) greatly impact people's way of treating nature and production. Due to the limited space, we will not discuss this point in depth here. But it's important to remember, new incentives and policies to encourage integration of sustainable technology with sustainable policy and culture should definitely be included as a necessary part of the integrated methods for biodiversity conservation and sustainable production as well. Only when natural conservation and sustainable production become a kind of culture embedded into policy making, daily life and production, can the aim of balance between biodiversity conservation and sustainable production be achieved.

5.6 Conclusion

To achieve the balance between biodiversity conservation and sustainable food production, the current widely discussed approaches – land sparing and land sharing approaches – do not provide perfect solutions. Integrated methods, including landscape assessment, landscape planning, ecological design, ecological engineering, intensive but resource-conserving or eco-efficient agriculture and biotechnology, are proposed as important technological solutions in this chapter. However, food security and environmental sustainability are not technological problems only, new incentives and policies integrating sustainable techniques with social, economic and cultural agents are also essential to achieve win-win situations between biodiversity conservation and food production.

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Chapter 6
Human-Elephant Relations Becoming Crisis in Xishuangbanna, Southwest China

Qingcheng He, Zhaolu Wu, Fengai Xu, Xianming Guo, and Ziyue Zhu

Abstract Wild Asian elephants surviving in nature reserves in Southwest China became aggressive. They sometimes encroach on human residential areas and cultivated fields, foraging agricultural crops, destroying property and injuring or killing people. Participatory rural appraisal method, field data, 3S and literature research were used to study changes of human-elephant relations (HER). The results indicated that HER became crisis and elephant survival degenerated in the past 50 years. Five stages of HER were identified. (1) Little interference (1959–1971): except for dung and footprints, there were few signs of wild elephants in the wild. (2) Frequent encounters (1972–1990): wild elephants moved close to human residential areas and cultivated fields due to the rapid agricultural growth and natural habitat fragmentation. (3) Conflicts becoming serious (1991–1995): wild elephants began to forage agricultural crops, destroy property and injure people and they were also killed illegally by poachers for ivory or by angry farmers.

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(4) Protection and antagonism (1996–2005): illegal poaching and other damages to elephants were put down by the strengthened policies but wild elephants moved in the fragmented landscapes, causing serious damages to local people. (5) Sawing confrontation (2006–2010): wild elephants moved between the reserves and human residential areas and cultivated fields, creating elephant-problems. It was discussed that the replace of traditional embedding spatial pattern of human residential areas and wild elephant habitats by the present crisscrossing one was the main reasons for the changes of HER from harmony to conflict.

Keywords Xishuangbanna • Human-elephant relations • Habitat fragmentation • Southwest China

6.1 Introduction

Wild Asian elephant (*Elephas maximus*), as one of Endangered Species by International Union for Conservation of Nature (IUCN), is listed in Appendix I of Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) (IUCN 2012; CITES 2012) and it is also one of the first class national protected animals in China (Wang and Xie 2009). Wild Asian elephants in China, with a population estimated at 200–250 individuals, distributed currently in separate areas of Xishuangbanna, Lincang and Puer in Yunnan Province (Chen et al. 2006). They were being protected strictly by laws but became aggressive. Serious human-elephant conflicts (HEC) happened annually. For example, a total of 120 wild Asian elephants were poached illegally during 1966–2005, and more than 30 people were died due to wild elephant attacks from 1991 to 2010 (Wu 2008). Based on the field survey carried out by a Scientific Investigation Team from Chinese Academy of Science in tropical forests of Xishuangbanna during 1957–1958, it was confirmed that wild elephants were living in South of Yunnan Province (Shou et al. 1959). Human-elephant relation (HER) at that time was described as "wild elephants inhabited in primary forest, and hardly attack human beings, in other words, human and elephants did not encroach each other" (Shou et al. 1959). Why did HER change evidently from harmony to conflict in China?

Serious HEC in China and in other places over the world threatened co-existence of both human and elephants, blocked nature conservation, even challenged management of nature reserve (Naughton 1998; O'Connell-Rodwell et al. 2000; Sukumar 2006; He et al. 2011). But there were few literatures to discuss in detail changes of HEC in a given place.

Therefore, it is necessary to study changes of HER for the sustainability of both human development and elephant survival. In this study, we will identify stages of HER over the past 50 years (1959–2010) and discuss main reasons for the changes of HER from harmony to conflict.

6.2 Study Areas

On the Asia map, one can find a large slope that spans southward from the Southeast Tibetan Plateau and extends down to the Indo-China Peninsula. Midway on this slope between 99°58′–101°50′ E and 21°09′–22°36′ N is Xishuangbanna, a Dai Ethnic Nationality Autonomous Prefecture of Yunnan Province, China. Xishuangbanna, with a total area of 1,912,450 hm^2, borders on northwest of Laos and northeast of Myanmar. Historical records showed that the ancestors of the Dai people resided in this region more than 2,000 years ago. In 1180, the chieftain of a Dai tribe conquered other tribes and founded a local Kingdom, which conquered 12 local districts. In the Dai language, "Xishuang" means 12 and "Banna" means districts, hence "Xishuangbanna" implies the 12 districts that existed in history.

Climatically, Xishuangbanna is best described as having a transition monsoon climate of the tropics and subtropics. The monsoons from the southwest carry large amount of warm and moist air masses into Xishuangbanna, but with no risk of typhoons. The area is very mountainous, reaching 2,429 m asl to the north, and sloping southwards to a low point of 477 m asl. The general topography consists of basins or valleys alternating with hills or mountains. Tropical climates prevail in the basins and low valleys, with a subtropical climate in the mountains and higher hills. Annually, summers are characterized by high temperatures and humidity, while winters offer little rain and much heavy fog, and gentle winds bode of spring. The region is free from frost all the year round. However, cold currents occasionally intrude in higher elevations, rendering cool and dry climates in relation to the tropics of Southeast Asia.

Xishuangbanna is a kingdom of fauna and flora biodiversity. The main vegetation types are tropical rain forests, tropical monsoon forests, and subtropical evergreen broadleaved forests. According to incomplete statistics, approximately 4,600 species of high plants have been discovered, of which 80 % belong to tropical and subtropical floral species. There are 343 species of high plants having been considered rare species. There is also an extraordinary abundance of fauna in Xishuangbanna, and 758 species of vertebrates have been identified. Of the 108 mammals, 36 species have been listed in the Chinese Fauna Red Book (Xu et al. 1987).

There are 13 ethnic groups with a larger population recognized in Xishuangbanna. Different ethnic groups occupy different environment. Dai, Han, and Hui resided in the basins and valleys and cultivated paddy rice in addition to earning income from handicrafts. Hani, Lahu, Jino, and Blang inhabited the upland areas and cultivated upland rice and tea, and collected or grew other cash crops. The social environment has been changed since the large amount of immigrants moved in to develop tropical agriculture in 1960s. The human population increased from 199,300 in 1949 to 1,130,000 in 2011.

Xishuangbanna National Nature Reserve, with a total area of 242,510 hm^2, was established to protect natural forests and wild plants and animals living in the forests in 1958 (Wu 2008). It was composed of five separated sub-reserves, namely

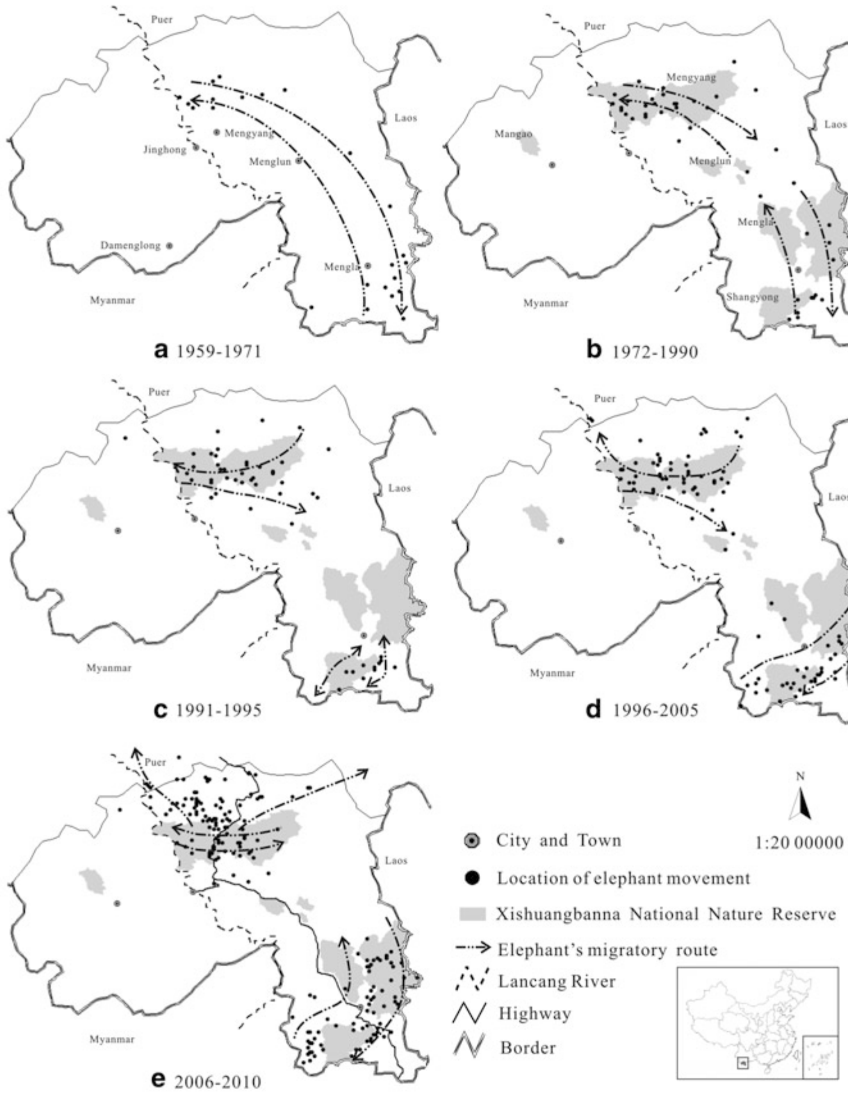

Fig. 6.1 The movement of wild elephant in Xishuangbanna (1959–2010). *Note*: There were no maps of reserves in (A) 1959–1971, due to reserve boundaries were identified in 1988

Mengyang, Menglun, Mengla, Shangyong and Mangao (Fig. 6.1). There were 132–204 wild Asian elephants estimated (Zhang 2006) and 260 villages with 51,545 inhabitants living in and around the reserve in 2007 (Wu 2008; Yang and Tang 2008).

6.3 Method

6.3.1 Data Collection

Wild elephant movement and community development were investigated by using Participatory Rural Appraisal (PRA), a method of 'hearing communities, learning and perceiving their needs' (Liu 2005) used to analyze and estimate current situation and development planning of communities by informal interviews with inhabitants (Yu et al. 2009). The investigation was carried out from July 2009 to May 2011. Aged villagers, village heads, forest rangers and villagers who knew intimately about elephant activities and village's development were interviewed to review and discuss the sequence of elephant activities and village's development. Data were verified from villagers to villagers and from villages to villages in order to ensure the authenticity.

At the same time, spatial locations and routes of elephant movement were recorded by using GPS set and mapped with a scale of 1:50,000. Literatures and unpublished documents were analyzed to collect historical data on number, distribution and food composition of wild elephants and to verify and supplement with field data.

6.3.2 Data Analysis

We compared human population, wild elephant number and landuse situation with Microsoft Office Excel 2003 to analyze the change of population, land utilization and wild elephants' movement. We used ArcView GIS 3.3 to differentiate classification of landuse, to determine geographical coordinate where wild elephant appeared, and to map changes in routes and areas of wild elephant movement over the past 50 years.

6.3.3 Identifying Stages of Human-Elephant Relation

Based on the field survey data and literature study, we identified five stages of human-elephant relation by the criterions listed in Table 6.1.

Table 6.1 Stages of human-elephant relations in Xishuangbanna (1959–2010)

Stage	Period	Elephant-problem	Elephant poaching	Protection activity	Local development activity
Little interference	1959–1971	No	No	Establishing reserves	Immigration and tropical crop cultivation
Frequent encounters	1972–1990	Little	Occasional	Demarcating reserves	State-run rubber farming
Conflicts becoming serious	1991–1995	Frequent	Frequent	Suppressing crime	Privately-run rubber cultivation
Protection and antagonism	1996–2005	Serious	Frequent	Strengthening policies and activities	Expanding rubber plantation
Sawing confrontation	2006–2010	Serious	No	Strengthening co-management	Highway building and elephant-problem insurance

6.4 Results

6.4.1 Little Interference (1959–1971)

During 1959–1971, there were few signs of elephants except for elephant dung and footprints in the wild. Wild elephants distributed in primary forests of northern Jinghong and eastern Mengla; only experienced hunters could find them. Their migratory routes spanned eastern part of Lancang River in Xishuangbanna (Fig. 6.1a). Human and elephants had little interference with each other.

People and elephants occupied different places in the embedding spatial pattern of biocultural landscapes. The Dai people lived in flat basins and other ethnic groups such as Blang, Jino and Hani resided in mountains; surrounding the residential areas were vast tropical and subtropical forests, where homed wild elephants and other wildlife. Native summarized the unique traditional ecological knowledge, benefiting conservation of wild elephants and their habitats. The Dai people for example created the forest priority ecological conception said “no water if without forest; no field if without water; no grain if without field; no people if without grain” (Dao 1996). Natives adored elephants as Gods, forming the unique elephant culture. According to the aged villagers interviewed, humans and elephants respect and love each other at that time.

6.4.2 Frequent Encounters (1972–1990)

Unfortunately, the traditional ecological knowledge and practices were broken in 1970s. During 1972–1973, an armed “capturing elephant” team organized and approved by government, with the assistance of local people, caught wild elephants in forests of Mengyang sub-reserve. They caught a young elephant with the cost of shooting five elephants to death and injuring four elephants. Leaning from this event, some of local people disbelieved the traditional elephant adoration and began to shoot elephants for different purposes. There were 18 wild elephants were shot to death from 1976 to 1990 (Chen et al. 2006). At the same time, elephant habitats were reclaimed on a large scale to plant rubber and other tropical crops. By 1990, the area of rubber plantations increased to 89,866.67 hm^2, which was 30 times of that in 1960 (Fig. 6.2).

As a result, human and elephants encountered frequently during 1972–1990. Wild elephants were found frequently in the wild and they sometimes passed quickly through cultivated fields and residential areas. Wild elephants distributed in Mengyang sub-reserve, eastern Mengla sub-reserve and southeastern Shangyong sub-reserve. However, their migratory routes between Mengyang sub-reserve and Mengla sub-reserve were blocked (Fig. 6.1b).

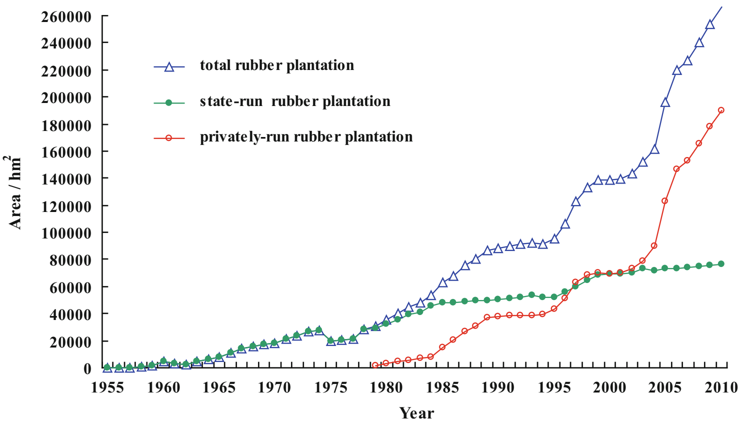

Fig. 6.2 The area of rubber plantation in Xishuangbanna (1955–2010)

6.4.3 Conflicts Becoming Serious (1991–1995)

Habitat degradation and available food changes forced wild elephants to forage in agricultural landscapes. Forests in reserves were protected well but undergrowth of forests were cleared and planted with *Amomum villosum*, an introduced medicinal plant, causing the shortage of natural food for elephants in forests of reserves (Wang et al. 1997; Wu 2008). Outside of reserves, elephant-preferring crop cultivation increased quickly. The area of sugarcane cultivation in Xishuangbanna for example increased from 1,610 hm^2 in 1990 to 14,432 hm^2 in 1995 (nine times!) (Chen et al. 2006). The different available food distribution inside and outside of reserves made elephants go out of reserves and forage crops in farming land.

In this period, illegal elephant poaching happened annually. Of the 30 elephants shot to death, 29 were shot for ivory and one was shot by local people during the elephant attack. Wild elephants concentrated in Mengyang sub-reserve and some of them emigrated northward gradually, even went across Lancang River westward to Lancang County in Puer Prefecture. Wild elephants in Mengla sub-reserve before emigrated to Shangyong sub-reserve (Fig. 6.1c).

At the same time, wild elephants began to attack people. Nine people were injured and two were killed due to elephant attacks. Human-elephant conflicts appeared and became serious quickly.

6.4.4 Protection and Antagonism (1996–2005)

To suppress the illegal elephant poaching, serious protection policies and activities including prohibition hunting and taking over firearms from public were carried out. Wild elephants had more chance to forage in reserves and agricultural landscapes. Wild elephants in Mengyang sub-reserve moved inside and outside the reserve and some of them emigrated northward to Puer Prefecture. By 2005, two groups of wild elephants settled in Lancang County and Simao County in Puer Prefecture respectively. Wild elephants in southeastern Xishuangbanna moved between Mengla and Shangyong sub-reserves and sometimes they moved to Phongsali and Luang Namtha of Laos (Fig. 6.1d).

However, human-elephant relation was in a dilemma in this period. Illegal elephant poaching still happened. 16 elephants were killed and three were injured, of which, ten were shot for ivory and nine were shot by local people due to elephants eating crops, destroying interests and attacking people. At the same time, elephant-problems happened frequently. In 2001, for example, 70 elephants crashed into Nanping, a village close to Shangyong sub-reserve, damaged houses and barns, and destroyed all the crop fields. In the early morning, 21 November 2002, a pregnant woman was crushed to death by elephants in her sugarcane field. Totally, 80 people were injured and 19 were killed due to elephant attacks from 1996 to 2005 in Xishuangbanna (Chen et al. 2006).

"Under the strengthening protection policies and activities, elephants become impudent and aggression", more than two thirds of interviewed villagers said.

6.4.5 Sawing Confrontation (2006–2010)

Facing the increasing elephant-problems and market demands, local people chose to develop more woody crops in their dry cultivated fields. Rubber plantations and tea gardens became the prevailing landscape elements (Figs. 6.2 and 6.3). At the same time, highway development broke elephant migratory routes drastically (Fig. 6.1e).

The Kunming-Bangkok Highway opened in Xishuangbanna in 2006. It passed through Mengyang sub-reserve and the area between Mengla and Shangyong sub-reserves, cutting off elephant migratory routes. Two overpasses and 23 underpasses were built for elephants in Mengyang sub-reserve but they were used less (Chen 2008). Elephants were broken into two large groups by the highway. Wild elephants climbed on the highway, or stopped and rushed blindly when they came to the highway. A 26-head elephant herd moved 50 km northeastward out of the reserve to a village named Kelian and stayed there from Aug. to Dec. 2010, ate and damaged almost all crops of the village. Elephant migratory routes between Mengla and Shangyong sub-reserves were also blocked. A group of more 30 elephants from Shangyong sub-reserves passed the highway to Mengla sub-reserve in Jan. 2009 and did not return. Two years later, 20 Jan. 2011, they went 20 km northward out of Mengla sub-reserve, stayed in the agricultural landscapes for one month and returned to the reserve.

In this period, no illegal elephant poaching happened but 11 people were killed due to elephant attacks. Wild elephants stayed in forests day time and moved towards crop fields and villages at sunset. To reduce HEC by attracting wild

Fig. 6.3 Facing the increasing elephant-problems and market demands, local people chose to develop more rubber plantations, forming the new biocultural landscape in Xishuangbanna. Wild elephants stayed in forests day time and moved towards crop fields and villages at sunset

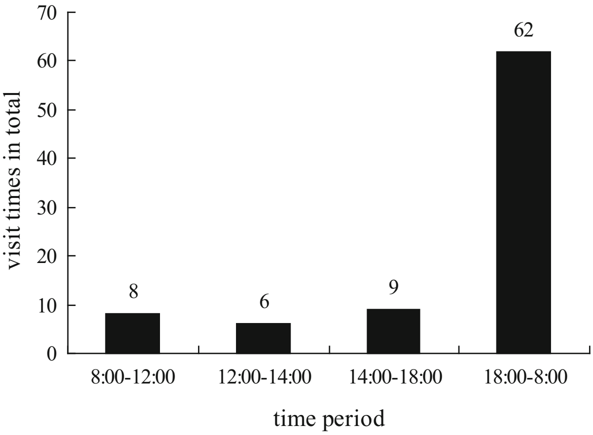

Fig. 6.4 Frequency of wild elephant's visit by time period to food-resources base daily in Mengyang sub-reserve (2005–2010) (Source: Xishuangbanna National Nature Reserve)

elephant return to forests of reserve, a food-resource base with a total area of 20 hm^2 was established in Mengyang sub-reserve from 2005 to 2010. It was recorded that 88 times of wild elephants visiting the food-resource base, of which, 70.5 % happened in the time period from 18:00 to 8:00 next day (Fig. 6.4).

To appease the frighten local people, programs in terms of co-management were implemented to help local people to avoid of elephant attacks. Elephant-problem insurance activities had been carried out since 2010.

6.5 Conclusions

Facing human disturbance, wildlife could make some inherent behavior including avoidance, defense, attack and migration (Jiang 2004). Results discussed above indicated that the interaction between human and wild elephant changed from harmony to conflict, and conflicts became crisis at present.

Up to 1960s, people with different cultures scattered in flat basins and slope uplands and wild elephants and other wildlife occupied vast tropical and subtropical forests, forming the traditional embedding spatial pattern of biocultural landscapes, which benefited human and wild elephants. People from other places in China were encouraged to move to Xishuangbanna to develop rubber plantation and other tropical crop production. The overlapped living space between human and elephants, forming the new biocultural landscapes at present: crisscrossing spatial pattern of human residential areas and wild elephant habitats. Habitats and migratory routes of wild elephants were destroyed and blocked, in particular, the highway opened in 2006. Wild elephants had to move between the reserves and human residential areas and cultivated fields, creating elephant-problems.

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Chapter 7
Ecosystem Services and Biodiversity of Traditional Agricultural Landscapes: A Case Study of the Hani Terraces in Southwest China

Yuanmei Jiao, Luohui Liang, Toshiya Okuro, and Kazuhiko Takeuchi

Abstract The traditional agricultural landscape has many ecosystem services as well as a rich biodiversity. This paper analyzes the multiple ecosystem services provided by the Hani Terrace landscape in southwestern China. The results indicate: the Hani Terrace landscape is a traditional sustainable rice agriculture landscape which has multiple ecosystem services and a rich biodiversity that are generated from the close relationships between the landscape elements/ecosystems that are maintained by local farmers. However, although the Hani Terrace landscape has almost maintained its original status, it is facing continuous pressures from social and economic development so adequate adaptive management strategies should be developed to meet the challenges.

Keywords Biodiversity • Ecosystem services • Hani Terrace landscape

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7.1 Introduction

Traditional agricultural landscape is the indigenous form of ecologically-based agriculture and relies on the co-evolution of local cultural and environmental systems. It exhibits a high ecological rationale, which is expressed through the intensive use of local knowledge and natural resources, including the management of agro-biodiversity in the form of diversified agricultural systems (Altieri 2004). Compared to modern industrial agriculture, traditional agricultural landscapes are more beneficial to natural ecosystems, but marketable crop yields and production are lower (Millennium Ecosystem Assessment 2005). According to previous study and field survey, we summarize the differences between traditional and modern industrial agricultural landscape by the components, ecological processes, ecosystem services and biodiversity (Table 7.1).

Because of the multiple ecosystem services and rich biodiversity, traditional agricultural landscapes have attracted more conservation concern in the past decade (Swift et al. 2004). Rice is the most important irrigated crop in the world. There are many kinds of traditional rice paddy landscapes in Asia due to the long history of rice cultivation. For example, the Cordillera rice terraces in the Philippines, the Satoyama landscape in Japan, and etc.

In this article, we take one traditional rice paddy/terraces landscape in eastern Asia, the Hani Terraces in southwest China, as a case study, analyze the desirable and non-target ecosystem services within and outside the landscape, and identify the mechanisms that maintain the ecosystem services and biodiversity in the Hani Terraces. We then consider their potential to improve the conservation and revitalization of similar landscapes.

7.2 Brief Description of the Hani Terraces Landscape

The Hani Terrace is a unique traditional agricultural landscape that is suited to the high-relief mountainous region with a subtropical monsoon climate. Due to its outstanding value in world, it was listed in the world cultural landscape heritages in June 2013. It is mainly located in the four counties of Honghe Hani and Yi Autonomous Prefecture, namely: Yuanyang, Honghe, Lvchun and Jinping, which are located in the southeastern part of Yunnan Province, southwestern China (Fig. 7.1). The landscapes are mainly composed of forests (including primary and secondary forests), villages and rice terraces which are flooded with water over the whole year. Its' simplified vertical structure is characterized as up-slope forests, middle-slope villages and down-slope rice terraces (Jiao et al. 2012). The ratio of the main land use systems is as follows: forests/terraces/crop land/other land uses = 3:1:2:1 at the Yuanyang county. People of various races, with Hani being the main ethnic group, have created this spectacular agricultural landscape over 1300 years.

Table 7.1 Landscape components, ecological processes, ecosystem services and the biodiversity status of traditional and industrial agriculture

Parameters	Traditional agricultural landscape	Modern industrial mono-agriculture
Landscape components	Mosaic of large-sized agro-forest land, middle-sized arable land and pasture, small-sized settlements and wet areas	Separated and large-sized arable land, together with pasture and timberland
Ecological processes within the landscape	Mass flows come from natural ecosystems (mainly agro-forest), such as water and renewable nutrients, which are continually moving into the arable land and settlements. Renewable energy from agro-forest and arable ecosystems also moves into the settlements. The whole landscape is under cyclic and dynamic conditions	Water flows and chemical fertilizers are used frequently during the crop growing season. Pesticides are used to kill pests (animals or micro-organisms feed on the crops). Non-renewable energy is used on the arable land and crop products are continually moving to market
Provisioning services	Food (including products from cultivated plants, livestock and the collection of wild flora and fauna), construction timber, firewood, fiber, fresh water and genetic resources	Crop products, timber and fiber
Supporting services	Soil formation, nutrient cycling and primary production	Primary production
Regulating services	Climate regulation, disease regulation, flood control and detoxification	Emissions contributing to climate warming, disease dispersal, flooding and drought, water eutrophication and toxification
Cultural services	Spiritual, recreational, esthetic, inspirational, educational, communal and symbolic values	Communal and symbolic values
Negative effects	Habitat degradation, insufficient product marketing and lower crop yields and production	Habitat loss, competition for pollination, water, pest damage and pesticide poisoning of non-target species
Biodiversity	Rich	Low

The Hani Terraces is a traditional subsistence farming system which provides a number of ecosystem services (Takeuchi 2010; Jiao et al. 2012) including provisioning services, i.e. species that provide us with food, timber, medicines, and other useful products; regulating services, such as flood control and climate stabilization; supporting services, such as soil formation and water purification, and cultural services, which are esthetic or recreational assets that provide both intangible and tangible benefits, such as ecotourism attractions (Kremen and Ostfeld 2005). In addition, it serves as a valuable model of a society in harmony with nature. It has a long history of adaptive management of the semi-natural environment which has led to a rich diversity of plants and animals. Thirdly, it is facing serious challenges at the local and global scale. For example, the Hani Terraces are under considerable

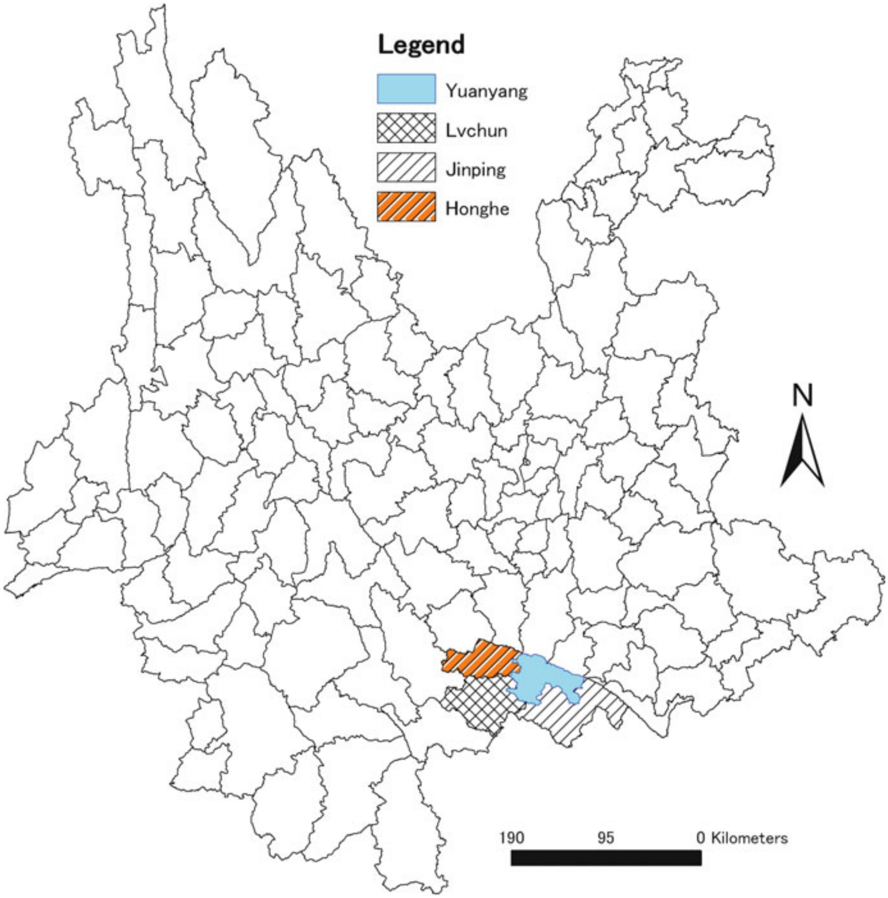

Fig. 7.1 Location of the Hani Terraces in Yunnan Province, south west China

pressure from economic development because of the poverty of local farmers and the under-developed socio-economic conditions.

7.3 Ecosystem Services Provided by the Hani Terrace Landscape

The Hani Terraces are a mosaic of well connected ecosystems including forests, terraces, cropland, grassland and wet areas. Each ecosystem in the landscape has its components, which have multiple ecosystem services that are directly or indirectly related to each other. Due to the spatial separation between on-site and off-site ecosystem services caused by the transfer of biological resources/flows

Table 7.2 Ecosystem services provided by the Hani Terrace landscape

Elements	Forest	Crop land	Wet areas	Settlements	Grassland
Components	Natural forest, natural sacred forest, natural timber-charcoal forest, semi-natural Caoguo forest and cultivated tea plantations	Small sized rice fields full of water, levees made using soil, river valley, channel systems and path systems	Numerous terraced ponds along the river valley, river and a small reservoir	House and livestock corrals, recreational places, roads, drinking water pool, waste water pool, horticultural land, bamboo, fruit trees or sparse trees	Natural grassland or newly planted Grain to Green land
Desirable ES within the landscape	P: fresh water for irrigation and drinking, firewood for heating and light, timber, poles for houses and fences, litter fall, bamboo shoots, wild animals, fruits and mushrooms and medicinal plants; C: cultural inheritance	P: rice, straw, fish and other aquatic animals for meat and semi-aquatic and aquatic plants for food; C: cultural inheritance	P: fresh water; R: flood and drought regulation	P: meat, vegetables, fruits, organic fertilizer; R: manage and maintain the whole landscape; S: cultivated soil formation; C: cultural center for residents and recreation	P: land for grazing, straw for houses and fertilizer
Desirable ES for crop marketing and production	P: Caoguo and tea	P: rice, fish; R: nutrient retention	P: many kinds of aquatic animals and plants	P: meat and vegetables	
Non-target ES outside the landscape	P: fresh water and semi-natural habitats; S: nutrient cycling, and carbon sequestration; R: climate and flood control; C: recreation	P: fresh water, wetland for organisms; R: climate and flood control; C: recreation	P: fresh water and numerous wetlands for organisms; R: climate control	R: multiple use of natural resources; C: ethnic culture, recreation and tourism	P: habitats for species; S: nutrient cycling

[a] *ES* ecosystem services, *P* provisioning services, *R* regulating services, *S* supporting services, *C* cultural services

(Guo et al. 2000), we must first classify the ecosystem services into those “within landscapes” and those “outside landscapes”. Secondly, provisioning services, including food, fiber, timber and other subsistence materials for life are the target ecosystem services for farmers, while others, especially regulating and supporting services, are the non-target ones that mainly provide benefits to the public. For this reason, we classify the ecosystem services into “target” and “non-target”. Using this dual classification system, we can summarize the ecosystem services provided by each ecosystem in the Hani traditional agricultural landscapes (Table 7.2).

The characteristics of the ecosystem services provided by Hani Terraces landscape are as follows. (1) The components of each ecosystem is very diverse, for example, the forest ecosystem composed of primary forests, secondary forests and shrub forest. (2) The Hani’s daily life is mainly dependent on the target provisioning services provided by the terraces and forests, such as rice, fish and other aquatic animals from the terraces, edible hygrophytes from terrace levees and semi-aquatic patches, firewood, timber, edible wild mushrooms, plants, insects and animals from forests. (3) Due to the water shortage for rice planting in high mountains subject to a subtropical monsoon climate, the Hani people have developed very efficient irrigation systems and water conservation strategies in order to regulate water flows. During the regulation process, the Hani have created target ecosystem services for water conservation and have also provided significant non-target regulatory and supporting services for the macro-climate, the hydrological cycle, soil formation and nutrient cycling. (4) The Hani’s worldview is one of natural religion, and they believe that many natural things, such as mountains, forests, rivers, terraced fields and rice, have a divine owner that must be respected. Therefore, the Hani have associated the landscape with many types of cultural services. In addition, after the spectacular landscape was publicized by Yann Layma, a French photographer during 1988–1993, the Hani Terraces landscape has become a world famous national and international tourist destination and provides a valuable recreation service.

7.4 Biodiversity Status of the Hani Terrace Landscape

The Hani Terraces are rich in biodiversity compared to China as well as the world (Table 7.3). The table shows the biodiversity in Yuanyang county is very rich in plant and animal species, due to the different vertical zonation of vegetation in the southern and northern parts and the complex terrain and macro-climate conditions (Fig. 7.2). Within the 2,200 km^2 area, the climate moves from a tropical to a temperate climate and the vegetation ranges from high humid monsoon rainforests to dry-hot valley vegetation that is similar to Savanna land. At the same time, centuries of exploitation and utilization by local people has led to diverse, species rich semi-natural habitats that are dependent on human disturbance. According to the YYFB (2011) statistics, the number of plant species used by the local people for timber, dyeing, edible foods, forage, fiber, spiceberry, medicine and oil are

Table 7.3 Species richness of Hani terraces in Yuanyang County of southwestern China. If land area is the denominator and species number is the numerator, then the number of species per 1,000 km^2 can be shown in following way (except the number for the World)

	World	China	Yunnan, China	Yuanyang, China
Area (1,000 km^2)		9,600	390	2.2
Data source	EAJ (2010)	Yang et al. (2004)	Yang et al. (2004)	YYFB (2011)
Mammals	5,490 (21)	0.064	0.779	37.727
Birds	9,998 (12)	0.130	2.077	73.636
Reptiles	9,084 (5)	0.039	0.436	19.545
Amphibians	6,433 (30)	0.030	0.308	17.273
Fish	31,300 (5)	0.402	1.108	49.545
Vascular plants	294,842 (3)	3.424	42.564	660.909

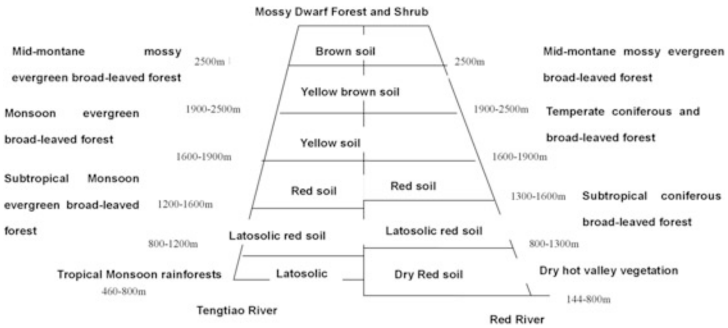

Fig. 7.2 The vertical zonation of vegetation in the southern and northern parts of Yuanyang County, south west China

33, 8, 52, 7, 14, 10, 98, and 23, respectively. In addition, the records of the Agricultural and Technology Office of the Yuanyang Agriculture Bureau showed that in 2008 there were 47 local rice landraces, although many others have been lost because of the expanded use of hybrid rice varieties after the 1980s (Jiao et al. 2012). Therefore, we can say that biodiversity plays an important role in providing provision ecosystem services that improve the wellbeing of the Hani and, at the same time, the semi-natural habitats created by the land management practices carried out by local people benefit biodiversity.

7.5 Discussion

The Hani Terraces landscape has changed very little over time, but the development of economy and society are putting continuous pressures on ecosystem services and biodiversity. For example, the wonderful beauty of the terraces attracts many national and international tourists, which has meant that tourism has become an important industry in Yuanyang County. Nevertheless, the conflicts between farmers and tourist companies are very serious because the beautiful scenery is created and maintained by farmers, but their considerable recreational value only benefits the tourist companies and local government. Secondly, large numbers of tourists consume lots of wild edible plants, as well as the upstream water. This has led to the local extinction of some wild species and water shortages for irrigation in downstream areas. Therefore, the balances between different ecosystem services, biodiversity and human wellbeing should be paid more attentions to solve them.

In conclusion, although the Hani terrace landscape has many target and non-target ecosystem services as well as a rich biodiversity, it will change with the pressures come from the inside and outside world. In order to keep the multifunction of the landscape, the multiple services it provides and the biodiversity it reserve, a sustainable management system should be adopted to conserve the whole landscape (Takeuchi et al. 2003).

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Chapter 8
Anthropogenic Effects in Landscapes: Historical Context and Spatial Pattern

Jan Bogaert, Isabelle Vranken, and Marie André

Abstract Bio-cultural landscapes are characterized by anthropogenic pattern features, of which the measurement constitutes a key step in landscape analysis. Metrics and strategies for this measurement of anthropogenic patterns and their dynamics are discussed, considering the pattern/process paradigm, the patch-corridor-matrix model and the complementarity of landscape composition and configuration as conceptual benchmarks. Historically, noticeable anthropogenic effects are accepted to have appeared in landscapes after the invention of agriculture and further trends of landscape change could be linked to the development of agriculture. Through time, a sequence of landscape dynamics with three stages is expected, in which a natural landscape matrix is initially substituted by an agricultural one; urban patch types will later on dominate the matrix as a consequence of ongoing urbanization. The importance of the development of agriculture and its productivity for the evolution of settlements, villages and cities is emphasized. Anthropogenic change of landscapes confirms the status of geographical space as a limited resource.

Keywords Agriculture • Anthropogenic effects • Domestication • Land cover dynamics • Landscape metrics • Urbanization

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8.1 Bio-cultural Landscapes and Anthropogenic Patterns

More than 75 % of the Earth's ice-free land shows evidence of alteration as a result of human residence and land use, with less than a quarter remaining as wildlands (Ellis and Ramankutty 2008). Globally most landscapes are blends of human activities with the expression of biodiversity, i.e. they are bio-cultural landscapes (Bridgewater and Arico 2002). This relationship between biological and cultural diversity has not been explored as biodiversity itself; this study of bio-cultural diversity involves a search for patterns across landscapes (Stepp et al. 2005). An intrinsic reciprocal relationship between culture and landscape structure exists: culture changes landscapes and culture is embodied by landscapes (Nassauer 1995).

In the current contribution, the cultural component of landscapes is generalized to the large-scale spatial footprint of Man's actions, which refer to agriculture, urbanization, industrial development, road infrastructure or any other substitution or alteration of an original natural land cover by an anthropogenic type. This latter process is denoted as "anthropization" (Bogaert et al. 2011b); the modification of landscapes by human action leads to anthropogenic landscapes, in which man-made features dominate and the original natural patch types often are reduced to a scattered pattern.

A series of typical changes in landscape and biological characteristics during the conversion of natural lands to human-dominated landscapes has been reported (August et al. 2002). Hobbs and Hopkins (1990) in McIntyre and Hobbs (1999) expressed the range of human effects on landscapes in terms of the prevalent land use and using four levels: conservation of a more or less unmodified system, utilization of components of the system (e.g., forestry), replacement of the system by another type (e.g., agriculture), and complete destruction (e.g., urban development). Anthropogenic activities that require much space and which destroy or replace original land covers will consequently dominate human-driven landscape dynamics; they are considered exogenous disturbances (McIntyre and Hobbs 1999; Fischer and Lindenmayer 2007). This human impact on ecosystems and landscapes has lead to the recognition of 18 "anthropogenic biomes", grouped in dense settlements, villages, croplands, rangelands and forested (Ellis and Ramankutty 2008).

Landscape ecology focuses on landscape pattern (Bogaert et al. 2011b; Bogaert and André 2013). Its central hypothesis is known as the pattern/process paradigm, which states that patterns and processes in landscapes are related in a way that landscape patterns condition those processes characterized by a spatial dimension, and that processes occurring in a landscape can modify landscape patterns (Turner 1989; Coulson et al. 1999; Noon and Dale 2002). The propagation of fire in a landscape as a function of vegetation and soil patterns (Diouf et al. 2012), biodiversity patterns as a function of landscape fragmentation (Barima et al. 2010a; Bogaert et al. 2011a), edge effects on soil parameters (Alongo et al. 2013), gap pattern dynamics in stressed vegetations (Van Peer et al. 2001), vegetation pattern change due to atmospheric deposits of heavy metals (Vranken et al. 2013), or periodic vegetation communities and the mechanisms behind their dynamics (Deblauwe et al. 2008, 2011, 2012; Diouf et al. 2010), can be cited as examples or closely related topics. This focus on spatial pattern distinguishes landscape ecology from general ecology (Fahrig 2005).

Consequently, many metrics have been developed and tested, also by the current authors (e.g., Salvador-Van Eysenrode et al. 1998; Bogaert et al. 1999b, 2000a, c, d, 2001b, 2002a, b). Analyses have shown that many metrics were correlated or mathematically related (Bogaert et al. 2002a; Bogaert and Hong 2004). It is recommended that those metrics are used for analysis which capture orthogonal pattern features (Bogaert and Mahamane 2005; Bogaert et al. 2011b). Many metrics have found applications outside landscape ecology (e.g., Bogaert et al. 2002c; Li et al. 2005; Hufkens et al. 2008), which illustrates the validity of the metrics involved and the aforementioned paradigm across spatial and temporal scales. This pattern-orientated identity of landscape ecology has created links towards other concepts such as fractal theory (e.g., Bogaert et al. 2000a; Imre and Bogaert 2004, 2006; Bamba et al. 2009; Bogaert et al. 2011b) or percolation theory (e.g., Bogaert and Impens 1998; Bogaert et al. 1999b, 2000b).

Landscape elements are generally classified as patches, corridors or matrix (Forman and Godron 1986; Urban et al. 1987; Forman 1995). Patches form the basic units of landscape pattern, and reflect homogeneous conditions significantly different from their surroundings. Patches representing a same land cover form a patch type or class. The definition of patches and patch types requires an application of the contrast concept, which corresponds to the magnitude of the difference between two patch types with regard to an ecologically significant characteristic (Forman 1995; Farina 2000b). Generally, morphological or structural characteristics are considered, such as vegetation type, density or height (Reino et al. 2009; Watling and Orrock 2010). A high contrast between adjacent land cover types generates edge effects, considered a main consequence of patch type fragmentation (Bogaert et al. 2011a); metrics have been developed by the current authors to quantify its impact (e.g., Bogaert et al. 1999a, 2001a, c, 2011a; Bogaert 2001; Salvador-Van Eysenrode et al. 2002; Barima et al. 2011; Vranken et al. 2011; Iyongo Waya Mongo et al. 2012, 2013).

Corridors can be considered a special type of patches, characterized by linear forms, and crucial for the connectivity of a patch type (Bogaert and Mahamane 2005). It should be noted that in most analyses, patch type connectedness is quantified instead of connectivity; the former concept refers to the physical links between landscape elements while the latter concept refers to the perception of connectedness by a particular species or group (Fig. 8.1) (Bogaert et al. 2000d). Therefore, the difference between patches and corridors is merely functional and often ignored in pattern analysis. In Fischer and Lindenmayer (2007), a third type is distinguished, "ecological connectivity" which refers to the connectedness of ecological processes across multiple scales, including trophic relationships, disturbance processes and hydro-ecological flows; its measurement remains however complicated.

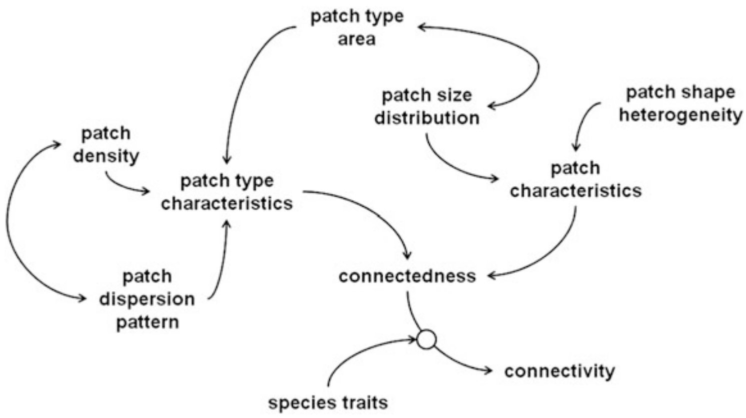

Fig. 8.1 Landscape connectivity and connectedness. Connectivity depends on patch type connectedness and its interaction with species traits. Connectedness depends on patch and patch type characteristics which can be related. Patch and patch type area, patch shape, patch density and the spatial dispersion of patches determine patch type connectedness

The landscape matrix is formed by these patch types (generally one single type but a co-dominance of two or more types cannot be excluded) dominating the landscape by their extent (Bogaert and Mahamane 2005); in case of the absence of a dominant patch type, the landscape is often considered a mosaic.

Urban et al. (1987) stated that the primary influence of Man is to rescale patterns in space and time. This relationship between temporal and spatial patterns is a key concept in landscape ecology (Turner et al. 2001; Wiens 2009). Every process is characterized by a particular temporal and spatial scale or range which defines its frequency or duration, and its extent (August et al. 2002). In general, larger time steps are characteristic for processes concerning larger areas, and vice versa. For example, global temperature change increases slowly while smaller areas have already shown significant changes over shorter time periods (Bogaert et al. 2002c). This space-time relationship can be used to detect anthropogenic landscape dynamics, since the speed and extent of land cover change indicate the cause of the dynamics, anthropogenic causes leading to rapid land cover change on a large extent (August et al. 2002; Wiens 2009).

The attention of landscape ecology for large scale patterns is directly related to the spatial scale that corresponds to landscapes. Hierarchy theory (Allen and Starr 1982; Urban et al. 1987; Forman 1995; Burel and Baudry 2003; Bogaert and Mahamane 2005) states that the biosphere can be considered a sequence of scales reflecting a range of complexity or spatial levels, starting with the biosphere itself and going down to the elementary particles composing atoms. Different levels are distinguished among which the landscape, situated directly above the ecosystem level. Thus, landscapes are composed of ecosystems, a vision which corresponds to the definition put forward by Forman and Godron (1986) and which can be shortened as "landscapes are eco-complexes"; small-scale pattern features are ignored when they correspond to the sub-patch level. Landscape ecology research is consequently posed from a scale of a few meters to a 1,000 km across which most ecological processes are completed (Farina 2000a; Farina et al. 2005).

8.2 Measuring Anthropogenic Patterns

Landscape pattern itself is generally divided in two components: landscape composition and landscape configuration (Bogaert et al. 2011b) (Fig. 8.2). Composition refers to the number of patch types present in the landscape, their area and their definition. Landscape configuration is conditioned by landscape composition and refers to the spatial arrangement and geometry of the patch types (shapes, sizes, density and dispersion of patches). Its assessment is based on a multi-scalar approach, integrating pattern features at the patch, patch type and landscape level. Juxtaposition between patch types can also be considered as a component of landscape configuration. Patch dispersion assessment is often limited to the detection of aggregated, random or uniform patterns (Havyarimana et al. 2013; Kumba et al. 2013; Rakotondrasoa et al. 2013).

Patch definition is the first step of a configuration analysis; it is based upon technical aspects such as the type of pixel connectivity considered in raster based data (4-connectivity is generally applied) and the application (or not) of the minimum mapping unit technique (Bogaert and Hong 2004; Bamba et al. 2008; Bogaert et al. 2008). Patch orientation and spatial resolution also influence the final size and shape of the patches.

The definition of patch types directly affects their number and areas (Colson et al. 2009; Bastin et al. 2011) and consequently, landscape composition. Landscape composition change is preferably assessed by a transition matrix (e.g., Forman and Godron 1986; Dale et al. 2002; Bamba et al. 2008; Barima et al. 2009, 2010b; Bogaert et al. 2011a; Diallo et al. 2011), which has two entries in a diachronic analysis, one for each land cover map. It is composed of three groups of values. Firstly, the row and column totals refer to the patch type areas for the first and second map, respectively. These data can be used for landscape matrix identification or for composition analysis by means of heterogeneity metrics, such as the Simpson or Shannon indices. Secondly, the central part of the transition matrix should be observed. Its values reflect transitions from the patch types on the rows to the patch types on the columns. This core part can be split up in two groups: the values on the diagonal, reflecting those areas which did not go through a change of their land cover, and the values outside the diagonal, representing land cover change. The higher the values on the diagonal relatively to those outside from it, the less dynamic a landscape was in the time period considered. To deal with a new patch type (i.e. a patch type not present on the first land cover map but appearing on the second map), a row should be inserted which contains only zero values. Patch types disappearing from the landscape will be characterized by the overall presence of zero values in their columns.

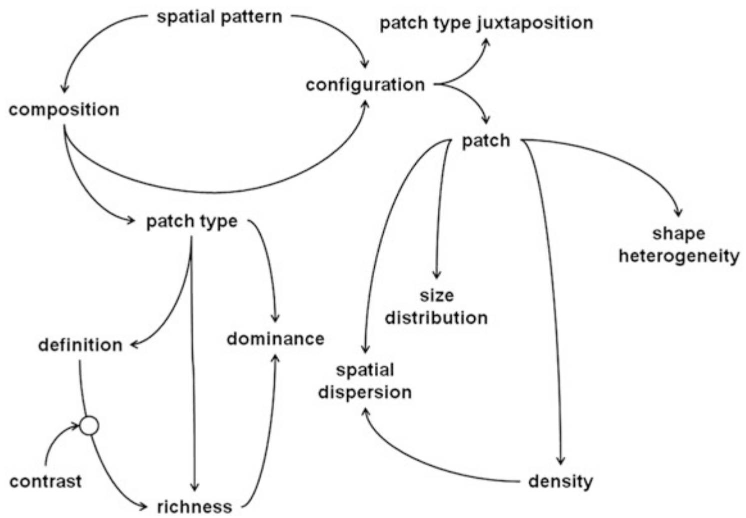

Fig. 8.2 Landscape pattern is determined by landscape composition (patch type dominance, definition, and richness) and configuration (shapes, sizes, dispersion and densities of patches; patch type juxtaposition). Patch type definition depends on the contrast between patch types

The interpretation of the transition matrix can be visualized by a scheme in which arrows indicate the areal exchanges between patch types. Metrics based on the transition matrix could be suggested. The ratio of the sum of the values outside the diagonal to the value on the diagonal could be used to express the dynamics of an individual patch type. Row and column values will enable distinct interpretation. The row values will reflect the tendency of the patch type to lose area to other types; the column values will reflect the tendency of the patch type to increase its extent through land cover change of other patch types. Analogously, the ratio of the sum of the values on the diagonal to the sum of the values outside the diagonal will reflect overall landscape dynamics; in case of maximum dynamics (every areal unit of the landscape is converted into another patch type), this ratio will equal zero; in case of a perfectly static landscape, the ratio will equal infinity.

To detect anthropogenic effects, the nature of the patch types should be taken into account. Exchanges in favor of anthropogenic classes such as urban zones or agricultural patch types will reflect a decrease in the degree of naturalness of the landscape. An application of the landscape disturbance index (O'Neill et al. 1988; August et al. 2002; Barima et al. 2011; Bogaert et al. 2011b; Mama et al. 2013) seems useful in this context. It can be used to verify the hypothesis which relates increasing landscape entropy, i.e. spatial compositional heterogeneity, to higher levels of anthropogenic impact (Bogaert et al. 2005). Figure 8.3 shows that maximum entropy is to be observed at intermediate levels of anthropogenic influence. The aforementioned trends observed by Bogaert et al. (2005) seem to correspond to the upward parts of the curves. The bell-shaped trends in Fig. 8.3 are not unexpected: the extremities of the curves correspond to landscapes with high

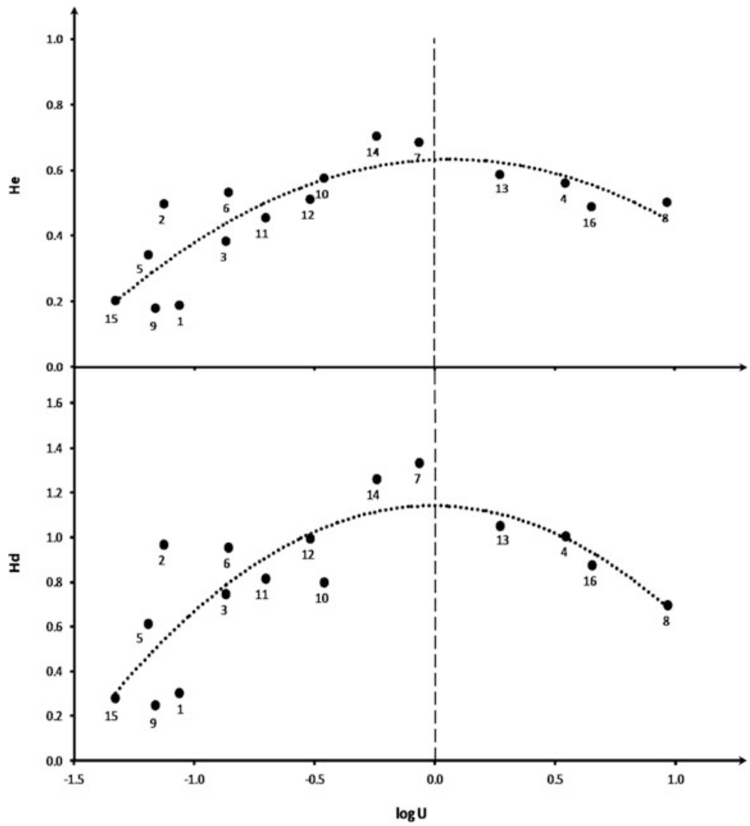

Fig. 8.3 Impact of anthropogenic landscape disturbance on landscape entropy. Compositional spatial heterogeneity is used as a proxy for landscape entropy and is measured by means of the Shannon evenness index (H_e) and the Shannon diversity index (H_d). Anthropogenic impact is measured by a logarithmic transformation of the U disturbance index (O'Neill et al. 1988) which is the ratio between the cumulative area of anthropogenic patch types and the cumulative area of natural patch types. Sixteen study zones from classified Landsat TM scenes in the Democratic Republic of the Congo (labels 4, 8, 9, 10, 14, 15, 16) and Benin (labels 1, 2, 3, 5, 6, 7, 11, 12, 13) have been used. A higher dispersion for landscapes dominated by natural land covers is observed; while natural patterns are generally site-specific and rather unique, patterns of urbanization and agricultural development can be site-independent, leading to pattern uniformity across sites within the same cultural area (Bridgewater and Arico 2002; Grimm et al. 2008). The different relative positions of landscapes in both graphs emphasize the interaction of the number of patch types with evenness

dominance, hence low heterogeneity; in between, equilibrium of anthropogenic and natural types is expected, characterized by higher index values for heterogeneity and evenness. This has noteworthy perspectives since entropy is considered a driver of biodiversity (Fahrig et al. 2011).

The transition matrix can be used to simulate future landscape evolution (Urban and Wallin 2002; Barima et al. 2010b, 2011; Vranken et al. 2011;

Toyi et al. 2013a). To decouple simulations from the time periods characterizing the transition matrix, annual probabilities of landscape change are to be determined. This operation is still subject to debate. The algorithm proposed by Urban and Wallin (2002) could not always be validated (data not shown). The determination of these annual probabilities seems more difficult than expected, and requires a profound mathematical analysis, as shown by Takada et al. (2010).

Patch shape analysis represents a central activity in pattern assessment. Two main analysis types can be distinguished. Firstly, patch shape can be compared to a reference shape, generally an isodiametric one such as a disk or square (Patton 1975; Bogaert et al. 2000c; Bogaert 2001). This analysis is useful when estimating edge effects, which are proportionally larger for elongated or complex shapes than for isodiametric ones of equal area (Forman and Godron 1986; Toyi et al. 2013b). The difference between both shapes can then be expressed by means of a perimeter-to-area ratio, obligatory dimensionless to avoid size effects (Fig. 8.4). Perimeter-to-area ratios are generally based on the isoperimetric principle, which states that of all shapes with an equal perimeter, the disk is characterized by the largest area (Fig. 8.5); the principle could also be interpreted otherwise: of all shapes with an equal area, the disk is characterized by the shortest perimeter. For raster based data, the reference perimeter does not correspond to a circular shape but is a function of the number of pixels composing the patch (Bogaert et al. 2000c; Bogaert and Hong 2004).

The second type of shape analysis consists of the determination of the fractal dimension. Since it cannot be determined for a single patch (i.e. when multi-scalar information is not available), a regression technique is applied to estimate it for a group of patches with similar geometry (Krummel et al. 1987; Imre and Bogaert 2004; Bamba et al. 2009, 2010; Bogaert et al. 2011b; Colson et al. 2011; Diallo et al. 2011). The statistical regression parameters can consequently be interpreted to validate this hypothesis; to guide the analyst in its selection, a common origin of the patches, i.e. a common shape-forming process, could be suggested. In case of shape regularity, which indicates anthropogenic effects, the fractal dimension will tend towards one; for increasing patch complexity, associated with natural patch forming processes, fractal dimension will be significantly higher, with two as its upper bound.

A relationship has been shown between patch size and fractal dimension (Krummel et al. 1987); larger patches are expected to be characterized by a larger fractal dimension since their shapes are determined by natural patterns, such as geomorphologic discontinuities; small patches are often anthropogenic and even when they are natural, their shape is usually determined by adjacent anthropogenic patches. Nevertheless, it should be noted that aggregation of anthropogenic patches can generate complex patch geometries which could be confounded with natural landscape elements (Fig. 8.6).

The dynamics of a patch type can be characterized by the identification of the corresponding transformation process (Forman 1995; Jaeger 2000; Bogaert et al. 2004, 2008; Koffi et al. 2007; Vranken et al. 2011). As for a transition matrix, two land cover maps are needed in a diachronic analysis; the analysis is done per

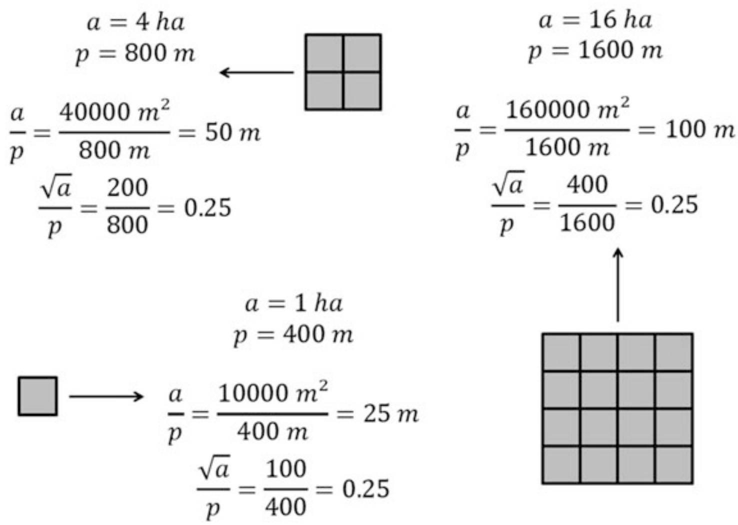

Fig. 8.4 The impact of patch size on patch shape assessment. a is the patch area, p is the patch perimeter. The three square shapes should generate an identical shape index value when their shape is quantified. This is observed for $\sqrt{a}/p$, which is dimensionless. When a/p is used (a non dimensionless metric), larger patches are characterized by larger values, which is to be avoided

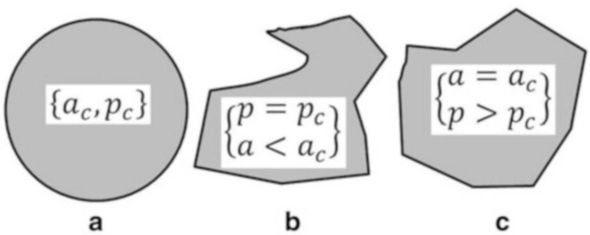

Fig. 8.5 The isoperimetric principle. (**a**) Circular shape with area a_c and perimeter p_c. (**b**) Irregular shape with perimeter $p = p_c$; consequently $a < a_c$. (**c**) Irregular shape with area $a = a_c$; consequently $p > p_c$. No shapes exist for which $p = p_c$ and $a > a_c$ or for which $a = a_c$ and $p < p_c$

patch type. The current technique has the advantage that it is based on basic pattern information (number of patches, patch type area, patch type perimeter) and that it is applicable to patch types with decreasing or increasing area, hence for natural and anthropogenic types, the latter generally characterized by an increase in their extent in time when anthropogenic effects become more dominant. A second advantage is the availability of a decision tree model which guides the analyst directly to the spatial transformation process for the patch type considered; in order to determine the transformation process, the model uses comparisons of the number of patches, patch type area and patch type perimeter before and after transformation of the type (e.g., Bogaert et al. 2004, 2008; Barima et al. 2009; Diallo et al. 2011).

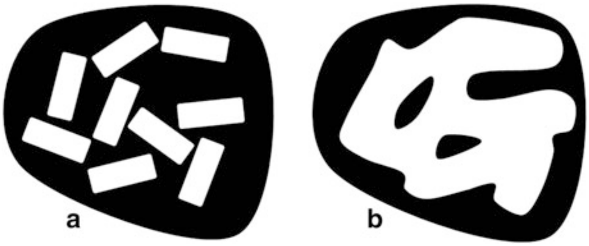

Fig. 8.6 Shape complexity assessment to detect anthropogenic landscape features. (**a**) Patches characterized by uniform and simple shapes are easily identified as anthropogenic landscape elements. (**b**) Patch aggregation and deformation leads to more complex contiguous shapes which could be confounded with natural landscape elements

The idea behind the transformation processes is that land cover dynamics can be represented by series of well-defined pattern change types. In a time series analysis, a process will be determined for each pair of land cover maps. Ten spatial transformation processes have been defined: aggregation, attrition, creation, deformation, dissection, enlargement, fragmentation, perforation, shift and shrinkage. In case of anthropogenic landscape dynamics, natural patch types will be characterized by attrition, deformation, dissection, fragmentation, perforation and/or shrinkage; patch types reflecting anthropogenic activities will show aggregation, creation, deformation, enlargement and/or shift (Fig. 8.7) (Bogaert et al. 2011b).

According to Forman (1995) and Bogaert et al. (2004), the aforementioned processes often show well defined sequences: fragmentation is generally preceded by dissection and/or perforation, and followed by shrinkage and attrition; creation is often followed by enlargement which could in its turn lead to aggregation. However, other sequences should not be excluded (Fig. 8.7), since the temporal resolution of the data influences the determination of the processes and long time periods can hide a series of processes (Bogaert et al. 2004).

The decision tree model enables a distinction between fragmentation and dissection, since the ratio between the patch type area after transformation to the area before transformation is used as an indicator of the impact of the transformation; low values of the ratio are interpreted as fragmentation, while small changes of patch type area suggest landscape dissection (Bogaert et al. 2004; Barima et al. 2009; Diallo et al. 2011). In Forman (1995), no pattern difference was made between both processes. Presumably less significant changes of the patch type pattern, although often easily detectable when expressed as relative changes, could be countered by a double analysis: one considering the change as significant followed by one considering both values as equal.

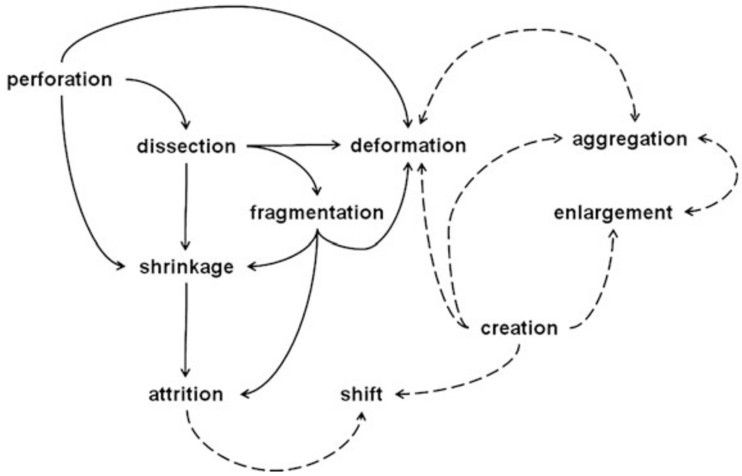

Fig. 8.7 Spatial transformation processes generally observed for natural and anthropogenic patch types. *Arrows* indicate causal relationships and expected sequences in time. *Solid arrows* refer to processes characterizing natural patch types. *Dashed arrows* refer to processes characterizing anthropogenic patch types

8.3 Historical Perspective on Anthropogenic Effects in Landscapes

Anthropogenic effects refer to those land use and land cover dynamics which are caused by human activities. Since Man replaces natural land covers by anthropogenic ones, and since this substitution is not a random one, landscape pattern can be used to detect anthropogenic influence. Historically, noticeable anthropogenic effects are accepted to be associated with the start of agriculture (Fig. 8.8). No other activity has transformed humanity, and the Earth, as much as agriculture (Tilman 1998). In ecological terms, agriculture represents a symbiotic relationship between humans and domesticated plants and animals (Cox and Atkins 1979). It is evident that also earlier in time, i.e. before the invention of agriculture, anthropogenic effects should have occurred; however, due to the low population density, the local (or even sub-patch) character of the land cover changes and the non-sedentary character of the populations involved, they can be accepted of little or no significance. Before the invention of agriculture, it is supposed that Man lived in equilibrium with its environment and that all landscapes were natural landscapes.

Three ages are generally distinguished to subdivide the Holocene: the Paleolithic pre-agricultural era, which ended about 10,000 years BP, the agricultural era, between 10,000 years BP and the industrial revolution (~1800), and the agro-industrial era, since the industrial revolution (Cox and Atkins 1979; Smith 1989; Gupta 2004; Pinhasi et al. 2005; Sheaffer and Moncada 2009; Balaresque et al. 2010). Landscape-scale dynamics have occurred since man has become sedentary. This change of life style is accepted to have been directly related to

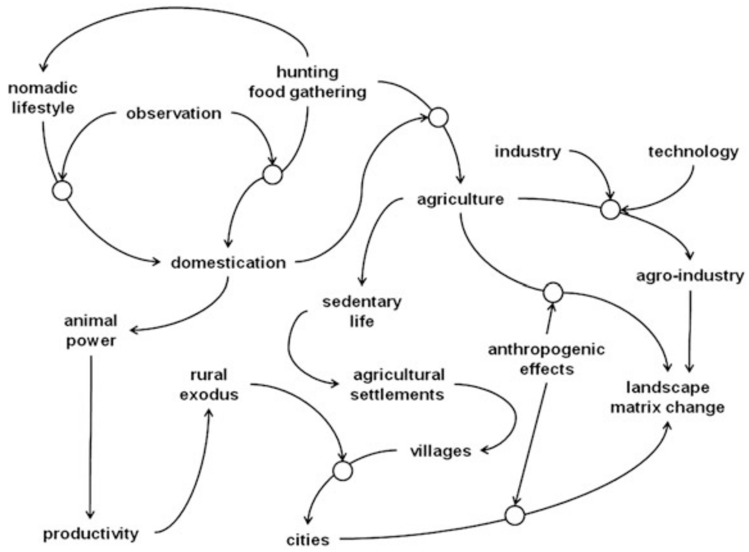

Fig. 8.8 Relationships between the development of agriculture, the evolution of Man's sedentary lifestyle and landscape change. After a period of hunting and gathering food in which nature and its biomass production were observed, Man developed a sedentary lifestyle through domestication of plants and animals. The natural landscape matrix was consequently replaced by an agricultural one. The use of animal energy enabled Man to increase agricultural productivity, leading to rural exodus and the development of villages and cities. After the industrial revolution, agriculture increasingly integrated with industrial activities. Urban development in recent times was only possible by these earlier developments in husbandry. Urbanization actually introduces new landscape dynamics replacing agricultural landscapes by urban ones

the invention of agriculture in the Neolithic era. Early hominids were hunters and gatherers who relied on naturally occurring vegetation, fruits, nuts, carrion and game for subsistence (Gupta 2004; Sheaffer and Moncada 2009). Hunters and gatherers did not establish permanent settlements such as villages. They moved their camps in response to changes in the season and climate (Gupta 2004).

Among the most significant examples of human impact on the evolution of ecological niches come from domestication of animals and plants; domestication refers to the process of reciprocation, by which animal and plant species come to depend on humans for survival, while providing humans with numerous benefits in turn (Cox and Atkins 1979; Gupta 2004). The process of domestication has been markedly important for spatial expansion and population increase of humans during the Holocene (Soja 2003; Gupta 2004; Sheaffer and Moncada 2009). It is however noteworthy that this link between agricultural development and population growth is still subject to debate (Childe 1950; Kohl and Wright 1977; Armelagos et al. 1991). Domesticated species were of prime importance for agriculture: without agriculture, the complex, technically innovative societies and large human populations that exist today could not have evolved (Gupta 2004). Husbandry is consequently defined as the cultivation of domesticated plants and animals for use by human societies, as many domesticated plants and animals would not survive without human intervention (Gupta 2004). As for grain crops, the main selection criteria involved, next to increased plant yield, also increased seed size, non shattering seed, naked seed and reduced seed toxins (Sheaffer and Moncada 2009).

Agriculture allowed and even forced people to become sedentary, which can be defined as living for a prolonged period in one place, as establishing permanent villages and towns and as developing classified societies that included dedicated social or professional segments such as farmers, artisans, soldiers, religious leaders, teachers and governors (Gupta 2004). The shift from the nomadic life style of the hunters and gatherers to the sedentary one of the early farmers was suggested to have been a consequence of the larger amount of energy required for hunting and gathering than for agricultural practices to obtain the same calories of food energy (MacDonald 2003; in Gupta 2004), together with the intrinsic dynamics of human populations and more favorable climates leading to the exuberance of vegetation and diversification of the plant communities (Gupta 2004; Sheaffer and Moncada 2009).

It is appealing to detail these links between the start of husbandry, the founding of settlements, the development of villages, and the origin of cities. Increasing agricultural productivity is suggested as a key concept in this sequence. While agricultural production itself refers to the total quantity of biomass produced, the productivity concept expresses this quantity as a function of the production factors used (e.g., Van Zanden 1991). These factors can be numerous and heterogeneous, such as the time between the preparation of the land and the final yield, the number of farmers involved in production, the production surface used, energy inputs, or the quantities and types of fertilizers used. The nomadic lifestyle of Man before the development of agriculture and its dependence on natural rhythms and production had taught Man to observe and understand its environment. Through this necessity to adapt his life style to nature, Man acquired knowledge on the production of biomass in nature (Braidwood 1979; Sheaffer and Moncada 2009). Later on, agricultural productivity was increased, e.g. by use of energy provided by domesticated animals (Demangeon 1933; Childe 1950; Davis 1955; Kohl and Wright 1977; Smith 2009). This enabled individuals to leave the agricultural sector. Through this tendency, the initial agricultural settlements, which were still dominated by farmers and their families, were converted into (non-agricultural) villages, and later on, into urbanized zones. Between 6000 and 4000 B.C., certain innovations (such as the ox-drawn plow) facilitated, when taken together, a more intensive and more productive use of the Neolithic elements themselves; the rise of cities and towns required in addition to highly agricultural conditions, a form of social organization in which certain strata could appropriate part of the produce grown by the cultivators (Davis 1955).

One can agree with the dominant view that the diverse technological innovations constituting the Neolithic culture were necessary to the existence of settled communities (Davis 1955). Surprisingly, Soja (2003) states that no agricultural surplus was necessary for the development of cities, but that cities were necessary for the production of an agricultural surplus, at least in certain regions in the world. This hypothesis is denoted a persistent error in the non archeological literature: archeological records show quite clearly and consistently throughout the world that the Neolithic revolution (agriculture) occurred first, and only afterwards did the first cities emerge (Smith 2009).

It should be noted that land change to build cities and to support the demands of urban populations itself drives other types of environmental change: urban dwellers depend on the productive and assimilative capacities of ecosystems well beyond their city boundaries (ecological footprint concept), to provide the flows of energy, material goods and nonmaterial services that sustain human well-being and quality of life (Grimm et al. 2008; Vranken et al. 2011; Seto et al. 2012).

Agriculture also evolved throughout history. A tendency towards uniformity (of production systems and crops) on large scales has been observed (Ramade 2005), stimulated, amongst others, by the green revolution (Evanson and Gollin 2003), the sustainability and socioeconomic impacts of which have been criticized. New technologies have been applied, and high levels of energy input have become characteristic for production. The use of energy in multiple farming systems and for different crops has been debated (Cox and Atkins 1979; Cleveland 1995; Ramade 2005; Gliessman 2006; Pimentel and Pimentel 2008; Pimentel et al. 2008; Pimentel 2009; Sheaffer and Moncada 2009); larger energy inputs are not always coupled to higher energy efficiency. Moreover, a shift towards the production of feed and biofuels instead of food has been observed, despite their less favorable energy balance and environmental issues (Pimentel 2003; Pimentel and Patzek 2005; Gliessman 2006; Groom et al. 2008; Pimentel et al. 2009). Growing crops for biofuel not only ignores the need to reduce natural resource consumption, but exacerbates the problem of malnourishment worldwide by turning food grain into biofuel (Pimentel et al. 2009): this raises major ethical and moral issues (Pimentel 2003; Pimentel and Patzek 2005). The aforementioned trends, combined with the increasing demographic pressure, will have profound impacts on landscapes, since larger areas will be required to produce biomass to directly feed humans, to grow livestock, and to provide alternatives for fossil fuels. This potential spatial impact of biofuel production is discussed in Groom et al. (2008).

8.4 Agriculture and Urbanization: Matrix Competitors

Agricultural development from a local, low productive activity to an extensive, high yielding production process based on high energy inputs, has put his footprint on societies and landscapes. Through technical developments and concomitant fossil fuel consumption, one farmer has nowadays become able to produce more per unit area and on larger extents than ever before. Therefore, it can be accepted that agricultural land uses became dominant in landscapes through time and have replaced the original natural patch types, such as forests, by anthropogenic ones, such as fields, fallow lands, pasture lands or agricultural buildings. This tendency,

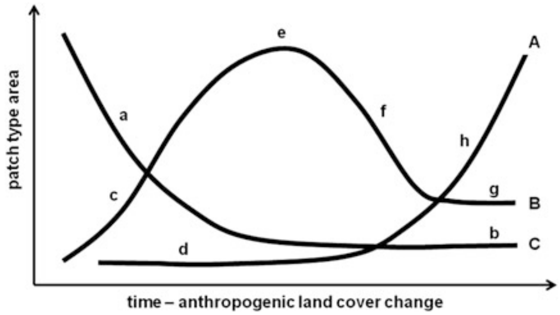

Fig. 8.9 Historical perspective of typical landscape dynamics (theoretical model). Initial natural patch types (*C*) decreased in area (*a*) after the invention of agriculture and were only partially preserved (*b*). Agricultural patch types (*B*) increased (*c*) after the invention of agriculture and became dominant (*e*). The decrease of agricultural patch types (*f*) and their smaller final extents (*g*) were caused by urban growth (*A*) which accelerated (*h*) due to continuous rural exodus and intrinsic urban population growth after an initial period of settlement (*d*). Trends shown are not to be interpreted quantitatively, since their magnitudes are not representative and intend to illustrate expected landscape dynamics only. Model mainly inspired on northern hemisphere landscapes

often detected as deforestation, has been frequently observed (Lepers et al. 2005). This increase of patch types related to farming consequently decreased the cumulative area of natural areas; often only non fertile areas or difficultly accessible zones such as mountains or swamps were not converted into farmland. Land accessibility is often cited as the main cause of landscape change, next to their intrinsic properties (August et al. 2002). The landscape matrix, which has been dominated exclusively by natural patch types before the arrival of agriculture, was consequently systematically replaced by an anthropogenic, agricultural matrix (Figs 8.9 and 8.10). The area increase of the anthropogenic type(s) was mainly caused by patch creation, enlargement and aggregation. The decreasing overall area for the natural patch types was the consequence of perforation, dissection, fragmentation, shrinkage and attrition.

Not only total patch type area, but also the number of patches per type was influenced by this substitution (Fig. 8.11). Initially, both types, natural and anthropogenic, were characterized by an increase in their number of landscape elements. This increase could have been expected to be faster for the natural than for the anthropogenic types, since anthropogenic activities, especially farming, are considered to have been more efficient when aggregated in space: short distances between farmlands were preferred and adjacent lands even more. This increase in the number of patches slowed down when patches started aggregating (for anthropogenic types) or disappearing (for natural types). When the substitution had continued, finally both types would have been characterized by a low(er) number of patches, and the final frequencies of patches could then be described using the typology of Forman and Godron (1986) categorizing them in disturbance patches, remnant patches, introduced patches and environmental resource patches, according to their origin or cause of existence (Fig. 8.12).

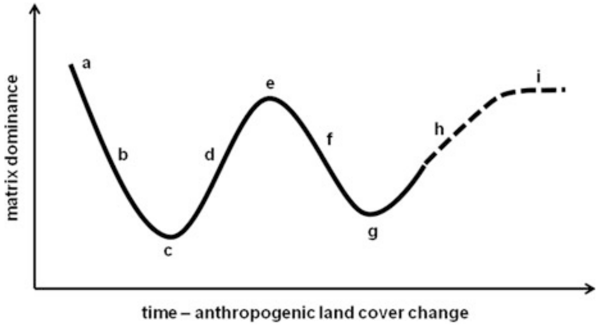

Fig. 8.10 Schematic representation of the historical evolution of the landscape matrix in which anthropogenic patch types have become dominant (theoretical model). (*a*) dominance of the initial natural patch types; (*b*) decrease of the matrix dominance of natural patch types due to area increase of agricultural patch types; (*c*) co-dominance of natural and agricultural patch types; (*d*) increasing dominance of agricultural patch types; (*e*) maximum dominance of agricultural patch types; (*f*) decrease of agricultural patch types because of substitution by urbanization; (*g*) co-dominance of urban and agricultural patch types; (*h*) increasing dominance of urban patch types; *i*) equilibrium state (hypothesis). Trends shown are not to be interpreted quantitatively, since their magnitudes are not representative and intend to illustrate expected landscape dynamics only. Model mainly inspired on northern hemisphere landscapes

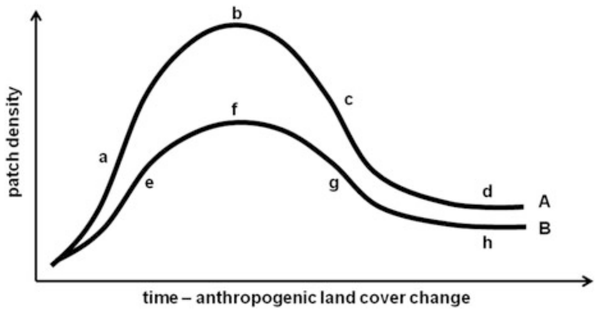

Fig. 8.11 Evolution of patch density when a natural land cover (*A*) is replaced by an anthropogenic one (*B*). Theoretical model of the replacement of a natural landscape matrix by an agricultural one. Initial patch density increase of natural patch types is mainly caused by dissection and fragmentation; the later decrease of patch density is caused by patch attrition. The initial increase of anthropogenic patch density is expected to be caused by patch creation. Due to patch proximity, patch enlargement, and ongoing patch creation, anthropogenic patches are hypothesized to aggregate more rapidly to form large contiguous landscape elements forming the landscape matrix, which decreases patch density of this type. Crossing curves should not be excluded

This substitution of a natural matrix (of which the land cover types were mainly determined by the abiotic context, such as the climate or geomorphology) by an agricultural one could have been repeated later on, but this time when an urban matrix was replacing the formerly dominant agricultural one. Urbanization is namely expected to be dominant in contemporary landscapes, with a dominant

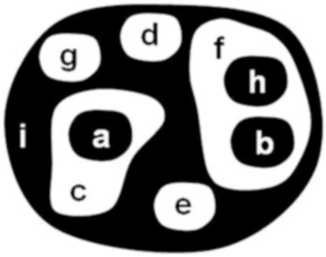

Fig. 8.12 Patch typology (Forman and Godron 1986). (*a*, *e*) disturbance patch; (*b*, *h*) remnant patch, natural patch type; (*c*, *d*) environmental resource patch, natural patch type; (*f*, *g*) introduced patch, anthropogenic patch type; (*i*) landscape matrix, natural patch type

urban world population projected for the middle of the twenty-first century (Grimm et al. 2008; Montgomery 2008); urban land cover could even increase by >1 million km^2 by 2030, nearly tripling the global urban land area circa 2000 (Seto et al. 2012). For centuries, cities were compact with high population densities, with limited physical extents; this trend has been reversed over the last 30 years with urban areas that are nowadays expanding on average twice as fast than their populations (Seto et al. 2012). For the United States, a >30 % of increase of the amount of land devoted to urban and built-up uses between 1982 and 1997 was noted (Alig et al. 2004).

Two major pathways of urban impacts on land cover are to be considered. In the developed world, large-scale urban agglomerations and extended peri-urban settlements fragment the landscapes of such large areas that various ecosystem processes are threatened; however, ecosystem fragmentation in peri-urban regions may be offset by urban-led demands for conservation and recreational land uses; on the other hand, in less developed countries, urbanization seems to outbid all other uses for land adjacent to the city, including prime croplands (Lambin et al. 2001). Urban zones are characterized by rapid enlargement and the management of peri-urban zones, where rural and urban areas meet and conflict, announces itself as a key issue for landscape ecology in the near future, although an unambiguous functional and morphological definition and identification of peri-urban zones remains subject to debate (Fig. 8.13) (Forman 2008; André et al. 2012). These peri-urban environments are the glue that link core cities in extended urbanized regions (Grimm et al. 2008): the “edge” of the city expands into the surrounding rural landscape, including changes in soils, built structures, markets, and informal human settlements, all of which exert pressure on fringe ecosystems.

Thus, according to the aforementioned landscape dynamics model, which can be denoted as the “nature-agriculture-urban model”, natural landscapes are replaced by anthropogenic ones, initially dominated by agriculture, later on by land covers reflecting urban development. It should be noted, however, that there are different trajectories of land cover change in different parts of the world (e.g., decrease of cropland in temperate areas and increase in the tropics) (Lepers et al. 2005). This observation confirms the aforementioned model with tropical countries still expanding their agricultural matrix while in temperate zones the urbanization has

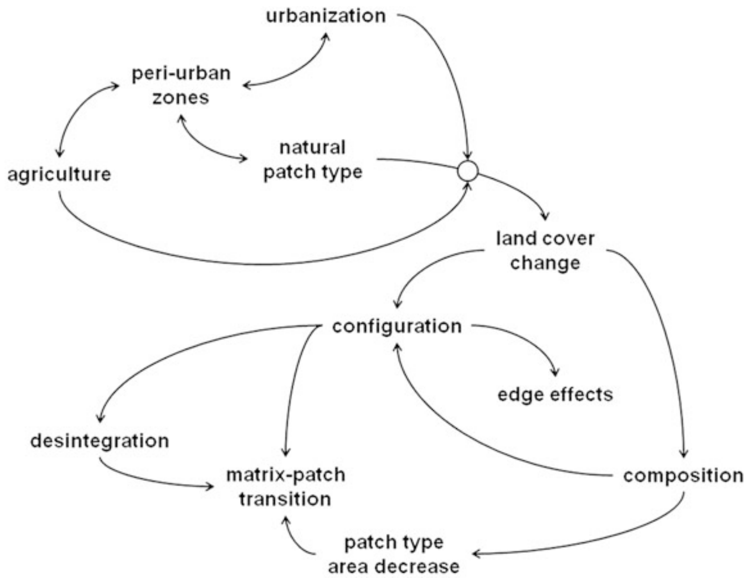

Fig. 8.13 Urbanization and agriculture alter the composition and configuration of natural patch types. A disintegration and area decrease of natural patch types is observed and contiguous zones are replaced by isolated patches subject to edge effects. The natural matrix is transformed into a scattered pattern of remnant patches. An anthropogenic matrix dominates now the landscape. Urban growth leads to functional and structural rural-urban conflicts in peri-urban areas

already taken over, although a co-dominance of both agriculture and urbanization should not be excluded. Agricultural development and urbanization are not synchronized between developed and developing countries but since both hemispheres seem to follow the same model, the outcome of both evolutions is predictable. In Forman and Godron (1986) a similar, five-step anthropization gradient was presented, with natural, managed, cultivated, suburban and urban landscapes.

8.5 Concluding Commentary: Space Is a Limited Resource

The concept of limited (or not renewable) resources refers to those elements that can be extracted or consumed but for which the available quantity is considered well-defined. When a fraction of the resource is used, the remaining quantity consequently declines. Sometimes, this consumed quantity can be restored after a long period, but the delay is often too long to consider the resource as renewable. This concept of resource limitation can also be applied in landscape ecology. Landscapes are composed of different types of land cover which each occupy a fraction of a geographical space. This geographical space is limited, i.e. it corresponds to a well-defined extent. Consequently, space could and should be considered as a limited resource: the use of space by one land cover type reduces the remaining space available to other types.

This recognition of space as a limited resource underlines the importance of landscape ecology in preserving sufficient space with an optimal configuration to enable a coexistence of the development of anthropogenic activities with the preservation of ecosystem services (Costanza et al. 1997; Pimentel et al. 1997), even in an urban context (Bolund and Hunhammar 1999; Tratalos et al. 2007). For the foreseeable future, the fate of terrestrial ecosystems and the species they support will be intertwined with human systems: most of "nature" is nowadays embedded within anthropogenic mosaics of land use and land cover; while climate and geology have shaped ecosystems and evolution in the past, human forces may now outweigh these across most of Earth's land surface today (Ellis and Ramankutty 2008).

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Chapter 9
Biodiversity of Traditional Agricultural Landscapes in Slovakia and Their Threats

Jana Špulerová, Marta Dobrovodská, Dagmar Štefunková, Andrej Bača, and Juraj Lieskovský

Abstract Traditional agricultural landscapes (TAL) represent ecosystems that consist of a mosaic of small-scale arable fields and permanent agricultural cultivations such as grasslands, vineyards and high-trunk orchards. Diversity of TAL was studied on two levels: as the ecosystem diversity based on the type and intensity of land use of these biocultural landscapes, focusing on habitats related to forms of anthropogenic relief (FAR), which are significant as unique islands of species-rich communities in the agricultural landscape. To classify the identified TAL we considered the presence of specific land use elements and we distinguished four classes of TAL: (I) TAL with Dispersed Settlements, (II) TAL of Vineyards, (III) TAL of Arable-Land, Grasslands and Orchards (IV) TAL of Arable-Land and Grasslands. Plant species composition on mapped FAR shows high diversity of habitats, from open secondary screens and rocky habitats through rural communities and semi-natural grasslands to shrubby habitats, lines of trees or other small woody patches.

Keywords Traditional agricultural landscapes • Slovakia • Biodiversity • Plant species

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9.1 Introduction

The present biocultural landscape is a result of development which has been carried out for several thousand years. Geological, geo-morphological, climatic diversity, variability of cultures, political-economic systems have created a favourable basis for diversity of differing types of cultural landscapes (Solymosi 2011). In Slovakia the agriculture was the most dominant human activity and the agrarian culture was the essential part of the culture of inhabitants. Over decades man applied its wisdom, knowledge and skills inherited over generations with respect to nature and its resources. Traditional, and low-intensity, land-use practices of agriculture and forestry greatly promoted habitat diversity in the European human-dominated landscapes in the past, before the rapid agricultural intensification after the Second World War (Bignal and McCracken 1996; Schmitzberger et al. 2005). Due to special land law and various natural and cultural conditions of Slovakia past agricultural landscapes were typical by variability in terms of land use, and plot shape and size. Secondary, creation of the *forms of anthropogenic relief* (FAR) – balks, as a result of improving soil and relief quality, created absolutely new stands for vegetation and animals. There were thousands of kilometres of such habitats and the biodiversity of agricultural landscape was very high in comparison to the forested land. They complemented productive lands and together they formed a mosaic-structured landscapes.

During the period 1950–1990 there was a rapid and large structural change of the agricultural landscapes in Europe caused by intensification and mechanisation of agriculture (Chamberlain et al. 1999; Donald et al 2001; Cebecauerova and Cebecauer 2008). Intensification of agriculture was linked with collectivization and removal of hedges and riparian vegetation, decreasing the mosaic of arable fields, grasslands and woods. Landscape mosaics were transformed into large-block fields. Only in less accessible, less fertile localities the original agricultural landscapes were partially preserved, and did not lose the shape of a cultural-historical countryside (Špulerová et al. 2010). These areas represent regions with specific combinations of natural and cultural diversity, including high visual quality of landscape. They can be described as *traditional agricultural landscapes (TAL)***,** represented by mosaic of small-scale arable fields and permanent agricultural cultivations as grasslands, vineyards or high-trunk orchards or early abandoned plots of low succession degree, which have not been affected by agricultural collectivization (Dobrovodská et al. 2010). They are characterized by some of the following features:

- small scale structure of plot division have been preserved
- original forms of anthropogenic relief (balks) have been preserved
- primary land use was not changed during collectivization of agriculture
- some features of traditional agricultural technologies have been preserved.

TAL represents a special type of biocultural landscape and it is found in areas where the past human activities marked the landscape with characteristic signs and where traditional agricultural land use persisted (Huba 1988). These areas have been preserved mostly as small remnants surrounded by intensive farmland or forest, they are becoming rare and therefore highly valuable in Europe. Facing the disappearance of these type of biocultural landscapes, an initial action was focused to get knowledge about the present state of TAL in Slovakia, to understand their role for biodiversity and pressures and to stimulate action for preserving their value.

The objective of the study was to point to the biodiversity of TAL and threats to it, based on the results of the countryside inventory of TAL over the entire Slovak territory.

9.2 Methodology

Countryside inventory of TAL was performed as a combination of methods of *visual interpretation* of aerial photos and *field survey*. In GIS, we identified TAL sites as polygons on aerial photos (taken in 2007) for the whole territory of Slovakia and registered their following characteristics: intensity of management, cover of present land use elements, abundance of non-forest vegetation, shape and position of land parcels towards the slope and presence of visible FAR.

To validate the above characteristics in the field and to record further ones, we randomly selected 20 % of identified TAL sites using statistical sampling within 15 natural-settlement nodal regions with administrative boundaries (Miklós 2002). These regions were determined in terms of analytical data on nature, contemporary landscape use and socio-economic elements. They reflect rugged topography of Slovakia from lowlands, hilly and uplands areas to mountain ridges, typological differences (including for instance economic, differences in accessibility of underground waters) and are characterized from point of view of position, dissection of their core parts and prevailing function.

In 2009–2011 the field team mapped selected sites in the field according to the handbook produced for this purpose by Dobrovodská et al. (2010). The field form consisted of three parts: (A) Basic mapping data, (B) Characteristics of TAL and (C) Additional information. Characteristics of TAL (B) were focused on the intensity of management, cover of present land use elements (including non-forest woody vegetation), shape and position of parcels and on parameters of present FAR. Special attention was paid to study the habitat diversity on FAR (including their species composition). The field team recorded the threats to TAL and took further notes on the present land use. Additional information (C) about elements of small architecture and significant species and habitats aimed to provide increased knowledge on significance and on historical, cultural and natural values of TAL.

From the biodiversity point of view we assessed especially the presence of types of FAR within the TAL classes, presence of habitat types and of special species on FAR (species with highest frequency and cover, threatened, protected and invasive species). Multivariate gradient analyses of species composition were run in the CANOCO software (ter Braak et Šmilauer 2002) to investigate variability of plant communities on FAR (across the range of different classes of TAL and types of FAR) and factors explaining this variability (altitude, latitude, longitude, proportion of rocky material in the substrate, the type of FAR, acidity of substrate, slope orientation and soil type).

9.3 Study Area

The Slovak Republic is geographically situated in the Carpathian Arch and Pannonian Basin in the altitude from 94 m up to 2,655 m. 41 % of the area represent lowlands and 59 % represent mountains. It belongs to mild climate zone with four distinct seasons (Landscape Atlas of the SR 2002). January is the coldest month and July the warmest month of the year. The average rainfall in Slovakia reaches 700 mm. Rainfall averages from 450 mm in the south-western part of Slovakia to 1,500 mm in the mountainous areas of the High Tatras. Twenty percent of the total annual precipitation is snowfall. Rugged topography of the country features regions of Carpathian Mountains, separated by valleys and intermountain basins and two large lowland areas on the south.

Varied topography of Slovakia supports a wide variety of vegetation. Based on floristic regionalization of Europe (Kolény and Barka 2002), Slovakia is part of Euro-Siberian sub-region and two provinces: Central-European and Pont-Pannonia.

Agriculture in Slovakia represents the most dominant activity of its inhabitants. It results from optimum conditions for plant and animal production and from social-political development as well. At the present time agricultural land occupies 49.2 % of Slovak territory. Of that, 58.7 % is arable land, 36.3 % permanent grasslands, 3.2 % gardens, 1.1 % vineyards and 0.7 % orchards (UGKK SR 2012). The production of crops is definitely the most dominant. From the point of view of space differentiation, the most intensive agricultural production, with the prevalence of large-block arable land, but with the lowest proportion of line vegetation and small-scale non-forest woody vegetation, is found in the south-western region of Slovakia in the productive Podunajská nížina lowland and Východoslovenská nížina lowland. The balanced share of arable land and permanent grasslands with the more expressive part of non-forest wood vegetation and the lower intensity of agricultural production can be found in the region of Slovak basins. The prevailing permanent grasslands with very low agricultural production are situated in the mountain areas of the Central and Eastern Slovakia, where TAL has been preserved.

9.4 Results

9.4.1 Countryside Inventory of Traditional Agricultural Landscapes in Slovakia

From the GIS analysis and field mapping we built up the database of sites of TAL of Slovakia. Altogether, a total of 3,010 TAL sites were identified across the whole Slovakia based on aerial photos. Out of that, 626 sites of TAL were validated in the field (20.6 %), finally altogether 593 relevés were recorded in the field.

On the basis of presence of dispersed settlements, vineyards, orchards we have distinguished four classes of TAL (Špulerová et al. 2011):

1. TAL with Dispersed Settlements,
2. TAL of Vineyards,
3. TAL of Arable-Land, Grasslands and Orchards,
4. TAL of Arable-Land and Grasslands.

From the database we conclude that the distribution of four classes of TAL throughout Slovakia is not balanced (Fig. 9.1). TAL with their small-scale mosaic elements are mostly preserved in hilly and mountain regions. These regions have unsuitable conditions for intensive agriculture.

9.4.2 Biodiversity of Traditional Agricultural Landscapes

Previous research study showed that habitats of TAL of Slovakia, which were not affected by intensification of agriculture, create islands of species-rich plant and animal communities (Imrichová 2006). As main sources of local biodiversity, they are linked to balks and margins of cross field tracks, original meadows and pastures, arable fields abandoned after collectivization and overgrown by grass, small wetlands or other low-production or unfavourable areas (Ružičková et al. 1999).

Results of our countryside inventory of TAL and its habitats on FAR approved this hypothesis. Altogether, a total of 938 plant taxa were recorded on 593 identified relevés of FAR. Out of that, 94 taxa represent trees and shrubs (11.5 %) that significantly increase spatial diversity of the landscape.

FAR were characterized by proportion of rocky material in the substrate, size parameters (width, height and length), percentage cover among other FAR, connectedness of shrubs and trees as well as the plant species composition. Six types of FAR that originated as a result of improving soil and relief quality of cultivated land were observed in the field (Fig. 9.2).

(a) Forms, which are result of the improvement of relief-soil quality, mostly further on directly cultivated:

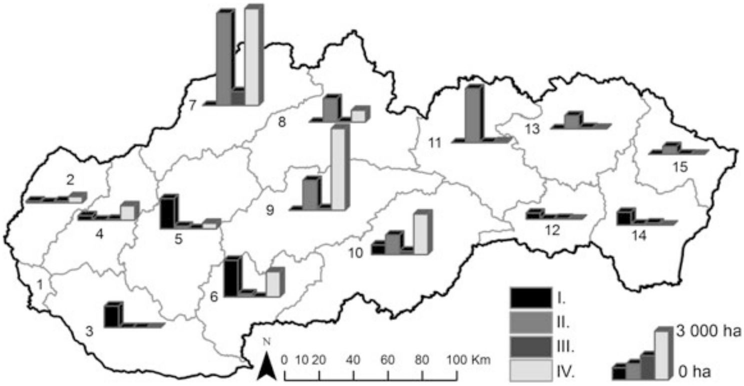

Fig. 9.1 Spatial representation of classes of traditional agricultural landscapes (*I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards, *IV*. TAL of Arable-Land and Grasslands) in Natural-settlement nodal regions of Slovakia (*Regions: 1*. Bratislavsko-metropolitný, *2*. Záhorský, *3*. Podunajský, *4*. Trnavský, *5*. Ponitriansky, *6*. Dolnohronsko-dolnoipeľský (Hontský), *7*. Považský (Trenčiansko-žilinský), *8*. Turčiansko-liptovsko-oravský, *9*. Pohronský, *10*. Novohradský, *11*. Spišský, *12*. Košický, *13*. Šarišský, *14*. Dolnozemplínsky, *15*. Hornozemplínsky) in ha

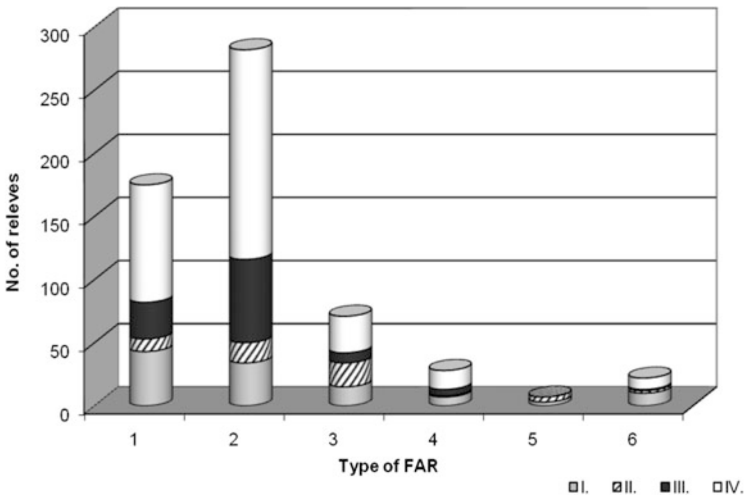

Fig. 9.2 The presence of forms of anthropogenic relief (*1*. terrace slopes, *2*. step balks, *3*. lengthwise mounds, *4*. solitary heaps, *5*. unconsolidated walls, *6*. mounds/heaps on terrace slopes) that were observed in classes of traditional agricultural landscapes in Slovakia (*I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards, *IV*. TAL of Arable-Land and Grasslands)

- *Terrace slopes* have been created in the course of long-term land cultivation of arable fields on steep slopes that resulted in parallel plateaus and grassy slopes (balks). Terrace slopes are composed of soil with different proportion of skeleton depending on type of soil and sub-soil layer. Proportion of skeleton on terrace slopes was increased also by farmers who accumulated here the stones removed from neighbouring managed plots. The terrace slopes represent the second largest group of mapped FAR and they are characteristic mostly for the TAL of Arable-Land and Grasslands. Average number of recorded species was high (38.4). Constant taxa with percentage frequency of occurrence more than 50 % for all recorded relevés on terrace slopes are *Rosa canina, Dactylis glomerata, Vicia cracca, Achillea millefolium, Galium mollugo, Hypericum maculatum, Arrhenatherum elatius, Agrostis capillaris, Ranunculus acris, Veronica chamaedrys.*

- *Step balks* were created on the bounds of fields through ploughing, without making the relief of arable plots horizontal. Unlike terrace slopes, they are situated on moderate slopes corresponding to these slopes. The height of step balks is up to 1 m. Skeleton and soil content of balks is indicated as muddy, muddy-rocky or less-frequent loamificated rocky, depending on soil and sub-soil layer. They represent the largest group of mapped FAR type. They are characteristic mostly for the TAL of Arable-Land, Grasslands and Orchards and for the TAL of Arable-Land and Grasslands. They are characterized by highest species richness (average number of recorded species on FAR – 41.1 species) and similar species composition as on terrace slopes (the same seven constant taxa with percentage frequency of occurrence more than 50 % – *Rosa canina, Dactylis glomerata, Vicia cracca, Achillea millefolium, Galium mollugo, Arrhenatherum elatius, Veronica chamaedrys).*

(b) Forms, which are result of the soil- skeleton removing, mostly further on directly not cultivated

- *Lengthwise mounds* have been created gradually by merging of heaps. They create linear concave stone features, characterized by different skeleton and soil content. Their length is at least three times longer than their width. They are less frequent (69 recorded sites) and they are equally presented in all TAL classes, with the highest proportion in the TAL of Arable-Land and Grasslands. Average number of recorded species for this type of FAR was 35.2. Spatial diversity is increased by the dominance of trees and shrubs, which are included among the constantly present taxa *Fraxinus excelsior, Acer campestre, Corylus avellana, Galium mollugo, Rosa canina,* less frequent *Prunus spinosa, Geranium robertianum, Swida sanguinea.*
- *Solitary heaps* were formed from the stones removed during annual ploughing and deposited to one place within a field or along its edge. They are concave stone features of elliptical to irregular radial pattern that was conditioned by cultivation of arable land along solitary heaps usually situated in the centre of the plots. Soil content is dependent on distribution of rocks, biomass decomposition, erosion and other processes. Open spaces and small coverage of vegetation makes of them habitats with the lowest

average number of species (24.6). The most frequent species were *Rosa canina, Urtica dioica, Acer pseudoplatanus, Veronica chamaedrys, Geranium robertianum, Galium mollugo, Fraxinus excelsior, Corylus avellana.* None of them has frequency of occurrence more than 50 %.

- *Unconsolidated (dry stone) walls* were built from stones as supporting walls for a vineyard terrace and somewhere for an orchard terrace. Terraces of vineyards and orchards were created by man and his direct transformation of relief. In the present many of walls are partly ruined due to lack of maintenance. They are very rare and were observed mostly within the TAL of Vineyards, less in the TAL with Dispersed Settlements. They are characterized by average number of recorded species 35 and by the constant taxa as *Rosa canina, Cerasus avium, Prunus domestica, Veronica chamaedrys, Anthriscus sylvestris, Acer campestre, Tithymalus cyparissias, Quercus cerris.*

(c) Forms, which are result of combination of the two mentioned methods of soil cultivation

- *Mounds/heaps on terrace slopes* were shaped by removing stones from the soil and by heaping them on the terrace slopes or step balks during annual ploughing. Their surface is irregular. To examine species richness, the average number of recorded species is 30.9, and four constant taxa were most frequent: *Veronica chamaedrys, Fraxinus excelsior, Cerasus avium, Fragaria vesca.*

Plant species composition on mapped FAR shows high diversity of habitats (Stanová and Valachovič 2002) from open secondary screens and rocky habitats through rural communities and semi-natural grasslands to shrubby habitats, lines of trees or other small woody patches (Table 9.1). Some of the mapped habitats represent vegetation units, as alliance or association. Some of them we could not assign to a particular syntaxin, whereas they are affected by human activities or different phases of successional development between grassland, scrubland and forest.

Forms of anthropogenic relief represent also a refuge for many rare and endangered species. Altogether, 62 species of rare and endangered species and 8 endemic species were recorded in the field, out of them 30 are protected under the Regulation of Ministry of the Environment No. 579/2008 of Col (Tables 9.2 and 9.3).

Indirect gradient analysis in CANOCO for Windows programme (ter Braak et Šmilauer 2002) of plant species composition of the mapped FAR did not show high dissimilarities of species composition between different types of FAR. On the other hand, the results reflected significant difference between the species composition of FAR present in the TAL of Vineyards and in other classes of TAL (see also Fig. 9.3), mainly due to the increased presence of synanthropic species in vineyards, as *Ambrosia artemisiifolia, Anagallis arvensis, Cannabis ruderalis, Conyza canadensis, Digitaria sanguinalis, Echinochloa crus-galli, Galinsoga urticifolia,*

Table 9.1 Presence of habitats on forms of anthropogenic relief within classes of Traditional Agricultural Landscapes (*I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards, *IV*. TAL of Arable-Land and Grasslands), expressed by number of recorded relevés

	Class of TAL (Number of recorded relevés)			
	I	II	III	IV
Scree and rocky habitats				
Secondary scree and rocky habitats		2	2	9
Secondary calcareous scree and rocky habitats	5	2		7
Secondary siliceous scree and rocky habitats		12	1	1
Seminatural dry grasslands				
Semi-natural dry grasslands and scrubland facies on calcareous substrates			1	
Rupicolous pannonic grasslands (*Stipo-Festucetalia pallentis*)				1
Xero-thermophile fringes			1	
Mesophilous fringes	6	2	9	19
Species-rich *Nardus* grasslands	1			
Herbaceous clearings				3
Ruderal communities outside of the settlements	11		6	27
Bare tilled, fallow or recently abandoned arable land				8
Meadows and pastures				
Lowland hay meadows	14	1	12	34
Mountain hay meadows	10		4	20
Mesophilous pastures	5	1	6	24
Eutrophic humid grasslands				1
Shrub habitats				
Slope and under-slope alder shrubs (*Corylo-Alnetum incanae*)				1
Habitats with *Sambucus nigra, Sambucus racemosa*		1		
Continental deciduous thickets				3
Rich-soil thickets	1		2	11
Peri-pannonic thickets	2	2	4	22
Subcontinental hazel thickets	7		5	17
Lines of trees				
Lines of fruit trees	3	2	14	6
Lines of deciduous trees	9	9	6	12
Lines/Small woodland of mixed successional trees	7	9	5	31
Lines/Small woodland of invasive trees				1
Not identified – combination of several communities/ succession	31	9	31	55
SUM	112	52	109	313

Geranium dissectum, Sambucus ebulus, Senecio viscosus, Setaria viridis, Solanum nigrum, Tithymalus tommasinianus, and others.

Even though not representing whole areas of the TAL sites, the plant species composition of FAR showed high similarity between the classes of TAL without vineyards. In fact they all contain arable fields and grasslands and from the landscape point of view they differ only due to the presence or absence of specific

Table 9.2 Occurrence of rare and threatened vascular plant taxa (Feráková et al. 2001) and species protected under the Regulation of Ministry of the Environment No. 579/2008 of Col. (labelling §) recorded on the forms of anthropogenic relief in traditional agricultural landscapes in Slovakia

Category of rare and threatened taxa	Species
Critically Endangered (CR)	*Colchicum arenarium* §, *Dactylorhiza maculata* §, *Polygonum arenarium* §
Endangered (EN)	*Bupleurum falcatum subsp. dilatatum* §, *Dianthus collinus* §, *Lychnis coronaria* §, *Medicago prostrata, Platanthera chlorantha* §, *Thalictrum lucidum, Tordylium maximum, Veronica agrestis*
Vulnerable (VU)	*Arenaria leptoclados, Bromus arvensis, Blechnum spicant* §, *Cephalanthera longifolia* §, *Cerasus fruticosa, Crepis praemorsa, Dactylorhiza fuchsii* §, *Dactylorhiza majalis* §, *Dianthus superbus* §, *Dictamnus albus* §, *Gladiolus imbricatus* §, *Gymnadenia conopsea* §, *Lathyrus nissolia* §, *Listera ovata* §, *Melampyrum barbatum, Nepeta pannonica, Orchis mascula subsp. signifera* §, *Orchis purpurea* §, *Platanthera bifolia* §, *Thlaspi caerulescens, Trollius altissimus* §, *Valeriana simplicifolia, Vicia incana* §
Lower Risk (LR)	*Anemone sylvestris* §, *Aquilegia vulgaris* §, *Aster amelloides, Campanula bononiensis, Calamintha menthifolia, Centaurium erythraea* §, *Convallaria majalis* §, *Cyanus segetum, Dianthus nitidus* §, *Epipactis helleborine* §, *Gentiana cruciata, Gentianella amarella, Geranium molle, Kickxia elatine, Knautia drymeia, Lactuca perennis, Lactuca quercina, Lilium martagon* §, *Linum flavum, Lycopodium clavatum* §, *Orobanche lutea, Pilosella cymosa, Pseudolysimachion orchideum, Saxifraga granulata, Silene donetzica subsp. sillingeri, Sorbus aria, Swida australis, Viola kitaibeliana*
Data Deficient (DD)	*Tithymalus tommasinianus*

Table 9.3 Occurrence of endemic vascular plants recorded on the forms of anthropogenic relief (Kliment 1999) in traditional agricultural landscapes in Slovakia

Endemism of geographical range	Species
Carpathian endemic species (K)	*Bupleurum falcatum subsp. dilatatum, Campanula serrata, Hylotelephium argutum*
Carpathian subendemic species (Ks)	*Cyanus mollis*
West Carpathian endemic (KZ)	*Bromus monocladus, Silene donetzica subsp. sillingeri*
West Carpathian subendemic species (KZs)	*Knautia kitaibelii*
Pannonian subendemic species (in broad terms) (Ps)	*Melampyrum barbatum*

land use elements (dispersed settlements and orchards). Slight differences were observed between habitats on terrace slopes and lengthwise mounds.

Direct gradient analysis (Fig. 9.3) confirmed significant influence of the following ten environmental factors on variability of plant species composition of FAR in Slovakia: altitude, latitude, longitude, proportion of rocky material in the substrate,

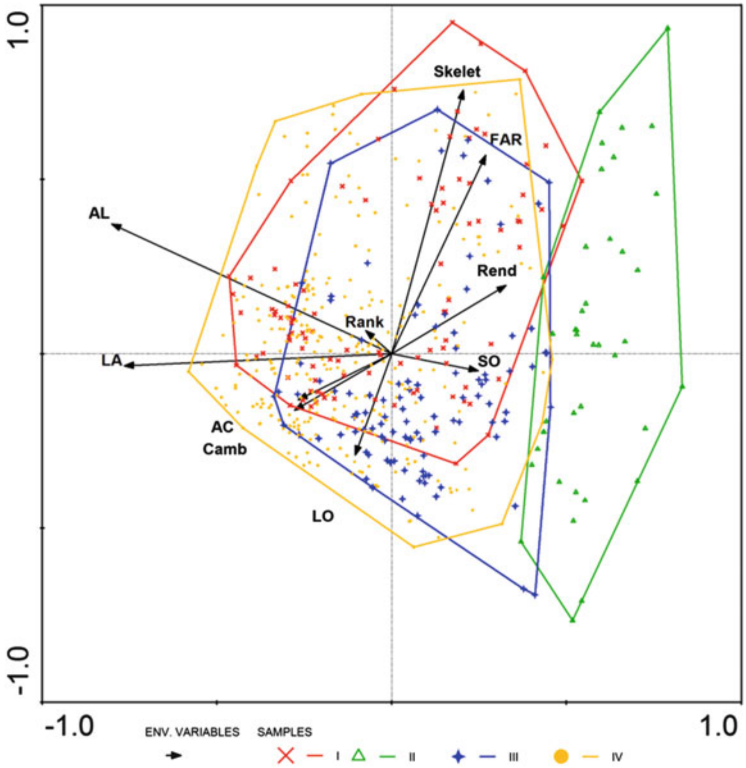

Fig. 9.3 Direct gradient analysis of vascular plant communities on forms of anthropogenic relief (grouped according to the classes of Traditional Agricultural Landscapes – *I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards, *IV*. TAL of Arable-Land and Grasslands) versus ten significant environmental factors/variables as altitude *AL* latitude, *LA* longitude, *LO* proportion of rocky material in the substrate (Skelet), the type of FAR (FAR), acidity of substrate (*AC*), north-south slope orientation (*SO*) and soil types of Cambisols (*Camb*) and Skeletic (*Rank*) and Rendzic Leptosols (*Rend*)

the type of FAR (correlated to the previous factor), acidity of substrate, north-south slope orientation and soil types of Cambisols and Skeletic and Rendzic Leptosols. It explained the specificity of FAR present in TAL of Vineyards (mentioned also above) – their plant species composition resulted as related to lower altitude and latitude and to south-oriented sites. Horizontal axis explains 28 % of the variability of the species-environment relation, together with vertical axis they explain 41.6 % of such variability.

9.4.3 Threats to Traditional Agricultural Landscapes

The main threats of TAL were determined on the basis of the comparison of conflicts between the present state of the ecosystems and the main potential and real drivers. Most of the areas with the present TAL are situated in regions marginal from economic, demographic and social points of view, and the local inhabitants are not very keen on managing the agricultural landscape because of low yields from the land. TAL depend on human activity and specifically on agricultural management.

Trends in management intensity in the TAL are shown in Fig. 9.4. Almost half of the TAL sites (51 %) are still regularly managed, being assigned to the first degree of management intensity (sites with more than 70 % of managed area). TAL of Arable-Land and Grasslands is the class most threatened by abandonment, being assigned to the third degree of management intensity (sites with less than 30 % of managed area) in more than 30 % of sites.

The development trends depend on the fact if the threats come true or not. The most significant threats to the TAL and its biodiversity as recorded in the field were: succession in correlation with abandonment, increasing tourism, urban development and reforestation (Fig. 9.5), as a consequence of changed employment structure, decreased number of residents or on the other hand due to intensification of agricultural use. The main threats for all classes of TAL are posed by succession and abandonment that reflects the lack of human resources, inappropriate economic conditions for real agricultural management of TAL and lack of real support subsidies and grant schemes. Agricultural fields are managed mostly by older farmers – young generation is not very interested in traditional management. The old farmers do not have financial and technical resources to be competitive to producers with intensive farming. Therefore the inputs are higher than outputs and it means unsustainable situation.

Tourism and urban development affect especially the TAL of Vineyards. Traditional vineyard cottages have been rebuilt to settlement or weekend cottages and surrounding vineyards are being replaced by lawns. The primary agricultural function of the TAL with Dispersed Settlements is also no longer performed at the same intensity. Houses of dispersed settlement have become more and more popular as cottages and recreational houses, and as a type of “the secondary re-settlement” this can mean an impulse for further development of the countryside (Petrovič 2006).

Decline of managed areas of TAL is a consequence of other threatening conditions:

- Intense pressure by owners and investors to convert agricultural land to construction land
- Lack of interest of owners to lease the land to wine growers for a long-term period
- Insufficient legislative support to protect the TAL

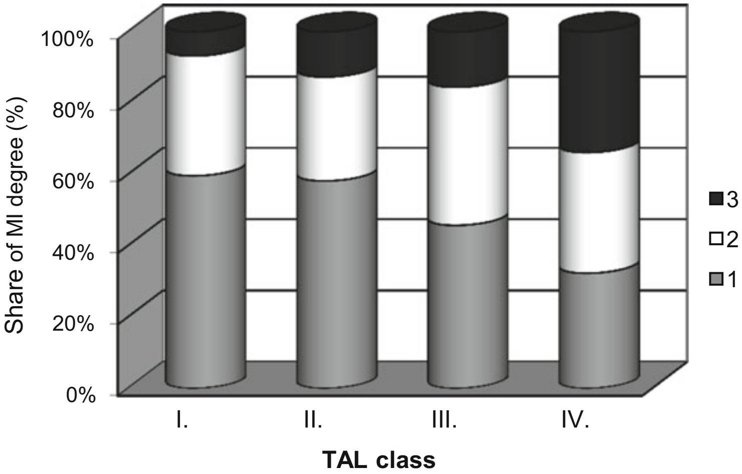

Fig. 9.4 Management intensity(MI) in classes of traditional agricultural landscapes (TAL classes – *I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards *IV*. TAL of Arable-Land and Grasslands) expressed by share of three MI degree (in percentage): (*1*) regularly managed sites – sites with more than 70 % of managed area; (*2*) occasionally managed or partially abandoned sites – 30–70 % of plots on the site occasionally managed; (*3*) mostly abandoned sites – sites with less than 30 % of managed area

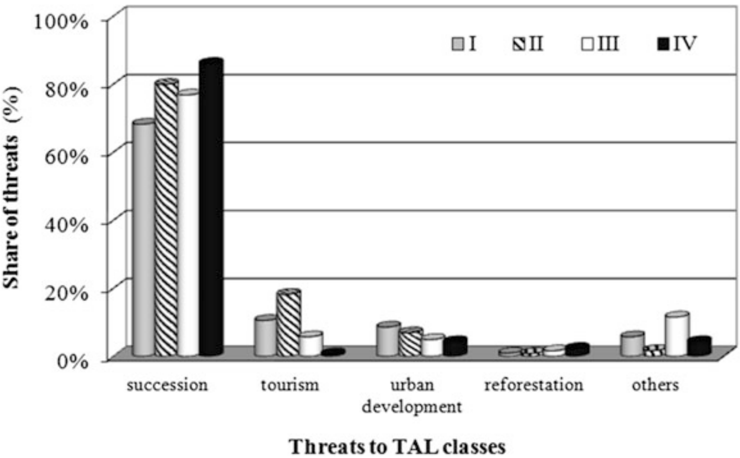

Fig. 9.5 Share of threatened polygons (in percentage) by succession, tourism, urban development, reforestation and others threats, to classes of traditional agricultural landscapes (TAL classes: *I*. TAL with Dispersed Settlements, *II*. TAL of Vineyards, *III*. TAL of Arable-Land, Grasslands and Orchards, *IV*. TAL of Arable-Land and Grasslands) observed in the field

- Poor publicity and awareness about TAL among the general public and state representatives
- Insufficient research and monitoring of changes in the TAL

9.5 Conclusion

Results of a complex inventory and typology of the sites of the TAL should significantly increase the knowledge on TAL in Slovakia and in Central Europe. Special attention was given to the significance of anthropogenically conditioned habitats and their function in the agricultural landscapes. Results show high significance of these habitats as islands of species richness, and they also fulfil many other environmental services as well. With regard to current global climate changes, the TAL with balks are also key features of water retention in the landscape, and this is very important for protection from floods, droughts and soil erosion.

The product of the field mapping throughout the Slovak territory is a catalogue of the sites of TAL, available also on web (http://www.uke.sav.sk/hspk/index.htm). Map of distribution of the sites of TAL may serve as a valuable document for territorial planning at regional and national levels, for proposal of measures and zones of protection and maintenance of the TAL. The interest to maintain the integrity of traditional landscapes comes out also from the European Landscape Convention (ELC 2004), because there are real threats to lose the traditional landscapes and their genius loci.

A key strategy in sustainable agriculture is to restore functional biodiversity of the biocultural landscapes (Altieri 1999). The optimal management strategy should prescribe conditions not only for protection of biodiversity, but for ecological management, protecting soil and water natural resources and for halting irreversible land use changes. The main goals of the strategy should be aimed at support of sustainable development and enhancement of human resources in the sphere of management and protection, enhancement of public awareness of TAL values, elimination of threats of TAL, support of appropriate socio-economic conditions regarding management of TAL, tourism, and regional development, assurance the strengthening of TAL protection, support of research and monitoring of TAL, applying appropriate practical management. It brings about not only protection of valuable habitats, but it should have positive impact on the health of local inhabitants as well as visitors by reduction of stress phenomena and by the production of healthy bio-products. The recovery of optimal agricultural activities enables the renewal of aboriginal cycles of production and consumption, with less waste-production.

Coordination and implementation of management measures into regional development plans and spatial plans are necessary to facilitate environmentally sustainable economic development, the minimisation of environmental risks and the preservation of natural and cultural values such as TAL. The recovery of optimal agricultural activities enables the renewal of aboriginal cycles of production and consumption, with less waste-production.

As preservation of TAL depends mainly on individual small-scale farming and on eventual state subsidies, it is a question if there is enough interest to stop abandonment of these traces of the past farming that are at the same time refuges of biodiversity. The challenge to maintain TAL in general, is addressed to individuals as well as to politicians who form the development policy.

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Chapter 10
Characteristics and Management of Old and Sacred Dangsan Forests in Korea

Jai-Ung Choi and Dong Yeob Kim

Abstract The traditional village forests represent unique cultural landscapes in Korea with histories of more than several hundred years. These forests are known as Bibo Forests (village protector) and Dangsan Forests (sacred place). Although Dangsan Forests have diminished over the years, a considerable number still exist in rural villages. In the Korean peninsula, the Dangsan Forests have at least one of the three elements: Dangsan trees, stone towers, and a shrine. Major Dangsan tree species are *Zelkova serrata, Pinus densiflora, Celtis sinensis,* and *Kalopanax pictus*. A village ancestral ceremony called Dangsan ritual is performed once or twice a year, which provides motivation for the conservation of Dangsan Forests as sanctuaries. In Jeju Island, Dang is the place where Dangsan Forest is located. The background of the Dang is animism and shamanism. There are Simbangs in Jeju Island who perform the Dang ritual and serve as mediators to gods. Most of the Dang are ancient and unremarkable. This may be the reason why it has not generated much public attention. Additionally, the level of preservation for the Dangsan Forests has been low. In the inland region, many Dangsan Forests were abused for recreation. In Jeju Island, the Dangs have been disturbed recently by road construction. In order to restore the authenticity of the Dangsan Forests, it is necessary to provide maximum preservation and maintain the original features and functions. A social mechanism needs to be established to support the recovery of the authenticity of the Dangsan Forest. Public awareness needs to be promoted to claim the value of Dangsan Forest as a unique biocultural landscape of Korea.

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Keywords Dangsan forest • Dangsan ritual • Sacred forest • Bibo forest • Traditional village forest • Animism • Shamanism

10.1 Introduction

The traditional village forests of Korea constitute unique cultural landscapes with a history of more than several hundred years. The traditional village forests in Korea are mainly known as Bibo Forests, which function to protect villages. The Dangsan Forests are sacred places where the Dangsan ritual is performed. Recently, traditional village forests in Korea have been classified into Dangsan Forest and Bibo Forest (Choi and Kim 2009) based on their characteristics and features. In general, the Dangsan ritual starts at midnight of January 15 of the lunar calendar. Although some Dangsan Forests have diminished with the abolition of the Dangsan ritual, a considerable number of rural villages still have them.

In Jeju Island, the Dangsan Forests have evolved into a different form. Jeju Island, a volcanic island, is a unique place which has been nominated as a Biosphere Reserve (2002), World Natural Heritage (2007), and Global Geopark (2010) by UNESCO. The traditional village forests in Jeju Island are composed of the Dang Forest and the Pojedan Forest (Choi et al. 2012). There are 368 oreums (parasitic volcanoes) and 391 altars of Dang (divine places) in Jeju Island. The Dang in Jeju Island, however, has been threatened by road constructions in seashore areas and the establishment of the Jeju Olle trail path. The rural villages in Jeju Island need to find a way to retain the sanctuaries of Dang and the oreums to enhance the value of the biocultural landscapes in Korea.

Ancient artifacts are valuable only when the authenticity is retained. Except for rural residents who perform the Dangsan ritual, there are not many people who recognize the value of Dangsan Forests. Throughout the wide spectrum of social changes resulting from the Korean War, rapid industrialization, and prevailing Christianity, Dangsan Forests have been forgotten. The traditional village forests of Korea in coastal and estuary areas are not only of ecological value, but also have a deep historical and cultural significance for linking men and natural landscapes (Hong and Kim 2011). Although Dangsan Forests is highly valued for representing Korean biocultural landscapes, it has been recognized only by a limited group of people. The objectives of this study were to understand the nature of Dangsan Forests and to find a way to restore its authenticity.

There are two distinct types of Dangsan Forests found in two regions; the Korean peninsula and Jeju Island. The characteristics of the Dangsan Forests and Bibo Forests in the regions were investigated based on physical features such as size, shape, location, and tree species composition, as well as cultural aspects and tradition (Choi and Kim 2009; Choi et al. 2009).

The possibilities of enhancing their value and benefits have been explored and discussed. Sites in Korean peninsula were investigated during 1999–2012 and a total of 40 villages, 20 villages from inland and 20 from seashore were studied

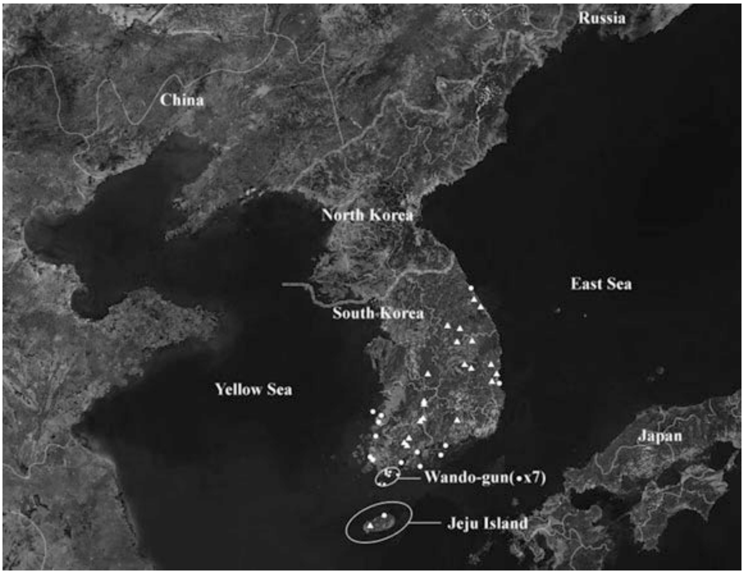

Fig. 10.1 Study sites in the inland and seashore areas of Korea including Jeju Island (Δ *Inland villages*, ○ *Seashore villages*)

(Fig. 10.1). Sites in Jeju Island were explored from 2006 to 2012, one at a mid-mountain village in Jeoji-ri, and the other at a seashore village in Sinheung-ri.

10.2 The Characteristics of the Dangsan Forests in the Korean Peninsula

10.2.1 The Pattern of the Traditional Village Forests

The traditional village forests of Korea have been discussed to function as a Bibo Forest or village protector (Kim and Jang 1994). However, recent findings suggested that the traditional village forests also have Dangsan Forests as an additional component (Table 10.1, Fig. 10.2).

Many traditional village forests of inland areas tend to have both Dangsan Forest and Bibo Forest. There are two types in general: 1) Dangsan Forest type I which is established as one Dangsan Forest, 2) Dangsan Forest type II which is composed of a Dangsan Forest and a Bibo Forest (or another Dangsan Forest). Those types were also found at seashore villages (Fig. 10.2, Table 10.3). The most frequent type was Dangsan Forest type I (Table 10.3). In case of Dangin-ri, Wando-gun, the village forest was composed of a Dangsan Forest and five Bibo Forests (Table 10.2).

Table 10.1 Elements of traditional village forests in Korean Peninsula (Choi and Kim 2009)

Characteristics	Dangsan Forest	Bibo Forest
Significance of space	A space for the Dangsan god and nature	A space created to protect the village and farmland
Philosophical background	Animism	Feng-shui theory
Function	A sacred place in village	Prevention from natural disasters (wind, flood)
Components	Must have at least one of the following: Dangsan tree, shrine, and stone tower	No Dangsan tree, shrine, stone tower

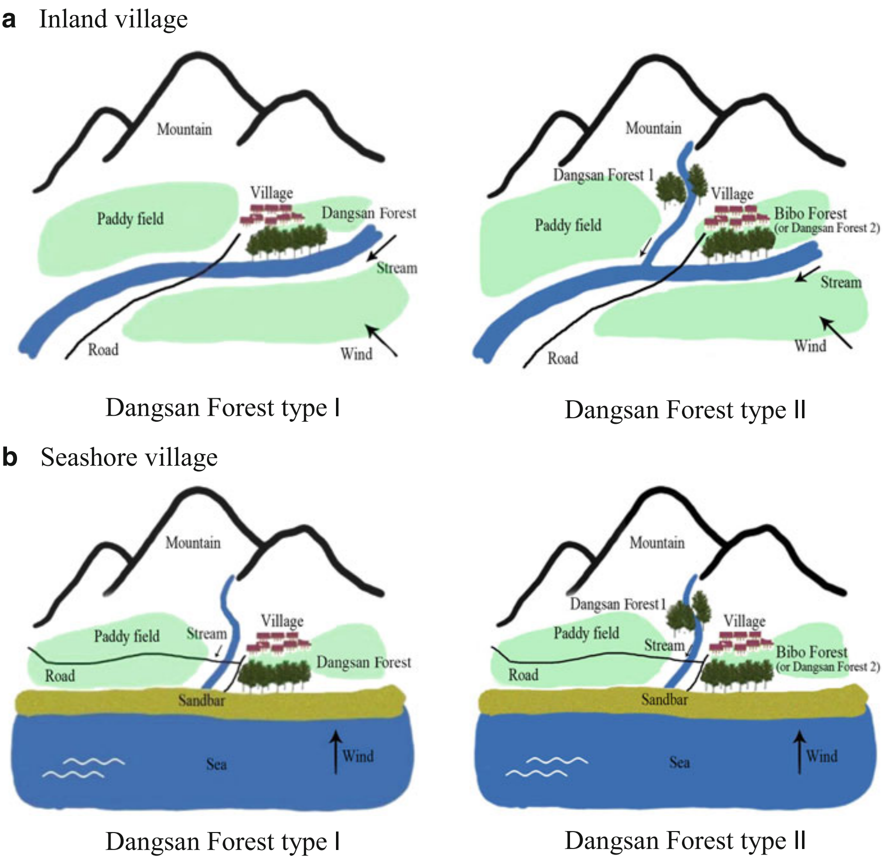

Fig. 10.2 Concept map of Dangsan Forest in traditional village forests in Korea (Choi and Kim 2009)

Table 10.2 The sizes of traditional village forests in the Korean Peninsula

Inland village			Seashore village		
Name	Forest type	Area (m^2)	Name	Forest type	Area (m^2)
Mati	Dangsan	2,100	Oeongchi	Dangsan	3,078
Nochi	Dangsan	620	Jin-ri	Dangsan	4,940
Gujung-ri	Dangsan	10,782	Jeungdo-ri	Dangsan	54,250
Mungok-ri	Dangsan	4,224	Oeam-ri	Dangsan	3,315
Yangsin-ri	Dangsan	16,475	Daldo-ri	Dangsan	44,000
Wolgye-ri	Dangsan	877	Nareampo-ri	Dangsan	1,250
Dochun-ri	Dangsan	20,368	Sunjung	Dangsan	8,500
Dongsan	Dangsan	4,550	Chilpo-ri	Dangsan	7,500
Dangchon	Dangsan	418	Maengseon-ri	Dangsan	5,500
				Bibo	10,800
Segan-ri	Dangsan	400	Singeum-ri	Dangsan	24,600
				Bibo	10,360
Sachon-ri	Dangsan	82,800	Woldu	Dangsan	(3,750)
				Bibo	(3,750)
Goeran	Dangsan	3,198	Dangin-ri	Dangsan	4,750
	Bibo	4,337		Bibo 1	5,130
				Bibo 2	11,550
				Bibo 3	1,600
				Bibo 4	5,260
				Bibo 5	750
Bukha-ri	Dangsan	1,160	Jangjwa-ri	Dangsan 1	840
	Bibo	1,880		Dangsan 2	2,100
				Bibo	3,892
Singi-ri	Dangsan	5,295	Dongho-ri	Dangsan1	32,225
	Bibo	2,250		Dangsan 2	1,500
				Bibo	12,300
Junam-ri	Dangsan	52,700	Daebang-dong	Dangsan 1	3,038
	Bibo	4,500		Dangsan 2	2,280
				Bibo	1,760
Dukdong	Dangsan	7,605	Wonchun-ri	Dangsan	324
	Bibo 1	1,564		Bibo	9,450
	Bibo 2	1,500			
	Bibo 3	1,950			
	Bibo 4	800			
Hahoe	Dangsan 1	2,500	Beopseong-ri	Dangsan	9,600
	Dangsan 2	3,400		Bibo 1	2,350
	Bibo	7,350		Bibo 2	8,842
Seongnam-ri	Dangsan 1	21,133	Jeongdo-ri	Dangsan 1	91,000
	Dangsan 2	2,537		Dangsan 2	4,500
Unyong-ri	Dangsan 1	625	Yesong-ri	Dangsan 1	1,900
	Dangsan 2	2,774		Dangsan 2	20,800
Songchun-ri	Dangsan 1	2,700	Seoseong-ri	Dangsan 1	6,900
	Dangsan 2	4,050		Dangsan 2	900

Table 10.3 The patterns of traditional village forests in the Korean Peninsula

Location	Dangsan Forest type I	Dangsan Forest type II	
	Dangsan Forest (alone)	Dangsan Forest and Bibo Forest(s)	Dangsan Forest 1 and Dangsan Forest 2
Inland village (20)	Mati village Nochi village Gujung-ri Mungok-ri Yangsin-ri Wolgye-ri Dochun-ri Dongsan village Dangchon village Segan-ri Sachon-ri	Goeran village Bukha-ri Singi-ri Junam-ri Dukdong village Hahoe village	Seongnam-ri Unyong-ri Songchun-ri
Seashore village (20)	Oeongchi Jin-ri Jeungdo-ri Oeam-ri Daldo-ri Nampo-ri Sunjung village Chilpo-ri	Maengseon-ri Singeum-ri Woldu village Dangin-ri Jangjwa-ri Dongho-ri Daebang-dong Wonchun-ri Beopseong-ri	Jeongdo-ri Yesong-ri Seoseong-ri

The traditional village forest in Dochun-ri had only one Dangsan Forest. Like most of the traditional village forests which function as riparian buffer, the Dangsan Forest in Dochun-ri was located nearby a stream. The size of the Dangsan Forest was 20,368 m^2, with major tree species: *Celtis sinensis*, *Zelkova serrata*, and *Cornus walteri* with average diameter at breast height (DBH) of 63 cm, 86 cm, and 51 cm, respectively. The Dangsan ritual has been performed at the shrine on January 15 of the lunar calendar. The traditional village forest in Junam-ri was composed of a Dangsan Forest and a Bibo Forest, with deciduous trees. Major tree species were *Ulmus pumila*, *Hemiptelea davidii,* and *Zelkova serrata*. The Dangsan tree was *Picrasma quassioides*. The Dangsan ritual has been performed on July 15. The traditional village forest in Songchun-ri was composed of two Dangsan Forests. The Dangsan Forest 1 was a deciduous forest, and the Dangsan Forest 2 was a mixed forest of *Zelkova serrata*, *Pinus densiflora*, and *Carpinus laxiflora*. The Dangsan ritual has been performed at midnight of January 1.

A similar pattern was found at the villages in seashore areas. Sunjung village's Dangsan Forest was composed of *Celtis sinensis*, *Aphananthe aspera*, and *Pinus thunbergii* with average DBHs of 68 cm, 72 cm and 44 cm, respectively. The Dangsan ritual has been performed at midnight of January 15. Evergreen broadleaf

Fig. 10.3 The pattern of the two Dangsan Forests in Jeongdo-ri, seashore village, Wando-gun (**a** The map of the village, **b** The shrine at Dangsan Forest 1, **c** Dangsan ritual)

forests are found in the southern coast areas and in Jeju Island. The Dangsan Forest of Singuem-ri was an evergreen broadleaf forest with *Castanopsis cuspidata*, and *Machilus thunbergii*. The Bibo Forest was composed of *Pinus thunbergii* which had an average DBH of 59 cm. The Dangsan ritual has been performed at the shrine at midnight of December 30. In Jeongdo-ri, the Dangsan Forest 1, alias 'Grandfather Dang Forest' was composed of evergreen broadleaf trees. The Dangsan Forest 2, alias 'Grandmother Dang Forest' was composed of deciduous trees with some evergreen broadleaf trees such as *Cinnamomum japonicum*. The Dangsan Forest 2 functioned as a wind break against strong winds from the sea (Fig. 10.3a).

The Dangsan ritual has been performed at the shrine of Dangsan Forest 1 at midnight of January 2, and later the ritual has been moved to the shrine of Dangsan Forest 2 (Fig. 10.3b, c).

10.2.2 Dangsan Ritual and Three Components of Dangsan Forest

Dangsan Forests are located in holy places where the Dangsan ritual is performed. A village ancestral rite called Dangsan ritual is performed once or twice a year. Dangsan ritual is a village-wide event to give thanks to the gods of nature and ancestors and to pray for prosperity and peace of the village. In general, the Dangsan ritual is performed in front of the Dangsan tree, shrine, or stone tower at midnight of January 15 of the lunar calendar. Dangsan ritual provides a motive for conservation of Dangsan Forests. Dangsan Forests get vital powers of sanctuary through the Dangsan ritual performed by local residents (Choi and Kim 2003; Choi et al. 2012). Among the 40 survey sites, Dangsan ritual was observed in 18 villages.

The Dangsan Forests in the Korean peninsula have at least one of the three elements (Choi and Kim 2000): Dangsan tree, stone tower, and shrine (Fig. 10.4a–c). The Dangsan Forest at Gujung-ri, has all three elements, which is a rare case (Choi and Kim 2003). The major Dangsan tree species were *Zelkova serrata, Pinus densiflora, Celtis sinensis,* and *Kalopanax pictus*. The remains of a stone tower were found at Seoji-ri. The three kinds of stone tower (Fig. 10.4d, left) were designated as 'Village Shrine at Seoji-ri, Andong' of Gyeongsangbuk-do province folklore cultural prosperities No. 100. The remains of three piles of big stones on the left of Fig. 10.4d were reported to be from the Bronze ages (tenth century BC) by the Cultural Heritage Administration (CHA) of Korea. The bottom stone was 2.5 m long, 1.8 m wide and 1.3 m high. It was estimated that this megalithic relic has been altered to a common stone tower later, which is shown on the right of Fig. 10.4d (Choi et al. 2010). The 'Village shrine at Seoji-ri, Andong' is a valuable relic which showed the origin of the stone tower. The performance of the Dangsan ritual has ceased since the Korean War, and was resumed recently by village people every January 15 of the lunar calendar (Fig. 10.4d, e).

Recently, Dangsan Forests have been discussed as a sacred natural site, an aspect of natural resources in UNESCO (Kim 2012). The jewel beetle (*Chrysochroa coreana*) (Natural Monument # 496) is in danger of extinction in Korea (Han et al. 2012). Horse trappings decorated with jewel beetle wings, dating back to 57 BC-935 AD during the era of Silla Dynasty, were excavated in Gyeongju in the early 1970s. The known habitat of jewel beetle is the stem of old *Celtis sinensis, Machilus thunbergii*, etc. Because the *Celtis sinensis* is one of the Dangsan tree species, the Dangsan Forest is important for conservation of the jewel beetle.

Fig. 10.4 Three components of the Dangsan Forest (**a** Dangsan tree in Suyoung-dong, Busan, **b** A stone tower in Geumnam-ri, Yecheon-gun, **c** A shrine in Sungnam-ri, Wonju-si, **d** The origin of the stone tower, Seoji-ri, Andong-si, **e** Dangsan ritual)

10.2.3 Water Quality and Dangsan Forests

Riparian buffers play a role to affect the quality of stream water (Forman 1995). Choi and Kim (2005) reported the results of a study designed to investigate water quality in relation to Dangsan Forests. Four study sites were selected, and water samples were collected at the spots 150 m before and after Dangsan Forests. Results showed that water temperature, electric conductivity, and total nitrogen were significantly different when there was a Dangsan Forest. Other water quality factors also seemed to indicate an improvement with the presence of Dangsan Forest (Table 10.4).

Table 10.4 Effects of Dangsan Forest on water quality (Choi and Kim 2005). Means with different *letters* are significantly different (p=0.1)

	Spots of sample collection	
	Before Dangsan Forest	After Dangsan Forest
No. of aquatic invertebrate species	7.50a	9.75a
Group pollution index	1.42a	1.35a
Dissolved oxygen (mg/l)	9.45a	9.42a
Temperature (°C)	20.40a	18.40b
pH	7.15a	6.94a
Electric conductivity (ds/l)	0.11a	0.09b
Biological oxygen demand (mg/l)	2.15a	1.04a
Chemical oxygen demand (mg/l)	18.80a	13.50a
Suspended solid (mg/l)	3.97a	2.92a
Total nitrogen (mg/l)	8.98a	6.92b
Total phosphorus (mg/l)	0.27a	0.25a

10.3 The Characteristics of the Dang Forests in Jeju Island

10.3.1 Jeju Island and Features of the Dang

Jeju Island is a special and unique place in Korea which has been nominated as a Biosphere Reserve (2002), World Natural Heritage (2007) site, and Global Geopark (2010) by UNESCO. In 2011, it has been proclaimed as one of the New Seven Wonders of Nature.

The place where Dangsan Forest is located is called a ‘Dang’ in Jeju Island. Life, culture, and tradition of rural villages are all connected with the Dang and oreum in Jeju. There are 368 oreums and 391 altars of Dang in Jeju Island. The island retains its beautiful scenery with its unique culture and history, making it worth visiting. In Jeju Island, people believe that there are 18,000 legendary goddesses who are connected to many stories of myth (Jeju Special Self-Governing Province and Jeju Traditional Culture Institution 2009).

Most of the villages in Jeju Island have retained the Dang and Pojedan (Table 10.5). Experts say that at first there was Dang only, and later, Pojedan was derived from Dang. The features of traditional villages are based on the Dang and the oreum in Jeju Island, and they are similar to the Dangsan and Bibo Forests in the inland region. Oreums are secondary volcanoes erupted after the major volcano activity. Most seashore areas are covered by volcanic rocks in Jeju Island, and windbreaks are hardly found. No stone tower was found in the mid-mountain villages. It was found, however, in many seashore villages. In Sinheung-ri, the stone towers were built to block evil spirits. But unlike in the inland region, rituals were not held at the stone tower.

The locations of the Dang were related to the topography created by volcanic activities. For example, the edges of the Dang Forest and the Pojedan Forest at Sangmyung-ri were on the slopes of basalt. The altar and the divine tree,

Table 10.5 Elements of traditional village forests in Jeju Island (Choi et al. 2012)

Characteristics	Dang forest	Pojedan (forest)
Significance of space	A space for the Dang god and nature	A space for the prosperity of village
Philosophical background	Animism + shamanism	Derived from Dang, Confucian ideas (located in forest, or paddy field, oreum)
Function	A sacred place in village	A sacred place in village
Components	Must have at least one of the following: altar (shrine), divine tree (Dang tree)	Altar (Pojedan) (stone tower of seashore village: substitute for Bibo Forest)

Castanopsis cuspidata were in a lava stone's crack. The topography seemed to be appropriate for the people at that time to establish the Dang (Choi et al. 2012).

10.3.2 Current Conditions of Dang

In Jeoji-ri, a Dang was located at the base of Jeoji oreum (Fig. 10.5a). Jeoji oreum had its crater with perimeter 800 m, diameter 255 m, and depth 62 m. There was a view point in the middle between the top and the bottom. The area of the Dang Forest was small at 23 m × 145 m. It was a mixed forest of *Pinus thunbergii* and *Celtis sinensis*. The size of the altar located inside the Dang Forest was 10 m × 7 m, and the divine tree species was *Elaeagnus umbellate*. The Dang of Jeoji-ri was inconspicuous, (Fig. 10.5) but this place was an important sanctuary for village women. Village women have visited the Dang Forest for prayer three times a month; 7th, 17th, and 27th. Jeoji-ri's Dang ritual was performed in the early morning of January 7 of the lunar calendar (Fig. 10.5). The Po ritual was interrupted by accident, and since then, the Pojedan Forest has been left alone. Jeoji-ri has been nominated as the fourth most beautiful village in Korea in August 2012.

The five stone towers at seashore in Sinheung-ri displays a spectacular view. The two among the five stone towers, is designated as 'Sinheung-ri's stone tower No. 1′ (Folklore material No. 8–10), and 'Sinheung-ri's stone tower No. 2′ (Folklore material No. 8–11) by Jeju Special Self-Governing Province. They have retained their original forms. On the other hand, the other three stone towers were rebuilt recently. The three stone towers on the sandbar were exposed at low tide, but partly submerged under water at high tide. There were small altars for Dang and the god of the sea on the seashore, sized 6 m × 7 m and 4 m × 3 m, respectively. The former divine tree, *Celtis sinensis,* still exists but the Dang ritual is not performed there anymore.

Fig. 10.5 Biocultural landscapes in Jeju Island (**a** Jeoji oreum and Dang Forest at Jeoji-ri, **b** The altar, **c** Offering a sacrifice on the altar during Dang ritual at Jeoji-ri)

10.3.3 Dang Ritual at the Dang Forest

The Dang is a symbol of Jeju Island's shamanism and animism. The Dang Forests in Jeju Island are distinct from those of the inland region. The special attribute of the Dang in Jeju is its practicing believers. There are village women who are in charge of the Dang. The Dang ritual is held at various dates: once or twice a year, four times a year, or 3–7 days per month, etc. The Dang ritual is performed by a Simbang, a male shaman, who mediates between the people and the gods. In the inland region, however, the shaman used to be a woman. In 2009, the Jeju Chimeoridang Yeongdeunggut ritual was nominated as an Intangible Cultural Heritage of Humanity by UNESCO.

Figure 10.6 shows a Dang ritual of Songdang-ri. Formally, the Songdang-ri Dang ritual is performed four times in a year. The Songdang-ri Dang (Folklore Material No. 9-1 by Jeju Special Self-Governing Province) is the origin of all Jeju Island's Dang.

10.4 Naming of the Dangsan Forests

Currently, natural monuments are designated and named by CHA based on the rule enacted in 1934. Many Dangsan Forests were named as evergreen forests. The 'Singeum-ri Dangsan Forest' was named as 'Oenarodo Evergreen Forest of Goheung' (Natural Monument No. 362), and the 'Kind of cultural properties' was introduced as 'Windbreak Forest'. This type of name does not represent the meaning of Dangsan Forest. Also, it is not correct that the Dangsan Forest of

Fig. 10.6 Village women of Songdang-ri watching a shaman performing of Dang ritual in the early morning of January 13 of the lunar calendar

riparian buffer at Sachon-ri, Uiseong was named 'Roadside forest in Sachon-ri, Uiseong' as Natural Monument # 405 (Choi et al. 2011). It was recommended that Dangsan Forest have their names as follows: 'Dangsan Forest at __', 'Dangsan Forest and Bibo Forest at __', or 'Dangsan tree at __' (Choi and Kim 2010).

10.5 Conclusion

The traditional village forests make unique cultural landscapes in Korea with histories of more than several hundred years. They have been acknowledged as Bibo Forests, which means protection of the village. The traditional village forests were found to have an additional component, the Dangsan Forest. These forests are holy places where Dangsan rituals are being held. Although many Dangsan Forests have been disturbed with the abolition of Dangsan ritual, a considerable number of rural villages still have Dangsan Forests. In the inland region, many Dangsan Forests were abused for recreational purposes. The Dang ritual in Jeju Island performed by village women and shaman provide motives to keep these biocultural landscapes. Some Dang altars have been disturbed by road construction near the seashore and the development of Jeju Olle trail paths. In order to restore the authenticity of the Dangsan Forests, the government needs to preserve them to maintain their original features and functions. A social mechanism needs to be prepared to support the recovery of the authenticity, and to enhance public awareness of the Dangsan Forests which represent a unique biocultural landscape of Korea.

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Chapter 11
Vision and Possibilities in Ecosystem Services of a Cultural Landscape: A Case Study in the Yanhe Watershed

Changhong Su and Bojie Fu

Abstract With increasing anthropogenic influences in the biosphere, the nature is gradually being encroached by human activities, which affect its capacity of providing ecosystem services. In this study, we took the Yanhe Watershed of China as a study area to valuate ecosystem services and their human driving mechanisms. Net primary production (NPP), carbon sequestration & oxygen production (CSOP), water conservation, soil conservation, and grain production were selected for ecosystem services. A quantitative human activity index (HAI) was formulated based on human population, farmland ratio, road networks, and residential areas. Landscape metrics were also used to quantify the land use change.

The results showed that, except the grain production, the regulating and supporting ecosystem services increased from 2000 to 2008, which demonstrated a conflict of tradeoffs. Spatially, ecosystem services showed conspicuous spatial patterns. Correlation analysis showed that soil conservation and water conservation are closely linked. HAI decreased from 2000 to 2008 with the center area decreased more than the peripheral area. Correlations analysis showed that the decreasing HAI significantly improved the soil and water conservation.

The landscape metrics analysis showed that watershed had a fragmentation tendency, simplification in shape, and enhanced patch connectiveness. For individual land use types, cropland had a strong tendency of fragmentation; grassland had an anti-fragmentation tendency; while forest didn't vary greatly.

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11.1 Introduction

Cultural landscape was first broadly defined as "landscape modified by human activity" by German geographer Ratzel (Jones 2003). American Geographer Sauer (1925) noted that 'the cultural landscape is fashioned from natural landscape by a cultural group. Culture is the agent, the natural are the medium, the cultural landscape is the result'. The World Heritage Committee stressed the role of interaction between man and nature in shaping the cultural landscape. In 1992, the World Heritage Convention categorized three types of 'cultural landscape's according to their 'tangibility': (1) "clearly defined landscapes designed and created intentionally by humans", (2) "organically evolved landscapes" resulting from successive interactions between people and natural environment, and (3) "associative cultural landscape" that have religious, artistic or cultural associations (UNESCO 1996). Outwardly, human-nature interactions of cultural landscape have apparent endemic characteristics, e.g., rice-fish agriculture (China), Maeul (Korea), Satoyama (Japan), Dehesa (Spain), Terroir (France) etc.

Since 1960, the concepts of 'cultural landscape' surged in the fields of human geography, anthropology, and environment management, which partially due to the fast pace human influence the ecosystem services. Nowadays, humans appropriate about 24 % of the Earth's terrestrial net primary productivity (Haberl et al. 2007), and almost all ecosystems and landscapes around the world have been influenced or even "domesticated" by humans (Kareiva et al. 2007). The general ecosystem demonstrated a tendency of structural damage and functional disorder.

As "cultural landscape" embraces a diversity of interactions between human and the environment, the fast pace of human's alteration on landscape advance the research in cultural landscape. The mere qualitative depiction of cultural landscape (e.g., the categorization by World Heritage Convention) retards a deep understanding of its origin, causing missed opportunities to tighten the connections between human beings and the physical environment. How to quantify the mechanism underlying cultural landscape remains a tough challenge. Forman and Godron (1986) advanced a landscape modification gradient pattern of natural – managed – cultivated – suburban – urban to analyze the human influences on the structure and function of landscapes. Based on the principle of 'disturbing intensity' and 'regenerative capacity', Naveh (1998) classified landscapes according to their energy inputs, self-organizing, and regenerative capacities on photosynthetic conversion of solar energy as: (1) "solar-powered" semi-natural and managed landscapes; (2) "intensive agro-industrial" landscapes; and (3) "technosphere" landscapes. Such analysis methods play key role in testing the relations between human society and nature, yet they fail to go any further than a qualitative portrait of cultural landscape.

At large scale, human affects the ecosystem by altering the land use pattern, which further impairs its functions in providing ecosystem services. Ecosystem service, human activities, and land use forms the core 'actors' of cultural landscape. Ecosystem services were widely defined as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily 1997). The Millennium Ecosystem Assessment (MA 2005) popularized the term of 'ecosystem services' and divided it into provisioning, regulating, supporting, and cultural services. In a regional scale, human activity affected ecosystems by altering land use pattern, biogeochemical and hydrological cycles. Fast social and economic development, characterized by industrialization, urbanization, population growth exacerbates the conflicts between high requirements for natural resources and the sustainable social and economic development in the long run. We intend to take Yanhe watershed of the Loess Plateau of China as a study area, to explore the mechanism of cultural landscape by tapping the interrelations between ecosystem services, human activities, and land use. The major aims are as:

1. Quantify ecosystem services, probe the interrelation, and analyze their anthropogenic driving forces;
2. Quantify the land use change through landscape metrics analysis;
3. Ecological management suggestion based on ecosystem service and human activity.

11.2 Methods

11.2.1 Study Sites

As a 'cradle' of Chinese civilization, the Loess Plateau is plagued notoriously by serious soil erosion. The Yanhe Watershed is located in the central Loess Plateau, with a geographic coordinate of 36°21′–37°19′N, 108°38′–110°29′E (Fig. 11.1). Thick mantle of loess, dry climate, and complex topography causes droughts, floods, and soil erosion. Fast population growth, clearance of natural forests, urban sprawling, farmland expansion, over exploitation of oil further degraded the ecological conditions. The area has a warm temperate continental monsoonal climate, with multi-year mean temperature ranging from 8.8 to 10.2 °C. Within the meager annual precipitation of 495 mm, over 65 % falls from June to September. Such uneven rainfall is likely to cause high erosive storm-lit. The Yanhe Watershed is mantled by thick loess, an erosion-prone fine silt soil. As a rugged area, over 90 % of the Yanhe Watershed was composed by gullies and ridges. For long history, farming is the pivotal means of livelihood (embodied by the high ratio of agricultural population of 82 %). In total there are 35 towns in this region under the administration of Yan'an City.

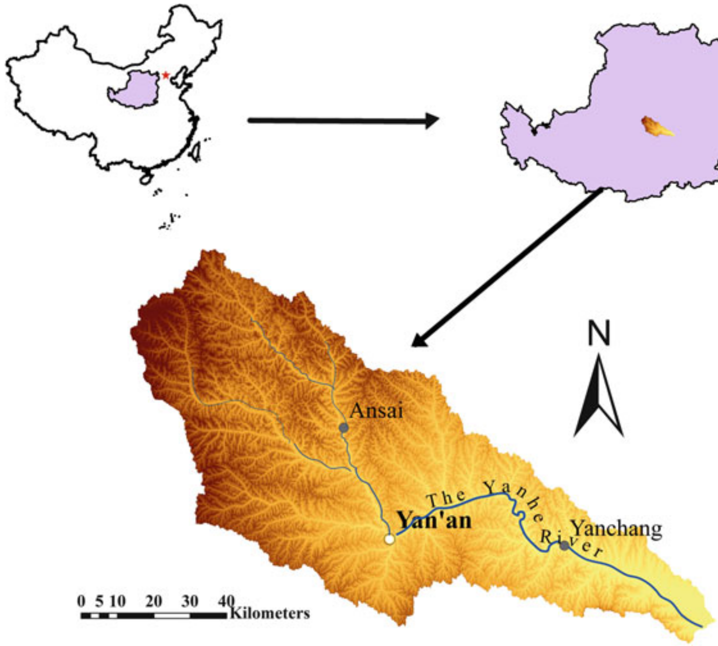

Fig. 11.1 Location of study area

11.2.2 Indicators Selection

The major ecological problems facing Yanhe Watershed are vegetation degradation, water loss, and soil erosion. Moreover, the practice of Grain for Green (GfG) project strongly affected the agricultural production. In such context, we selected net primary production (NPP), carbon sequestration & oxygen production (CSOP), water conservation, soil conservation, and grain production as indices for ecosystem services.

As a major driving force for social and economic development, population is a must for human activity assessment. In Yanhe Watershed, the increasing population leads to expanding demand for farm produce and natural resources. Rapid economic development drives urban sprawling rapidly. Under such context, we selected human population, farmland ratio, influence of residential settlement, and influence of road network as indices for human activity assessment.

Landscape metrics was applied to quantify the land use change. Although relevant software makes it possible to calculate large number of landscape metric indices, high correlations existing within some indices imply that selection too much index is not necessary. In this study, we selected 12 landscape metrics index of three groups: (1) area/density/edge metrics: class area (CA), number of patches (NP), patch density (PD), edge density (ED), landscape shape index (LSI), and largest patch index (LPI); (2) shape metrics: perimeter-area ratio (PARA), shape index (SHAPE), continuity index (CONTIG), and fractal dimension index (FRAC); (3) contagion/interspersion metrics: aggregation index (AI) and splitting index (SPLIT).

11.2.3 Quantification of Ecosystem Services

NPP was calculated by the process-based Carnegie-Ames-Stanford Approach (CASA) model based on the principle that plant productivity is correlated with the amount of photosynthetically active radiation absorbed or intercepted by green foliage (Monteith and Moss 1977; Potter et al. 1993). According to the photosynthetic equation, the ratio of organic matter produced, and carbon sequestered, and oxygen released by the photosynthesis process is 1:1.47:1.07. The volume of CSOP was calculated from NPP based on this ratio. Vegetation conserves water through the process of rainfall interception, evaportanspiration, sorption and storage (Li et al. 2006). Water conservation was calculated by summation of rainfall intercepted by the processes of canopy retention, litter absorption, and soil storage. Soil conservation is calculated by the empirical model of RUSLE (Revised Universal Soil Loss Equation). Grain production was obtained from the statistical data, in which, grain yield was divided by the township area, and then input to the attribute table of vectorized township administrative map for spatialization.

11.2.4 Quantification of Human Activities

We formulated an integrative human activity index (HAI) based on human population, farmland ratio, road network influence, and residential influence. The weights of these four factors were assigned by Analytic Hierarchy Process (AHP) as: human population 0.3, farmland 0.3, road influence 0.2, and residential influence 0.2. The equation is as follows:

$$\mathrm{HAI} = \mathrm{P} \times 0.3 + \mathrm{C} \times 0.3 + \mathrm{R} \times 0.2 + \mathrm{S} \times 0.2$$

Where: P, C, R, and S stand for the standardized human population, farmland ratio, road network influence, and the residential influence respectively. By reference to the State Basic Geographical Data Coding System, we assigned the values of influences to residential site and road network (Su et al. 2012).

11.2.5 Quantification of Landscape Metrics Index

Three sets of satellite images (Landsat TM for 1995 and 2000, and one Cbers-2B for 2008) were interpolated and calibrated with field survey. The data were classified in six domains: (1) cropland, including dry cropland of various slope and irrigated cropland; (2) woodland, including evergreen coniferous woodland, deciduous broad-leaf woodland and mixed broadleaf-conifer woodland; (3) grassland, including typical grassland and shrub land; (4) construction land, including urban construction land, rural settlement, and transportation facility areas; (5) water body, including swamp, lake, river, and wetland; and (6) wasteland, including naked rocks, bare land, and sand land. These vectorized images were converted into grid format of 30 m resolution to calculate landscape metrics by the software of FRASTAT 3.3.

11.2.6 Data Sources

MODIS images of 1-km resolution of 2000 and 2008 (for NPP, CSOP) were downloaded form internet (http://labsweb.nascom.nasa.gov/data/search.html). Land use data (for soil/water conservation, land metrics) were extracted from Landsat TM image (2000) and Cbers-2B image (2008). Topographical data (for soil conservation) was obtained from 1:50,000 digital elevation map (DEM). Soil types (for soil conservation) were obtained from the 1:50,000 soil map. Precipitation (for soil/water conservation) and temperature (for NPP and CSOP) were obtained form the Meteorological Bureau of Yan'an City. Grain production, human population, and cropland ratio (for HAI) were obtained from statistical data. Township administrative maps (for ecosystem services allotting) and residential sites (for HAI) were obtained from local civil affairs department. Road network map (for HAI) were extracted form atlases of Shaanxi Province.

11.3 Results

11.3.1 Spatiotemporal Patterns of Ecosystem Services and HAI

11.3.1.1 NPP and CSOP

In 2000, NPP/CSOP demonstrated a gradient increasing tendency from northwest and southeast to the southwest. 2008 saw a big increase of NPP/CSOP across the whole area. The spatial pattern of NPP/CSOP showed a difference from that of

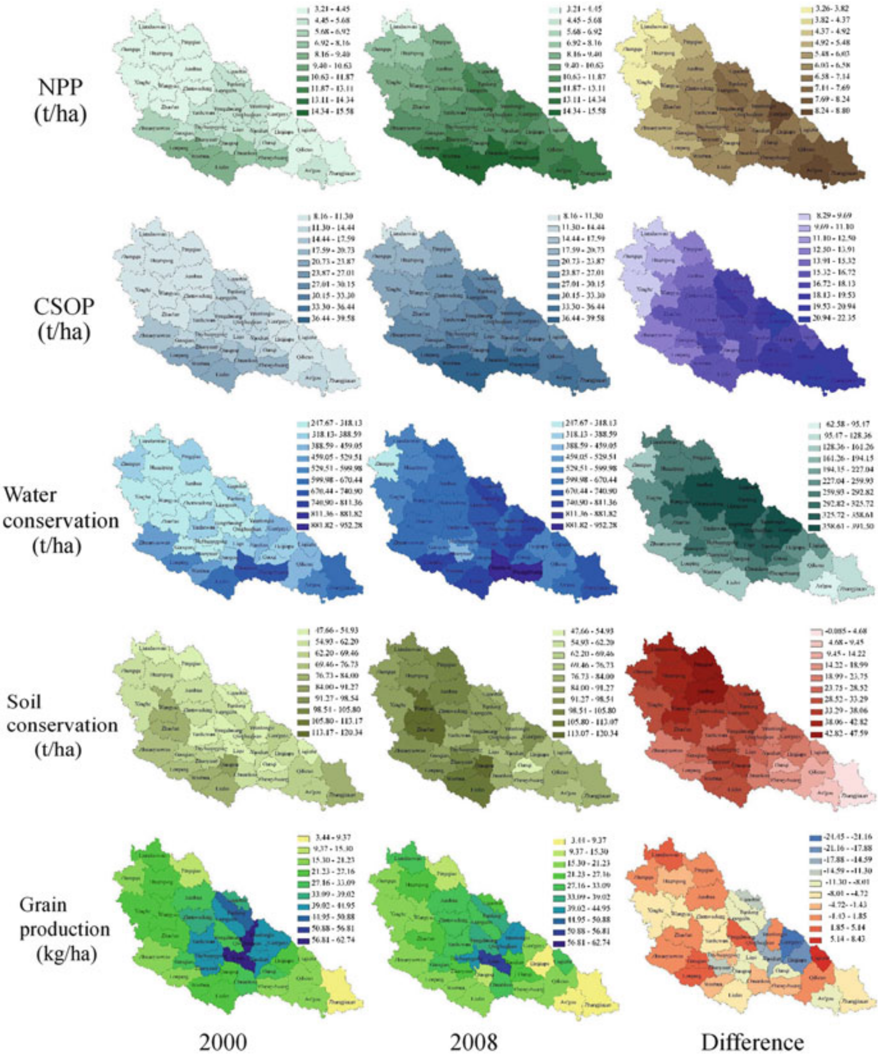

Fig. 11.2 Spatial variation of ecosystem services. Grain production was calculated through dividing the grain yield by the territory area of the township. The variation of ecosystem services was obtained through subtraction of ecosystem service images of 2008 by those of 2000. *NPP* net primary production, *CSOP* carbon sequestration and oxygen production

2000, with high NPP/CSOP townships distributed more eastward. The increment of NPP/CSOP assumed a spatial pattern of gradual increasing from the northwest to the southeastern (Fig. 11.2).

11.3.1.2 Water Conservation

Water conservation in 2000 assumes a rough increasing tendency from the northwest to the southern fringe. In 2008, the spatial pattern is somewhat obscure with some high water conservation townships in the north. Water conservation is greatly increased from 2000 to 2008 with a spatial pattern of fanning-out decreasing from the northeast to the surrounding area (Fig. 11.2).

11.3.1.3 Soil Conservation

Soil conservation in both 2000 and 2008 shows somewhat obscure spatial pattern. In 2000, soil conservation shows a spatial pattern high in the south and low in the north, which changed greatly in 2008 as high in the west and low in the east. Temporally, soil conservation is greatly increased from 2000 to 2008, with a conspicuous spatial pattern of gradual increase from southeastern to the northwestern (Fig. 11.2).

11.3.1.4 Grain Production

Grain production in both 2000 and 2008 demonstrated a centrifugally decreasing tendency fanning out from the center to the peripheral area. Temporally, grain production decreases for the bulk of the area (26 out of 35 townships). The remaining 9 townships shows a marginal increasing ranging from 0.17 kg/ha to 8.43 kg/ha. Overall, grain production decreased by 17.25 % from 27.59 kg/ha in 2000 to 22.83 kg/ha in 2008 (Fig. 11.2).

11.3.1.5 HAI

HAI of both 2000 and 2008 demonstrated a gradient decreasing tendency from the urban area through the surrounding area to the remote area. The total area underwent a sharp decrease from 2000 to 2008 in HAI with a distinct spatial pattern of converging from the peripheral area to the northwest (Fig. 11.3).

11.3.2 Correlations and Tradeoff Analysis

Using SPSS 11.5, we analyzed the correlations of the differences of each individual ecosystem service and that of HAI between 2000 and 2008 on basis of township. Two pairs of significantly negative correlations (at 0.01 levels) were observed between soil conservation and HAI and between water conservation and HAI,

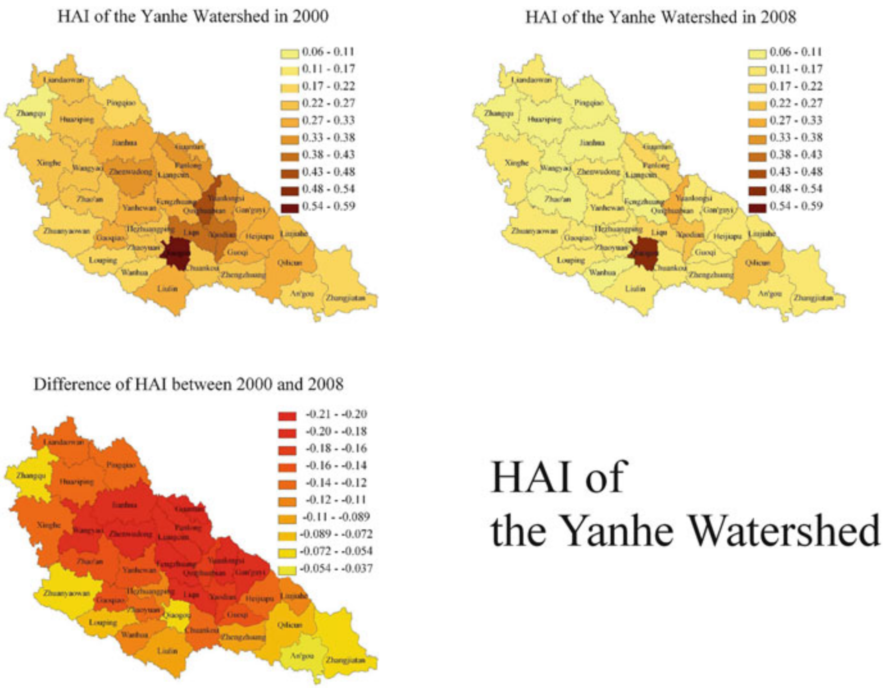

Fig. 11.3 Spatial variation of HAI. HAI is dimensionless

which demonstrated that the decreasing HAI significantly enhance soil and water conservation (Table 11.1). Within the ecosystem services, soil conservation and water conservation are significantly positive correlated (at 0.01 levels). Grain production is negatively correlated with NPP/CSOP (Table 11.1). As CSOP is deducted from NPP, the two is naturally highly positive correlated. 'Spider diagram' is a simple yet powerful approach in portraying tradeoffs between ecosystem services. We divided each individual ecosystem services of 2008 by that of 2000 to show their temporal variations. A quotients-based spider diagram shows tradeoff existing between provisioning services vs. regulating and supporting services (Fig. 11.4).

11.3.3 Landscape Metrics Index

Due to the inception of GfG project from 1998, the Yanhe Watershed underwent a conversion from cropland to woodland and grassland from 2000 to 2008, e.g., 165,800 ha and 8,477 ha cropland were converted to grassland and woodland respectively.

Table 11.1 Correlations of ecosystem services and HAI

	NPP	CSOP	SOIL	WATER	GRAIN	HAI
NPP	1	1**	−0.600*	−0.004	−0.423*	−0.070
CSOP	1**	1	−0.600*	−0.004	−0.423*	−0.070
SOIL	−0.600**	−0.600**	1	0.561**	0.106	−0.489**
WATER	−0.004	−0.004	0.561**	1	−0.212	−0.957**
GRAIN	−0.423*	−0.423*	0.106	−0.212	1	0.185
HAI	−0.070	−0.070	−0.489**	−0.957**	0.185	1

NPP net primary production, *CSOP* carbon sequestration & oxygen production, *SOIL* soil conservation, *WATER* water conservation, *GRAIN* grain production, *HAI* human activity index
**Correlation is significant at the 0.01 level (two-tailed)
*Correlation is significant at the 0.05 level (two-tailed)

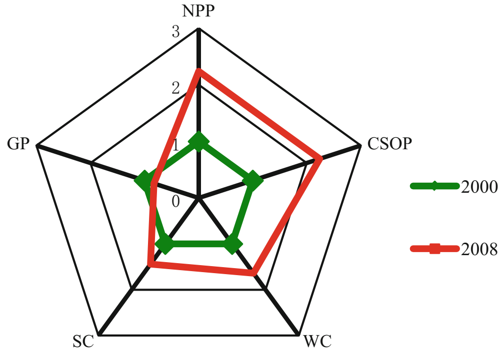

Fig. 11.4 Diagram illustrating the trade and synergy between ecosystem services. Individual ecosystem service of 2008 was divided by that of 2000 to show their temporal variation

11.3.3.1 For the Total Landscape

NP and PD increased from 1995 to 2008, indicating a fragmentation tendency (Fig. 11.5). ED slightly increased from 1995 to 2000 and then decreased sharply after 2000, indicating a simplification in shape (Fig. 11.5). LSI and PARA remained relatively stable from 1995 to 2000 and then decreased after 2000, well echoing the ED. CONTIG decreased slightly between 1995 and 2000 and then increased drastically after 2000, indicating an enhanced contiguity. AI showed a decrease-and-increase curve from 1995 to 2008, which is in sharp contrast to SPLIT, indicating more aggregated patches (Fig. 11.5). Both SHDI and SHEI increased slightly between 1995 and 2000 and decreased sharply after 2000, implying a diversification and even-distribution tendency (Fig. 11.5). FRAC decreased linearly from the whole period from 1995 to 2008, while LPI decreased slightly before 2000 and increased after 2000, indicating more frequency of large patches (Fig. 11.5). In conclusion, land use in the Yanhe Watershed assumed a fragmentation tendency, with a simplification and uniformity in patch shape.

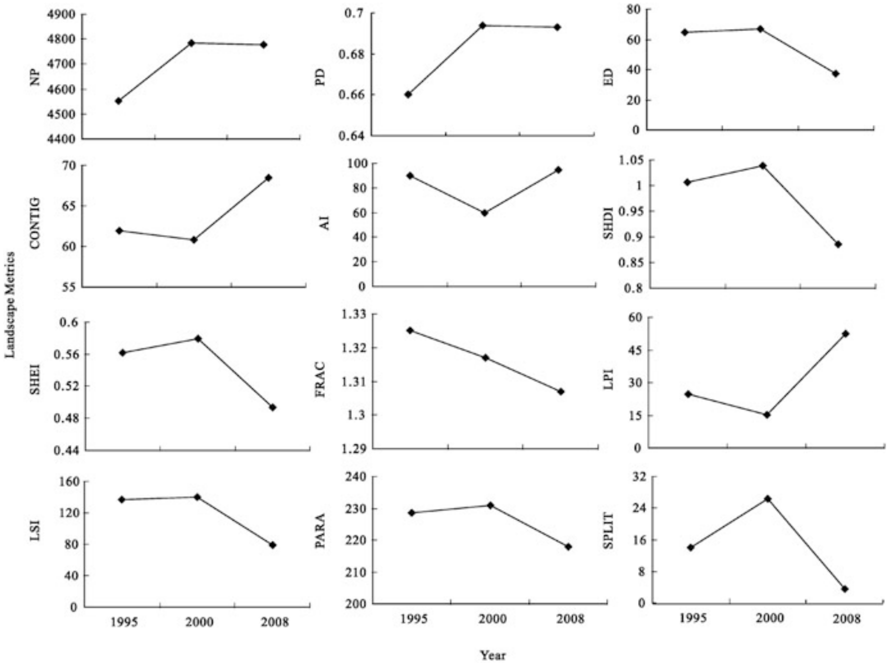

Fig. 11.5 Changes of landscape metrics at landscape level. *NP* number of patches, *PD* patch density, *ED* edge density, *CONTIG* continuity index, *AI* aggregation index, *SHDI* Shannon's diversity index, *SHEI* Shannon's evenness index, *FRAC* fractal dimension index, *LPI* largest patch index, *LSI* landscape shape index, *PARA* perimeter-area ratio, *SPLIT* splitting index

11.3.3.2 For Different Land Use Types

The landscape metrics of different land use types varied greatly. (1) For cropland, the decreasing CA versus increasing NP & PD indicate fragmentation tendency of cropland, which was well echoed by the gradual decrease of LPI (Fig. 11.6). LSI, SHAPE, and ED of cropland decreased, implying a simplifying tendency of shape. The increase of SPLIT of cropland implied the patches are more separated (Fig. 11.6). (2) For grassland, the increasing CA versus decreasing NP & PD demonstrates an anti-fragmentation tendency. The ascending LPI demonstrated that large and continuous patches appeared in grassland (Fig. 11.6). Similar to cropland, the grassland also demonstrated a simplification in shape implied by the decrease of LSI, SHPAE (Fig. 11.6). The increase of AI indicated that grassland patches are more aggregated. (3) For woodland, Landscape metrics varied very slightly possibly due to the woodland's strong resilience to environmental change and the difficulties of woodland's regenerating with high requirements for site condition. As the other three land use types of construction land, water body, and wasteland occupied very small area, the landscape metric index of which are likely diluted by even small systematic error and can not reflect much spatial pattern.

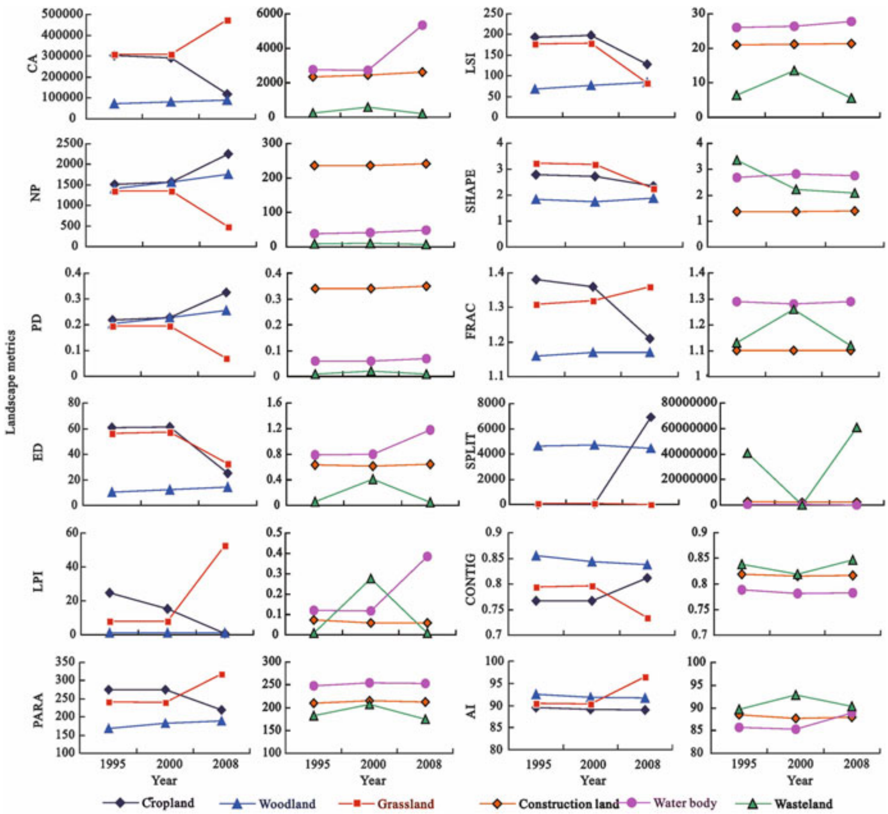

Fig. 11.6 Changes in landscape metrics at class level. *CA* class area, *NP* number of patches, *PD* patch density, *ED* edge density, *LPI* largest patch index, *PARA* perimeter-area ratio, *LSI* landscape shape index, *SHAPE* shape index, *FRAC* fractal dimension index, *SPLIT* splitting index, *CONTIG* continuity index, *AI* aggregation index. Every two neighboring subplots in one row share the same y-axis

11.4 Discussion

The interaction between man and nature brings about cultural landscapes which constitute a testimony of the past and present relationships between society and its environment. Ratzel's concise definition of cultural landscape as 'landscape modified by human activity' provided a basic direction, yet failed to provide an operable methodology on quantifying the mechanism underlying cultural landscape. Recognition and categorization by World Heritage Convention as cultural landscape were strongly biased by 'culture', without touching the 'scientific' essence. Big challenges in cultural landscape research lie in distilling the 'plausible' indicators and seeking the suitable quantifying methods, either by empirical analysis or by models. Here we selected five ecosystem services endeavoring to depict the general ecological situation of the study area. We also attempt to grasp the basic human activity underlying the ecosystem services by formulating an integrative HAI. As the most explicit manifestation human exert on ecosystem is land use, we quantified the land use through analyzing a series of landscape metrics index. The possible vision/ possibility of cultural landscape lie in:

11.4.1 The Tradeoff Between Ecosystem Services

Ecosystem services offer an operable concept for quantifying the capability cultural landscapes provide the natural assets for humans. Ecosystem services are diverse, including 'intangible' supporting and regulating services that underpin life on Earth, as well as 'tangible' goods which are directly or indirectly involved in the social, ecological, economical, and cultural sectors (MA 2005). Potential interlinks exist within different ecosystem services due to the common drivers therein. Ecosystem services are strongly scale-dependent. Interlinks of ecosystem services are also contingent to the scales. Such relations boil down to tradeoff and synergy, with the former being more significant for enacting a prudent ecological policy. Ignoring tradeoff is prone to cause double counting in economic valuation of ecosystem services (Fu et al. 2011). In our research, the increase of grain production and other supporting and regulating services forms conspicuous tradeoff, which constitute the core of the GfG project, i.e., balancing agricultural production and ecological renovation.

11.4.2 The Challenge in Human Activity Quantification

As integral players or agents of the cultural landscape, humans play significant roles in shaping the landscape and influencing the relations between biotic species and abiotic environment. Quantifying the human activity remains a tough challenge as there is various uncertainties and bias, especially for the most unquantifiable factor – policy. Selection of the right indicators is a challenge as human activity is endemic and there is no ubiquitous rule across different localities. The rationale of our selection of HAI composing factors is based on series factors closely related to the GfG projects, i.e., farming shrinkage, population transfer, countryside upgrading movement, and urban development. Of cause the weights we assign for each indicators is not without biasness, which calls for further improvement.

11.4.3 Lack of Ecological Implication of Landscape Metrics

The ultimate purpose of landscape metrics analysis is quantifying the interrelations between landscape pattern and ecological process. Unfortunately, current landscape metrics index were established at the early stage of landscape ecology, which stress the mathematical statistics, geometry characteristics, and spatial relations, yet neglect the potential ecological meaning. Consequently, the landscape metrics is sensitive to the classifying system of the data sources, and the sampling scale, but not sensitive to the landscape function. In our study, we tried but failed to build a quantitative links between ecosystem services and the land use metrics. Even so, we settle for a links between the variation of ecosystem services and the variation of finer land use types (Table 11.2). The result shows that the increase of grassland facilitates soil & water conservation; the increase of forest helps to enhance water conservation; shrinkage of slope farmland of 10–25° plays significant roles in improving soil & water conservation.

11.4.4 Human-Nature Research and Its Implication in Ecosystem Management

Human nature relation constitutes the core of cultural landscape, which has high potentials in ecosystem management. The IUCN Commission for ecosystem management (IUCN-CEM) defined that ‘ecosystem management is a process integrating ecological, social-economic, and institutional factors into a comprehensive analysis and action in order to sustain and enhance the quality of the ecosystem to meet current and future needs’ (Pirot et al. 2001). This definition necessitates the imbedding of Coupling Human and Nature System (CHANS) in the ecosystem management process. Unfortunately, due to the influence of ‘Ecological Determinism’ (Paine 1984), the traditional ecosystem management excessively stressed physical conditions, and neglected human factors. Based on ecosystem services and HAI of 2008, we used SPSS 11.5 software, clustering the Yanhe Watershed townships into four groups (Fig. 11.7). Suggestions for ecosystem management were also provided catering to each group as: (1) group 1 (urban area): As the economic and political center, this area should be given full use of secondary and tertiary industries to create more job opportunities to absorb the influx of population from ecologically vulnerable areas. Forest parks, city greenbelt, wetland park, and urban river system should be established. Tourism should be developed as various revolutionary historic relics are scattered through the area. (2) Group 2 (suburban area) is the most productive both in agriculture and industry. The farming system should be enhanced by increasing high value-added sideline productions, such as animal husbandry and cash crops. Intensified farming should be practiced, e.g., advanced irrigation techniques, agricultural mechanization, and high-yield varieties. Conservation farming practices, such as straw mulching, and reduced or eliminated tillage, should be encouraged to curb

Table 11.2 Correlation between ecosystem services and land use change

	Forest	Shrub	Grassland	Slope cropland					
				<5°	5–10°	10–15°	15–20°	20–25°	>25°
NPP	0.032	−0.143	0.084	0.177	0.371*	−0.007	−0.251	0.206	0.620**
CSOP	0.032	−0.143	0.084	0.177	0.371*	−0.007	−0.251	0.206	0.620**
SOIL	0.306	−0.046	0.512**	−0.099	−0.313	−0.525**	−0.340*	−0.654**	−0.550**
WATER	0.435**	0.021	0.946**	−0.159	−0.232	−0.937**	−0.915**	−0.729**	−0.121
GRAIN	−0.075	0.221	−0.314	−0.162	−0.07	0.254	0.367*	−0.015	−0.206

NPP net primary production, *CSOP* carbon sequestration and oxygen production, *SOIL* soil conservation, *WATER* water conservation, *GRAIN* grain production, *HAI* human activity index
**Correlation is significant at the 0.01 level (two-tailed)
*Correlation is significant at the 0.05 level (two-tailed)

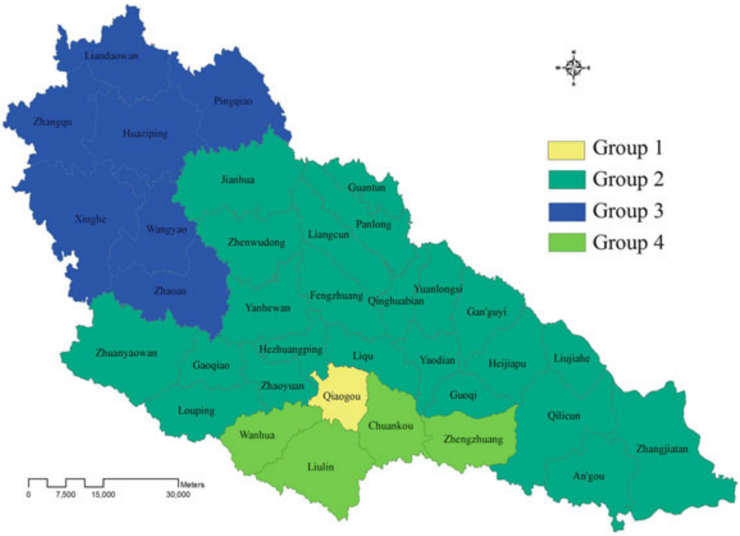

Fig. 11.7 Clustering of townships in the Yanhe watershed based on ecosystem services and HAI

soil and water losses. Check-dam is an advisable engineering measure at the lower reaches to control soil losses. (3) Group 3 (remote farming area), located in the upper reaches of the Yan River, is the most ecologically degraded area. The mountains in this area need to be closed completely in order to allow ecological recuperation. Farmland on slopes over 25° and yield less than 750 kg/ha of grain should be converted to forests or grassland (State Council of the People's Republic of China 1998). Within the GfG project area, the ecological forests should overwhelm the commercial forest. The low ecological capacity of this area necessitates resettlement of the vast population to other areas. (4) Group 4 (ecological shelterbelt) has well-established vegetation coverage and play significant roles in safeguarding the whole watershed. As a shelterbelt, this area should be well nourished. Farming should be prohibited and large populations be resettled. Ecotourism should be enhanced to improve the ecological self-reliance of this area.

11.5 Conclusions

Under the concept of cultural landscape concept, this chapter endeavor to quantify the underlying mechanisms of cultural landscape based on ecosystem services, human activity, and landscape metrics of the Yanhe watershed. The conclusions are as follows:

The regulating/supporting services of NPP, CSOP, water/soil conservation increased during the period of 2000–2008. While the provisioning service of grain production decreased. Tradeoff exists between the regulating/supporting services and the provisioning services, while slight synergies exist within the regulating services. HAI decreased accordingly, which significantly drives the water/ soil conservation services. Both ecosystem services and HAI have diverse and conspicuous spatial patterns.

The landscape metric indexes implied that Yanhe watershed has a fragmentation tendency, simplification in shape, and enhanced patch connectiveness. For specific land use type, cropland has strong tendency of fragmentation; grassland has an anti-fragmentation tendency; landscape metrics of forest varied mildly.

The coupling ecosystem services and human activity provide a useful means for enacting spatial explicit ecosystem management policy.

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Chapter 12
Biocultural Landscape Dynamics in Japanese Rural Regions

Jae-Eun Kim, Sun-Kee Hong, and Nobukazu Nakagoshi

Abstract Rural landscape has been established by reciprocal relationship between nature and human through so long time. Changes in rural landscape have occurred frequently during the last century in the world. These changes of agricultural systems and socio-economic environments in rural landscape led to the change of rural ecosystems. These changes induced the usage of natural resources in rural landscape. Changing of rural ecosystem is the result of changing human activities which are the main driving forces to landscape changes. Two study areas in Japan also changed in socio-economic environment. Farm household population decreased continuously from 1970. In addition, proportion of old age farmer increased in same period. Agricultural fields decreased in MK and MW. *Pinus densiflora* areas as a main landscape element among landscape elements decreased while *Quercus* spp. and plantation areas increased in both study areas. Spatial heterogeneity increased in both areas. Main plant life-form is the phanerophytes and hemicryptophytes and species diversity given life-form types is different in each area. Community group using cluster analysis divided five groups based on community characteristics. Community distribution on PCA ordination was decided by shrub development, which positively correlated with axis 1, and herb layer coverage and species number, that are negatively correlated with axis 2. *P. densiflora* in regression analysis between spatial pattern and species diversity given life-forms was significantly related with perennial herb species in patch shape metrics. The criteria hierarchies, such as elevation, aspect, slope, geology, vegetation, and distance from inhabited area were decided by pair-wise comparison

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method. Relative percentage of suitable management area for *P. densiflora* occupied more than 90 % in MK, and MW. It means that Japan is the more suitable place for management of *P. densiflora*.

Keywords Biocultural landscape • Traditional landscape • Agriculture • Human impact • Landscape dynamics • Vegetation structure

12.1 Introduction

The twentieth century has seen dramatic changes in the way humans use the landscapes of the world. Industrial developments gave birth to change of socio-economic environments which strongly influence rural landscapes (Marsh 1997; Skinner et al. 1997; Palang et al. 2005). Traditional rural landscapes have a long reciprocal relationship between nature and human impacts. In particular, Asian rural landscapes as a cultural landscape having influenced mainly from rice paddy fields which are the main component and product in agriculture industry. Changes of agriculture system and socio-economy induce rural landscape changes. In socio-economic development among Asian countries, Japan is the most developed country. Therefore, influence of socio-economic environments is fast and they show the changing landscape structure, function and prediction of rural landscape in Asia (Kim et al. 2006). Japan will explain as an example of rural landscape change for future rural landscape planning and management in other Asian countries.

The analyses of landscape changes and their factors related to human activities are main issues of rural landscape ecosystem or landscape planning. Social, culture and economic conditions are potentially the most influential factors in forming landscape structure and its change. They help to explain landscape structure, and suggest the array of possible human actions and desirable designs to promote ecological function (Nassauer 1995; Kamada and Nakagoshi 1997; Fukamachi et al. 2001).

Rural landscape located in the space between city and mountainous area not only geographically but also ecological flow as well as cultural diversity. Rural landscape ecosystems have the unique function due to reciprocal relationship between human and nature therefore they make different habitats environments not like a city and mountain. Landscape planning for biodiversity conservation is a critical issue in rural landscape. Considerable attention has been given to describing changes in landscape through time, however, some studies have attempted to understand economic and ecological influences on landscape structure (Kamada and Nakagoshi 1996; Turner et al. 1996; Hong 1998). In a changing landscape, the spatial distribution of species would be dependent on their biological characteristics and patterns of land use. It is necessary to consider both natural condition and human impacts to fully understand the relationships between landscape change and its habitat environments for biodiversity at spatial and temporal scale (Duelli 1997; Kim et al. 2006).

Traditional rural landscapes are social and ecological networks of a village and its surroundings, which include agriculture lands, open forestlands and forests, and which have maintained a high diversity of plants, insects and small-to-medium-sized vertebrates (e.g., Tabata 1997; Moriyama 1998; Takeuchi et al. 2003). In order to understand the development of land use changes which have occurred in rural landscapes, it is imperative to consider their relationship with human impacts (Kamada and Nakagoshi 1996, 1997; Kim et al. 2006).

In this chapter, we focused on which landscape elements (land use type) were affected by human activities over a decade, and tried to determine which factors were most effective in controlling changes in the landscape structure. We also tried to understand relationship about spatial pattern and habitat environments and will make suggestions for rural landscape planning for sustainable management.

12.2 Study Areas

12.2.1 Minamikata (MK), Kitahiroshima-cho, Hiroshima

The study areas are Minamikata (lat. 36°34′~36°41′N, long. 132°30′~132°36′E) at Kitahiroshima-cho in Hiroshima Prefecture, western Japan (Fig. 12.1; -cho represent different levels of administration and they correspond to township, in English). Both two study areas were set longitudinally from the sea to mountain in Hiroshima Prefecture.

Actually, Minamikata (MK) was in Chiyoda-cho, however, according to local government strategies of political boundary, MK is mapped in Kitahiroshima-cho from Feburary 1, 2005, this is combined by several – cho and make a bigger – cho. These political strategies follow several purposes which were caused by increasing old aging population, fund of local government and specialization for local characteristics and so.

The altitude of MK ranges from 250 to 815 m above sea level. The geological condition consists mainly granite, therefore, the soil of the study area is generally yellowish-brown forest soil and immature soil. Annual precipitation is 1,733.6 mm and annual mean temperature is 14.8 °C (Fig. 12.2). Mean maximum temperature is 19.9 °C and mean minimum temperature is 10.6 °C. Potentially belong to the evergreen broad-leaved forest zone.

12.2.2 Miwa-cho (MW), Miyoshi City, Hiroshima

Miwa-cho (lat. 34°32′~34°43′N, long. 132°46′~132°52′E) in Hiroshima Prefecture, western Japan (Fig. 12.1; -cho represent different levels of administration and they correspond to township, in English). Miwa-cho actually, changed the political

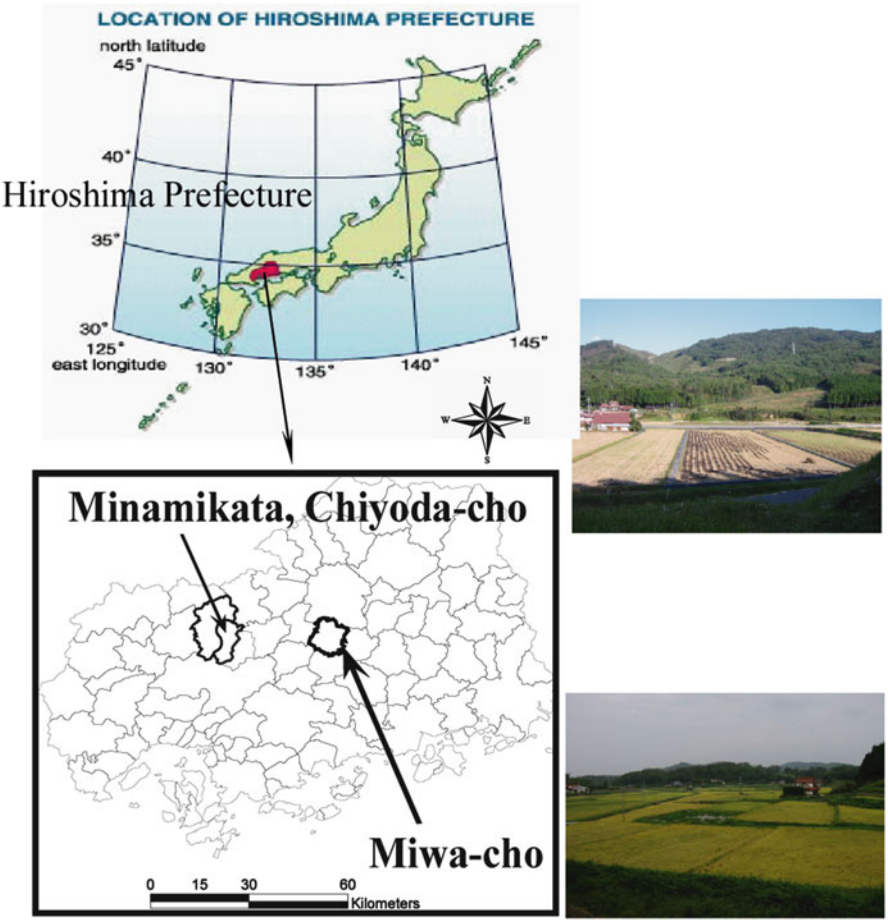


Fig. 12.1 Study areas

district which was Hutami-gun but now is Miyoshi City according to the government strategies of political boundary from April 1, 2004. The reason was already mentioned previously.

Miwa-cho is located in a basin located in the central part of Hiroshima Prefecture. The altitude of Miwa-cho ranges from 250 to 800 m above sea level. The area consists mainly of alluvial soil used for rice paddies and human settlements. The mountainous geology consists mainly of granite. The soil of the study area is generally yellowish-brown forest soil and immature soil (Nakagoshi et al. 1992). Annual precipitation is 1,517.4 mm and annual mean temperature is 13.0 °C (Fig. 12.2). Mean maximum temperature is 19.9 °C and mean minimum temperature is 10.6 °C. Potentially belong to the evergreen broad-leaved forest zone.

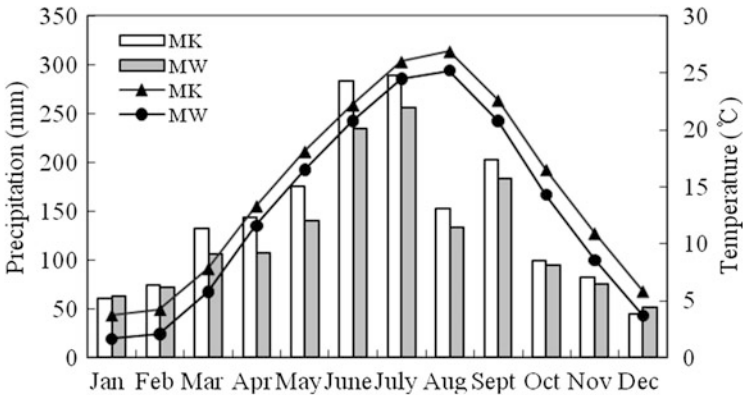


Fig. 12.2 Annual mean precipitation and temperature of study areas (*MK* Minamikata, *MW* Miwa-cho)

12.3 Materials and Methods

12.3.1 Socio-economic Background

Rural landscapes are affected by a reciprocal relationship between nature and humans as previously mentioned. Therefore, rural landscape studies should consider the socio-economic environments in this regard. A durable socio-economic existence is often argued as a very important goal to achieve in order to create a sustainable rural system. Rural sustainability is often a concern when human activities concerning land-use planning and management are at stake. A very important aim for land-use planners was always, and still is, to improve the socio-economic situation of the rural population. One of the means was to create changing agricultural system, increase production, create village, move the population etc. There are great opportunities for land-use planners to help the development of rural areas towards a more sustainable system (van Lier 1998).

Socio-economic background information (e.g. human population movement, forest production, agricultural productivity etc.) structuring the landscape and ecosystems was obtained from each study area (Figs. 12.3, 12.4, and 12.5).

12.3.2 Landscape Pattern Analysis: Mapping and Spatial Indices

Research of landscape ecology is usually based on map interpretation of aerial photographs and field surveys (Turner et al. 1996, 2001). The landscape mapping

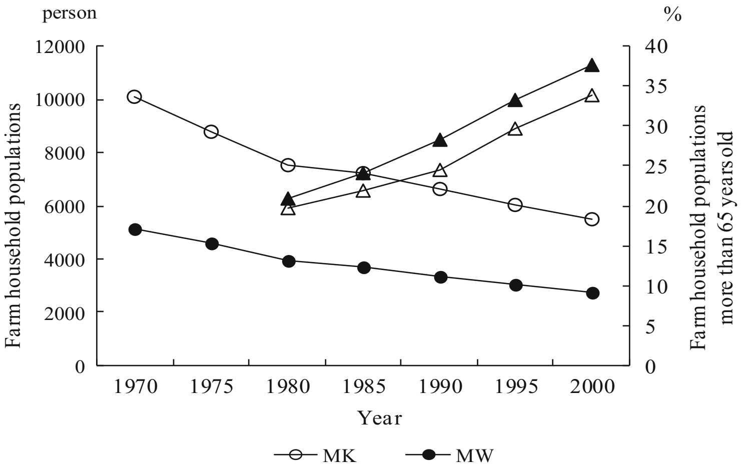


Fig. 12.3 Trend of farm household population in both study areas. *MK* Minamikata, *MW* Miwa-cho

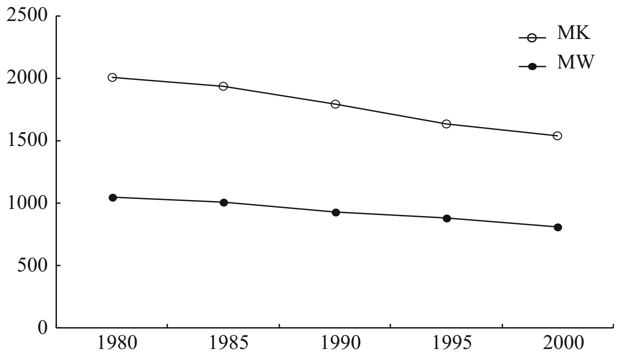


Fig. 12.4 The number of total agricultural household in both study areas

was carried out twice at each area, in 1988 and 2002 for TD and TS, and in 1992 and 2003 for YH.

The concept and scheme of landscape vegetation mapping employed was that according to Nakagoshi et al. (1992). The term "vegetation patch" was used to describe each area recognized by its dominant species at the highest layer of vegetation and its height on the actual vegetation map.

Landscape elements were divided into three major types, i.e. natural, mixed and introduced types, according to their origin. The natural type contained the secondary vegetation or patch type due to natural regeneration, although landscape management was later employed. *Pinus densiflora*, *Quercus* spp. and other secondary forests are included in this type. The introduced type is vegetation and

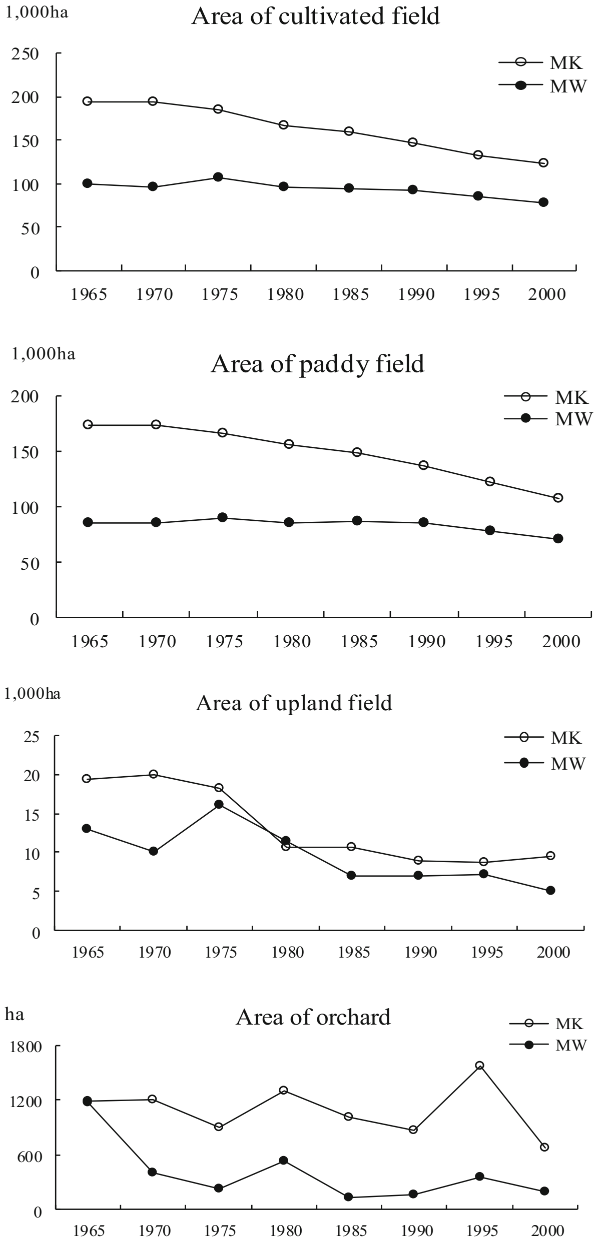


Fig. 12.5 Trend of agricultural field since 20 years in both study areas

landscape originally human-induced for some economic purposes. The mixed type is a combination of both the natural type and the introduced type.

Landscape elements used to compare the 2 years when data were collected. Characteristics of spatial pattern were categorized by main landscape elements. The number of some patches was very small, and so it was difficult to compare these patches. Natural types were composed of *P. densiflora*, *Quercus* spp. and others of natural type. Introduced types were composed of plantation, agricultural fields and others of introduced type. Mixed types were the same as those previously mentioned. The Mann-Whitney *U*-test, statistical analysis was used to compare the different changes in proportion of landscape element changes.

Landscape ecological studies have focused on spatial pattern and ecological process (Forman 1995; Pickett and Cadenasso 1995; Turner et al. 2001). Consequently, landscape change studies recognized the spatial pattern of changes induces by the changing ecological process. Many landscape ecologists refer to the importance of landscape spatial heterogeneity. From the ecological point of view, landscape spatial heterogeneity has been the cause the varied ecological phenomena (O'Neill et al. 1988; Wu et al. 2002; Steiner and Köhler 2003).

To measure of landscape spatial heterogeneity used to landscape indices. It is always necessary to take into account the ecologically relevant attributes when we want to use this approach for any landscape mosaic. These attributes express qualitative (land use type), and quantitative (size, number) characteristics of landscape elements or landscape as a whole (Turner et al. 2001; Corry 2005).

Spatial characteristics (i.e. pattern, diversity, heterogeneity, etc.) of the landscape spatial pattern were analyzed by FRAGSTAS of spatial statistics (McGarigal and Marks 1995). In particular, spatial indices (i.e. size, number and patch density) for each land use type were adopted to understand the relationship between each patch type in the landscape mosaics (Table 12.1).

The landscape indices Mean Patch Size (MPS) and Patch Density (PD) in patch area metrics, the Mean Patch Edge (MPE) and Total Edge (TE) in edge metrics, Area-Weighted Mean Shape Index (AWMSI) and Area-Weighted Mean Patch Fractal Dimension (AWMPFD) in patch shape metrics, were applied to measure spatial pattern (McGarigal and Marks 1995; Turner et al. 2001; Corry 2005).

MPS and PD were used as indicators habitat fragmentation and habitat quality. It is a fundamental aspect of landscape structure. When the MPS of a patch type within a single landscape, is smaller than another patch type, it is considered more fragmented. PD, in the entire landscape mosaic, could serve as a good heterogeneity index because a landscape with greater patch density would have more spatial heterogeneity (McGarigal and Marks 1995).

MPE and TE in edge metrics of a landscape are important to many ecological phenomena. In particular, a great deal of attention has been given to wildlife-edge relations. In landscape ecological investigations, much of the presumed importance of spatial pattern is related to edge effects. The forest edge effect, for example, results primarily from differences in wind and light intensity, and quality reaching a forest patch that alter microclimate and disturbance rates. These changes, combined with changes in seed dispersal and herbivory, can influence vegetation composition and structure.

AWMSI and AWMPFD are more suitable than MSI (Mean Shape Index) and MPFD (Mean Patch Fractal Dimension) when a few land use types are dominant in

Table 12.1 The configuration of total landscape elements identified from maps in MK

	1987			2003		
Landscape elements	No. patch (%)	Patch density	Area (ha) (%)	No. patch (%)	Patch density	Area (ha) (%)
Natural types						
Pinus densiflora						
Tall	35 (12.7)	0.96	1,994.8 (54.6)	99 (18.8)	2.71	1,150.1 (31.5)
Mid-height	12 (4.4)	0.33	65.8 (1.8)	3 (0.6)	0.05	13.1 (0.4)
Short	18 (6.5)	0.49	76.0 (2.1)	1 (0.2)	0.05	12.4 (0.3)
Sub-total	65 (24.1)	1.7	2,136.5 (58.4)	102 (19.4)	2.79	1,163.2 (31.8)
Quercus spp.						
Tall	50 (18.2)	1.37	666. 4 (18.2)	31 (5.9)	0.85	925.4 (25.3)
Mid-height	4 (1.5)	0.11	56.6 (1.5)	1 (0.2)	0.03	1.7 (0.05)
Short	2 (0.7)	0.05	5.7 (0.2)	–	–	–
Sub-total	56 (20.4)	1.5	728.8 (19.3)	32 (0.1)	0.87	927.1 (25.3)
Quercus spp. and *Pinus densiflora*	–	–	–	46 (8.7)	1.26	503.5 (13.8)
Introduced types						
Plantation						
Chamaecyparis obtuse and *Cryptomeria japonica*						
Tall	38 (13.8)	1.04	115.6 (3.2)	60 (11.4)	1.64	111.5 (3.1)
Mid-height	21 (7.6)	0.57	82.2 (2.2)	17 (3.2)	0.46	58.8 (1.6)
Short	18 (6.5)	0.49	68.5 (1.9)	60 (11.4)	1.64	321.2 (8.8)
Sub-total	77 (30.0)	2.1	266.3 (7.3)	137 (26.0)	3.75	491.6 (13.4)
Scrub community at clear cutting site	19 (6.9)	0.52	41.8 (1.1)	57 (10.8)	1.56	58.9 (1.6)
Miscanthsus sinensis	1 (0.4)	0.03	6.7 (0.2)	–	–	–
Paddy field	11 (4.0)	0.30	432.6 (11.8)	9 (1.7)	0.25	375.8 (10.3)
Upland field	18 (6.5)	0.49	28.3 (0.8)	26 (4.9)	0.71	24.3 (0.7)
Inhabited area	28 (10.2)	0.77	15.1 (0.4)	101 (19.2)	2.76	92.6 (2.5)
Others	–	–	–	16 (3.0)	0.44	19.0 (0.5)
Total	275 (100)	7.52	3,656 (100)	526 (100)	14.39	3,656 (100)

study areas (McGarigal and Marks 1995). The complexity of patch shape was measured using AWMSI, which can be used to compare changes in the shape of landscape mosaics. AWMSI and AWMPFD are indices which show the patch shape by patch area and perimeter, and are usually used as indicators for wildlife habitats. They indicate that the patch shape is more natural, or in other words has more complicated boundaries, if the value is high (Turner et al. 2001). The Mann-Whitney *U*-test, statistical analysis was used to compare the different changes in spatial pattern.

GIS ArcView version 3.2a (Environmental System Research Institute 1998, version 3.2a) was applied to construct the land use map. All land use types were identified and their number and size were measured by spatial statistics.

12.3.3 Field Survey, Vegetation Dynamics and Plant Life-Form Analysis

The field surveys for plant community structure in three study areas were carried out in August, the same period with the land use mapping, in August. Permanent quadrat plots (10×10 m^2 in tree layers, 5×5 m^2 in herb layers) in TD, TS and YH were set, 1988 in TD and TS, and 1992 in YH. The coverage and abundance of each species were also measured. All vascular plants were surveyed by the Braun-Blanquet (1964) method and arranged by table method. The second survey in 2002 and 2003 was carried out in the same place as the previous survey. If the same plot was not found in 2002 and 2003, the survey was carried out in the same land use using vegetation patches, including the original plot, and the species names used were according to Lee's (1996) illustration.

Plant life-form indicates the ecosystem function (Walker and Langridge 2002) which may explain the changing landscape ecosystems through time in rural forest. Raunkiaer's life-form system was introduced to consider the degree of forest development and structure (Nakagoshi et al. 1992). Therefore, life-form data, together with the relative species richness and species diversity were used as a quantitative data set. Species diversity was measured through Shannon-Wiener's diversity index (H′) (Saïd 2001). Relative species richness and species diversity of each of the given life-forms for this study explained the ecosystem environments (Saïd 2001).

$$\mathrm{H}' = -\sum_{i=1}^{s} P_i \log P_i$$

where, S is total number of species, $Pi = Si/S$, Si is the number of species i.

The community defined by homogenous physiognomy was confirmed by the procedure of phytosociology (Braun-Blanquet 1964), and each plant community was identified by finding the dominant species.

Communities indicate community characteristics of forest structure and species composition simultaneously on the vegetation landscape map. Morisita's similarity index $C\lambda(p)$, which explains the inter-stand similarities, (Morisita 1959) was used for this community analysis. This index is calculated based on the floristic compositions and their coverage. The formula is as follows:

$$C\lambda(p) = \frac{2\sum_{i=1}^{n} p_{1i} p_{2i}}{\lambda_{1(p)} + \lambda_{2(p)} \sum_{i=1}^{n} p_{1i} \sum_{i=1}^{n} p_{2i}},$$

$$\text{where} \quad \lambda_{1(p)} = \frac{\sum_{i=1}^{n} p_{1i}^2}{\left(\sum_{i=1}^{n} p_{1i}\right)^2}, \lambda_{2(p)} = \frac{\sum_{i=1}^{n} p_{2i}^2}{\left(\sum_{i=1}^{n} p_{2i}\right)^2}$$

P_{1i}, P_{2i} = coverage in percent of species *i* in the species of each community of each plot.

Cluster analysis based on the vegetation similarities was carried out and grouping was classified based on the Group Linkage Method (the Ward's Method), using the Euclidean Distance Measure.

To understand the vegetation dynamics and community characteristics, Principle Component Analysis (PCA) based on vegetation similarity index was conducted. Moreover, the PCA ordination (PC-ORD ver. 4.01) was applied to estimate the vegetation changes on a spatio-temporal scale.

Ordination is the collective term for multivariate techniques that arrange sites along axes on the basis of data on species composition (Jongman et al. 1995). This means that the vegetation arrangement in relation to each other (similarities in species composition and/or their associated environmental gradients) can indicate community characteristics in rural forest.

12.3.4 Statistical Analysis

Regression analysis was carried out to understand the relationship between changing spatial pattern and qualitative community in rural forests. Landscape indices indicate landscape structure especially spatial patterns in rural landscape, and also species diversity of each type of given plant life-forms indicate the status of rural forest ecosystem. This result may explain what qualitative and quantitative effects would have to vegetation according to changing spatial pattern over time.

12.4 Results

12.4.1 Landscape Element Descriptions and Socio-economic Environments

The effects of the upward growth of the Japanese economy however, began to emerge in changes of traditional land use types. In the beginning of the 1950s, lands used for shifting cultivation began to decrease, and by 1970 had disappeared apparently in Japan. After 1960, the demand for traditional land use types decreased due to the widespread use of chemical fertilizers. A decrease in traditional rural landscape can also be attributed to the abandonment of paddy fields, caused by a shift in migrant field labors to find work in national forests. Although economic stability was the justifiable reasoning behind the move, this too ultimately reduced the total area of agricultural fields.

Trend of farm household population continuously decreased since 1970 (Fig. 12.3). In addition, proportion of old age population increased (Fig. 12.3). Figure 12.4 shows the number of total agricultural household for 20 years in both study areas. Actually, the number of total agricultural household continuously decreased in both areas. Therefore, increasing population density in MK may not have any meaning about the influence in rural landscapes.

Total agricultural area and paddy field area decreased in both areas (Fig. 12.5). However, upland field area and orchard area shows a fluctuation. The main type of agriculture is rice paddy field which was occupied by more than 90 % in both areas (Fig. 12.6). Orchard occupied blow 1 % out of total agricultural area. The proportion of main agricultural type is not so different in both areas during 20 years. Rice production between 1995 and 2000 decreased.

The continual efforts to rebuild Japan from the destruction of the Second World War helped to expand the demand for both timber and pulpwood. Related to this, silvicultural activities involving Japanese cedar (*Cryptomeria japonica*) and cypress were economically promoted to meet the demands set by the Forestry Agency, and both public and private plantations were subsidized directly by the national and local governments. During the Second World War, the ratio of fuel wood and charcoal to timber production was 64 % to 36 % in Japan. However, the rapid increase of cheap imports of oil and natural gas from abroad in the 1960s would drastically alter these statistics. The revolutionary change to the widespread use of propane gas would by the 1970s, clearly decrease the use of rural forest for fuel wood and charcoal, leading to managerial abandonment of rural forests in most areas. At approximately the same time, *Pinus densiflora* began to die as a result of pine wilt disease. To complicate matters, logging for pulpwood by local enterprises created relatively large, cleared areas among private, old-age, broadleaf forests, making it difficult for forests to regenerate.

Timber production decreased in MK while increased in MW. Main ownership of MK and MW is private with nearly 95 % (80,791 ha) of the 84,143 ha and nearly 93 % (30,047 ha) of the 37,489 ha respectively.

Mapping shows the changes of landscape structure by temporal in both areas of MK (Figs. 12.7 and 12.8) and MW (Figs. 12.9 and 12.10). Total landscape elements by mapping are summarized on Tables 12.2 and 12.3 of both study areas. Main landscape element type was divided into two types one is natural type another is introduced type.

In MK, *P. densiflora* in all level of height decreased in area and number of patch and also patch density decreased except in tall height (Table 12.1). Total area of *Quercus* spp. increased especially, tall height while mid-height and short height decreased. Patch of mixed vegetation type such as *P. densiflora* and *Quercus* spp. occurred in 2003. Plantation in introduced type species generally was the

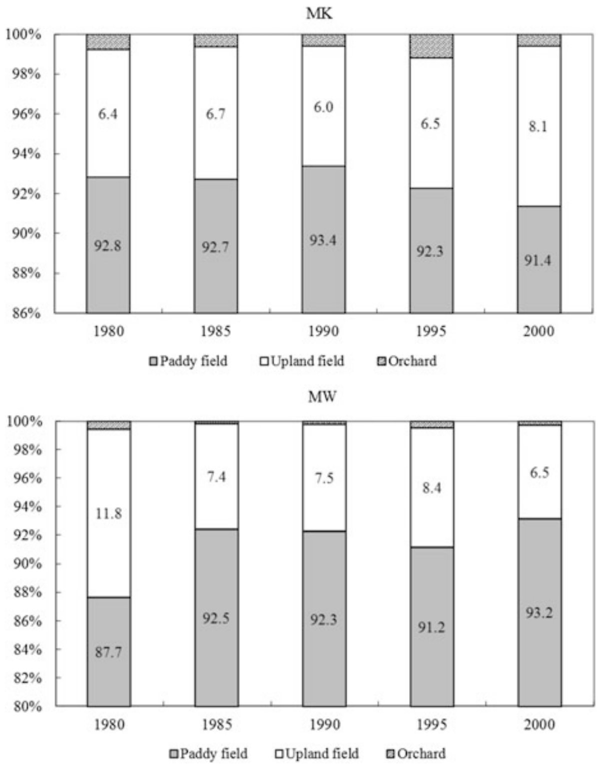


Fig. 12.6 Proportion of three main agriculture types in both study areas. The number on the *bar* is the proportion of each agriculture type in the out of total area and proportion of orchard occupied blow 1 %

Chamaecyparis obtuse and *Cryptomeria japonica*. Total area on plantation increased especially, shot height increased almost five times compared in 1987. It means that plantation area increased currently because so many of *P. densiflora* died due to pine wilt disease. Moreover, scrub community at clear cutting site also increased that area will be a plantation area. Agricultural area in paddy field and upland field decreased while inhabited area increased in area, number of patch, and patch density.

In MW, *P. densiflora* area in all level of height decreased while number of patch in tall height increased therefore, patch density increased (Table 12.2). *Quercus* spp. area increased while evergreen *Q. salicina* patch was disappearing. Plantation area and number of patch increased in all level of height. Phylostachys plantation increased and artificial grassland disappeared probably due to abandonment. Scrub community at clear cutting site area did not change however, number of patch increased. It means that clear cutting site was made by small scale likely fragment. Agricultural area, in paddy field, upland field, and orchard areas decreased while inhabited areas increased.

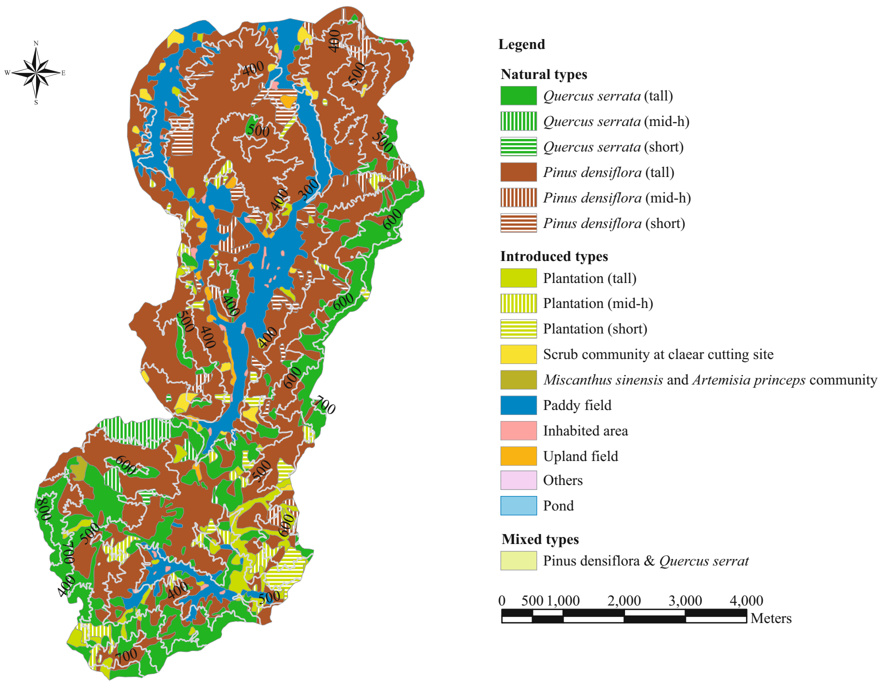


Fig. 12.7 Vegetation landscape map of MK in 1987

12.4.2 Changes of Landscape Mosaics and Spatial Pattern

The main composition elements in MK were *Pinus densiflora* in 1987 (Fig. 12.7). However, proportion of *P. densiflora* area in MK decreased (Fig. 12.11) significantly from 58.44 to 24.13 % (Table 12.3). Moreover, proportion of number of patch on *P. densiflora* also decreased. Proportion of area and number of patch on *Quercus* spp. also decreased but the change was not significant. Plantation area increased almost four times (34.91 %) compare to previous year and the change was significant ($p < 0.01$). The proportion of patch number also increased. The proportion of area and patch number in agricultural area decreased. However, proportion of area and patch number at other introduced type increased and the change was significant ($p < 0.01$).

The main composition elements, *Pinus densiflora*, in MW were not changed (Fig. 12.7), however, proportion of area decreased to 54.34 % compared with 70.68 % and the change was significant (Fig. 12.12). *Quercus* spp. and plantation increased in area and patch number and the change was significant ($p < 0.01$). Agricultural area in both measure method values decreased and the change was significant ($p > 0.05$). Others in introduced type increased in both measure methods values but the change was not significant. Proportion of grassland area increased to 4.86 % compared with 0.84 % and the change was significant ($p > 0.05$).

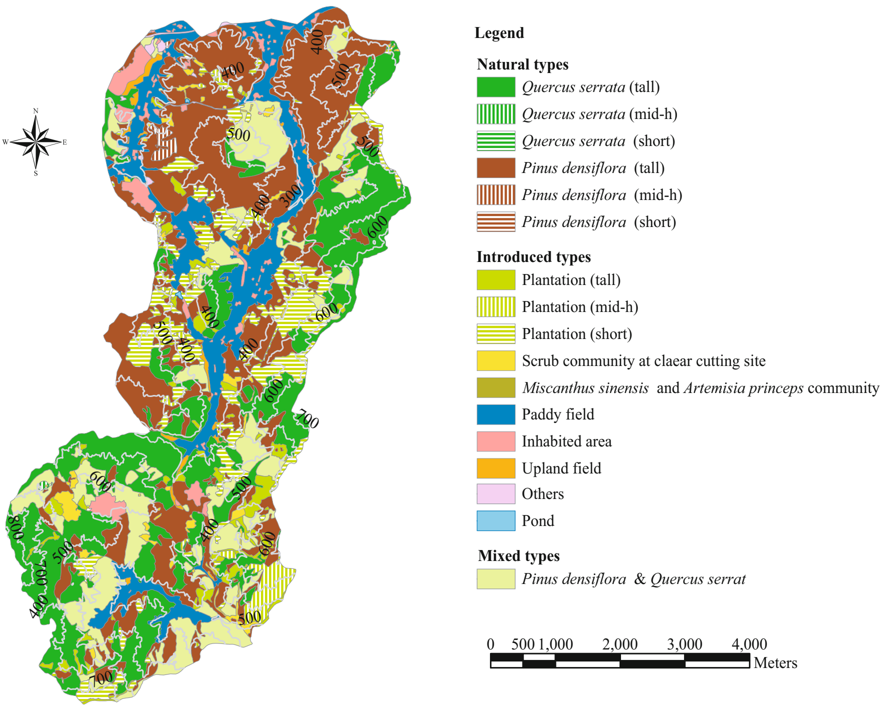


Fig. 12.8 Vegetation landscape map of MK in 2003

Configuration of spatial pattern in area metrics (MPS and PD), edge metrics (MPE and TE), and shape metrics (AWMSI and AWMPFD) are shown in Table 12.4. MPS in MK decreased except others in introduced type but the change was not significant (Table 12.5) while, MW increased except agricultural area and the changes were significant ($p < 0.001$). Patch density of MK increased but the changes were not significant. Patch density of MW increased except *P. densiflora* and agricultural area but the changes were not significant.

MPE in MK decreased except *Quercus* spp. and others in introduced type but the changes were not significant. However, in MW there was an increased in all classified landscape elements and also the changes were significant ($p < 0.05$). TE increased in both areas except *P. densiflora* but the changes were not significant.

AWMSI increased except *P. densiflora* and *Quercus* spp. in MK and the changes were significant ($p < 0.01$). MW also increased except *P. densiflora* and the changes were significant ($p < 0.01$). AWMPFD decreased except plantation and agricultural area in MK and the changes were significant ($p < 0.01$) while, MW increased except *P. densiflora* and the changes were significant ($p < 0.01$).

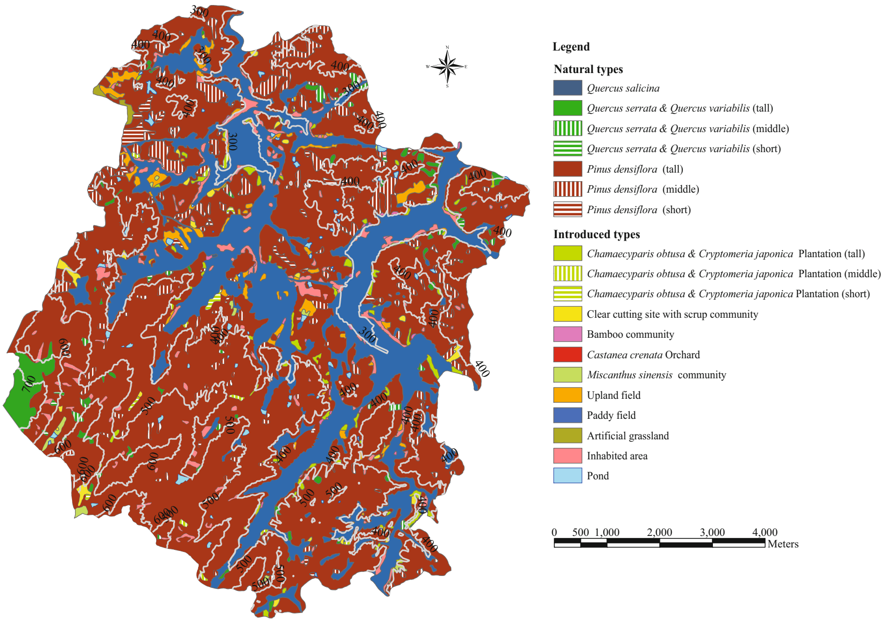


Fig. 12.9 Vegetation landscape map of MW in 1992

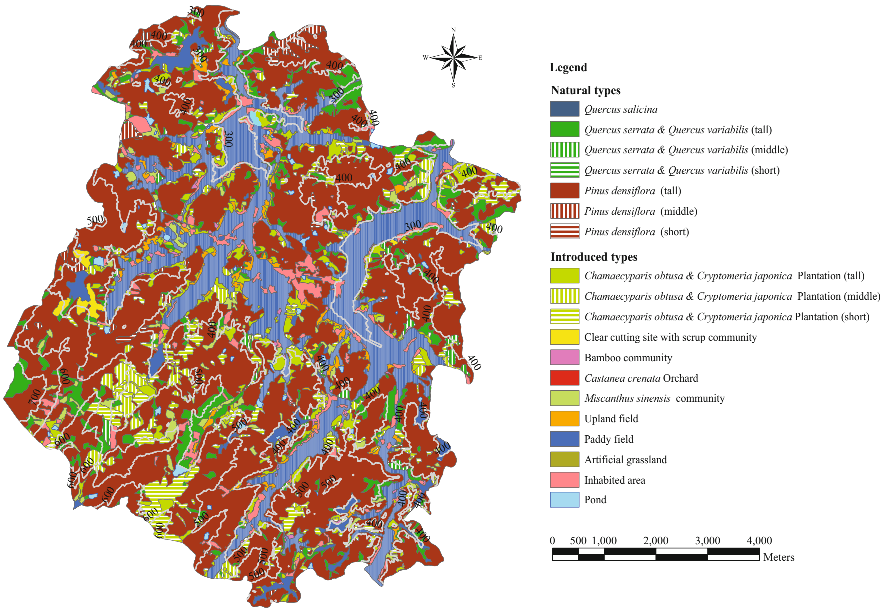


Fig. 12.10 Vegetation landscape map of MW in 2004

Table 12.2 The configuration of total landscape elements identified from maps in MW

	1992			2004		
Landscape elements	No. patch (%)	Patch density	Area (ha) (%)	No. patch (%)	Patch density	Area (ha) (%)
Natural types						
Pinus densiflora						
Tall	62 (7.4)	0.85	4,721.9 (65.1)	90 (7.1)	1.26	3,795.6 (53.3)
Mid-height	171 (20.3)	2.36	358.7 (4.9)	19 (1.5)	0.27	56.4 (0.8)
Short	26 (3.1)	0.36	46.0 (0.6)	12 (0.9)	0.17	18.0 (0.3)
Sub-total	249 (30.8)	3.43	5,126.6 (70.6)	121 (9.5)	1.70	3,870.0 (54.4)
Quercus spp.						
Tall	48 (5.7)	0.66	129.2 (1.8)	212 (16.7)	2.98	500.1 (7.0)
Mid-height	22 (2.6)	0.30	32.6 (0.4)	23 (1.8)	0.32	54.5 (0.8)
Short	7 (0.8)	0.10	7.3 (0.1)	1 (0.1)	0.01	0.9 (0.01)
Sub-total	77 (9.1)	1.06	169.1 (2.3)	236 (18.6)	3.31	555.5 (7.8)
Quercus salicina	1 (0.12)	0.01	0.5 (0.01)	–	–	–
Introduced types						
Plantation						
Chamaecyparis obtusa and *Cryptomeria japonica*						
Tall	75 (8.9)	1.03	73.4 (1.0)	214 (16.9)	3.01	335.6 (4.7)
Mid-height	10 (1.2)	0.14	13.9 (0.2)	72 (5.7)	1.01	175.2 (2.5)
Short	6 (0.7)	0.08	10.3 (0.1)	135 (10.6)	1.90	313.0 (4.4)
Sub-total	91 (10.8)	1.25	97.6 (1.3)	421 (33.1)	5.91	823.8 (11.6)
Phyllostachys plantaion	40 (4.7)	0.34	14.5 (0.2)	57 (4.5)	0.80	19.5 (0.3)
Artificial grassland	3 (0.4)	0.04	8.5 (0.1)	–	–	–
Miscanthsus sinensis	13 (1.5)	0.03	16.6 (0.2)	110 (8.7)	1.54	136.7 (1.9)
Scrub community at clear cutting site	25 (3.0)	0.34	35.6 (0.5)	8 (0.6)	0.11	35.6 (0.5)
Paddy field	29 (3.4)	0.40	1,466.1 (20.2)	30 (2.4)	0.42	1,298.9 (18.2)
Upland field	68 (8.1)	0.94	107.3 (1.5)	63 (5.0)	0.88	94.4 (1.3)
Orchard (*Castanea crenata*)	2 (0.2)	0.55	16.6 (0.02)	1 (0.1)	0.01	0.7 (0.01)
Inhabited area	159 (18.9)	2.19	168.1 (2.3)	159 (12.5)	2.23	240.1 (3.4)
Pond	76 (9.0)	1.05	40.7 (0.6)	64 (5.0)	0.90	46.1 (0.6)
Total	843 (100)	11.62	7,121 (100)	1,270 (100)	151.6	7,121 (100)

12.4.3 Vegetation Dynamics and Plant Life-Form

The total 216 plots and 372 species by phytosociological data were surveyed two times each year, in 1987 and 2003 in MK and in 1992 and 2004 in MW.

Life-form was distinguished by five classifications, i.e. Phanerophytes (Ph), Chamaephytes (Ch), Hemicryptophytes (H), Geophytes (G) and Therophytes (Th). Figure 12.13 shows the relative species richness of given life-form along each year in both study areas. The main life-form type in both study areas was the

Table 12.3 The *p* value using Mean-Whitney *U*-test for classified landscape element area of different year

Classified landscape elements	MK (Minamikata) (1987–2003)	MW (Miwa-cho) (1992–2004)
Pinus densiflora	0.005**	0.001**
Quercus spp	0.113	0.003**
Plantation	0.008**	0.007**
Agricultural area	0.898	0.021*
Others in introduced type	0.005**	0.068
Gassland	0.006**	0.021**

Others in natural type could not analyze due to not enough value between 2 years
*$p < 0.05$, **$p < 0.01$

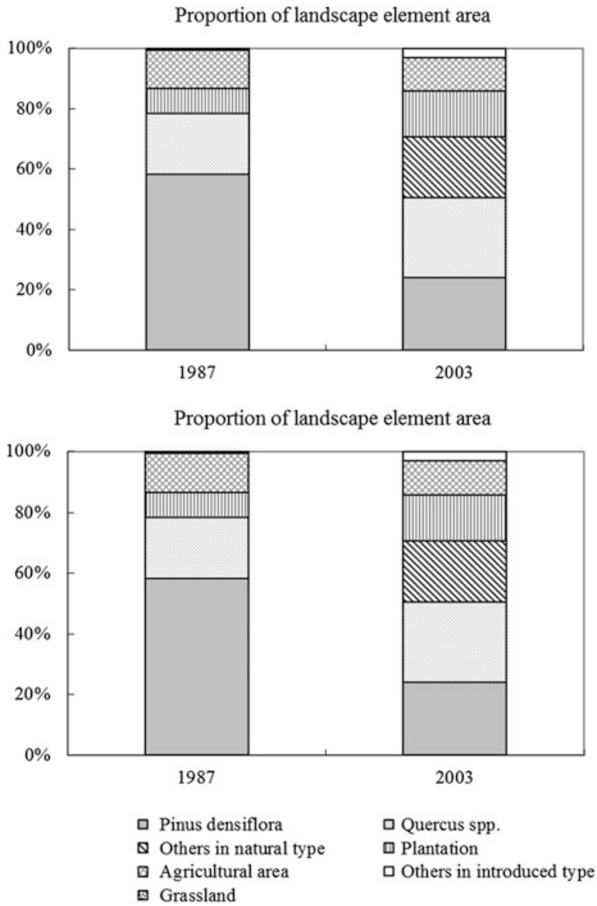
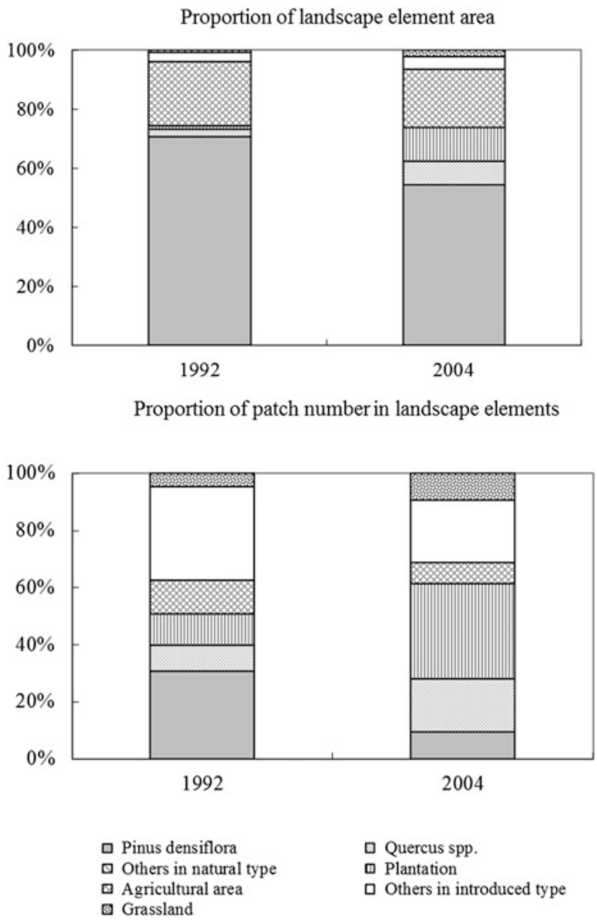


Fig. 12.11 Proportion of area and patch number in classified landscape elements in MK

Fig. 12.12 Proportion of area and patch number in classified landscape elements in MW



Ph (phaneophytes) and H (hemicryptophytes) that is more than 70 % and 10 % occupied in each year respectively. This means that mainly tree species and perennial herb species occupied both study areas. However, relative species richness given life-form in MK slightly changed in the life-form types and in MW, life-form on herb species such as H (Hemicryptophytes) and Th (Therophytes) decreased.

Species diversity given life-form, Ch (Chamaephytes), increased in both study areas (Fig. 12.14). In other words, increasing species diversity in Ch indicates the increasing shrub species. Ph increased to 2.143 compared with 1.683 in MW while, slightly decreased to 1.690 compared with 1.702 in MK. G (Geophytes) decreased in both study areas.

Table 12.4 Configuration of landscape structure in two study areas owing to year

Landscape indices	Area	Year	*Pinus densiflora*	*Quercus* spp.	Others in natural types	Plantation	Agricultural area	Others in introduced types	Grassland
MPS (unit: ha)	MK	1987	32.9	13.0	–	3.22.5	15.9	0.5	6.7
		2003	6.8	12.7	11.1	2.5	9.7	0.9	–
	MW	1992	19.8	2.2	0.5	1.1	15.9	0.8	1.5
		2004	32.0	2.4		2.0	14.8	1.1	1.5
PD	MK	1987	1.78	1.53	–	2.63	0.79	0.77	0.03
		2003	3.55	2.08	1.83	5.90	1.15	3.23	–
	MW	1992	3.57	1.06	0.01	1.25	1.36	3.79	0.57
		2004	1.70	3.31	–	5.91	1.32	3.93	1.66
MPE (unit: m)	MK	1987	3,363.2	1,920.4	–	816.1	2,519.0	313.6	1,301.8
		2003	1,237.2	2,066.7	1,858.3	766.0	2,211.3	384.8	–
	MW	1992	2,027.2	548.0	310.9	469.1	2,398.1	405.2	528.9
		2004	3,902.6	828.9	–	706.4	2,816.0	524.4	619.2
TE (unit: km)	MK	1987	218.6	107.5	–	78.3	73.1	8.8	1.3
		2003	160.8	157.1	124.5	165.5	92.9	45.4	–
	MW	1992	525.0	42.2	0.3	42.7	237.4	111.4	21.7
		2004	472.2	195.6	–	297.4	264.7	146.8	73.1
AWMSI	MK	1987	4.102	2.987	–	1.676	4.605	1.295	1.422
		2003	2.268	2.164	2.050	2.049	5.369	1.562	–
	MW	1992	5.707	1.493	1.206	1.375	7.576	1.503	1.430
		2004	4.162	2.063	–	1.855	12.462	1.897	1.706
AWMPFD	MK	1987	1.353	1.343	–	1.314	1.393	1.345	1.291
		2003	1.327	1.321	1.317	1.344	1.424	1.327	–
	MW	1992	1.373	1.296	1.339	1.332	1.422	1.349	1.322
		2004	1.370	1.360	–	1.350	1.465	1.367	1.385

MPS Mean Patch Size (ha), *PD* Patch Density, *MPE* Mean Patch Edge (m), *TE* Total Edge (km), *AWMSI* Area-Weight Mean Shape Index, *AWMPFD* Area-Weight Mean Patch Fractal Dimension, *MK* Minamikata, *MW* Miwa-cho

Table 12.5 The *p* value using Mean-Whitney *U*-test to landscape indices for spatial heterogeneity by different year

Classified landscape elements	MK (Minamikata) (1987–2003)	MW (Miwa-cho) (1992–2004)
MPS	0.248	0.000**
PD	0.443	0.530
MPE	0.419	0.011*
TE	0.644	0.263
AWMSI	0.001**	0.001**
AWMPFD	0.000**	0.002**

$*p < 0.05$, $**p < 0.01$

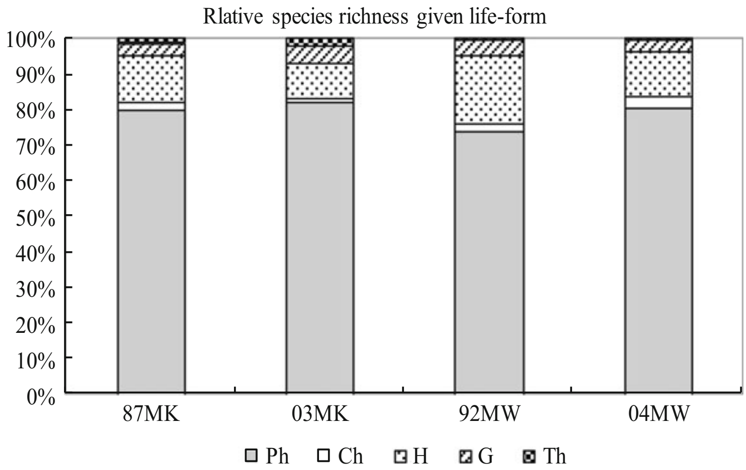


Fig. 12.13 Relative species richness of given life-form in both study areas. *87MK* Minamikata in 1987, *03MK* Minamikata in 2003, *92MW* Miwa-cho in 1992, *04MW* Miwa-cho in 2004, *Ph* Phanerophytes, *Ch* Chamaephytes, *H* Hemicryptophytes, *G* Geophytes, *Th* Therophytes

Owing to phytosociological data, Cluster and PCA ordination using inter-stand similarity index by Morisita (1959) was applied to elucidate the community characteristics.

Cluster dendrogram shows the group by Morisita's index (Fig. 12.15). Cluster analysis of all 216 plots identified five groups that differ in species composition and structure. Group 1 mainly consists of *Pinus densiflora* and *Quercus* spp. as a dominant species. The understory is generally more dense than group 2 however, the vertical structure is well developed. Group 2 consists of mainly *P. densiflora*, a few of mixed community such as *P. densiflora* with *Quercus* spp. community and *Quercus* spp. community. *P. densiflora* is dominant species in this group and sub-tall tree layer was occupied by *Quercus serrata* and *Sasa* species in understory occupied more than 70 % in more than 70 % of the plots. Group 3 mainly consists of *P. densiflora*, andmixed community such as *P. densiflora* with *Quercus* spp.

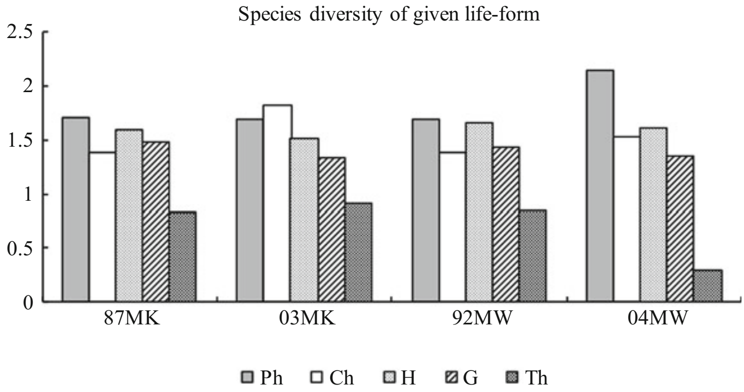


Fig. 12.14 Species diversity of given life-form in both study areas. *87MK* Minamikata in 1987, *03MK* Minamikata in 2003, *92MW*: Miwa-cho in 1992, *04MW* Miwa-cho in 2004, *Ph* Phanerophytes, *Ch* Chamaephytes, *H* Hemicryptophytes, *G* Geophytes, *Th* Therophytes

community. Many of the *P. densiflora* in tall tree layer died due to pine wilt disease. Group 4 evenly consist of all of community types. Especially, *Miscanthsus sinensis*, clear cutting site community, and mixed community *P. densiflora* and *Quercus* spp. are main vegetation types. The understory is generally dense and species abundance is high. Group 5 mainly consists of plantation community such as *Chamaecyparis obtusa* and *Cryptomeria japonica*. The vertical structure was very poor usually only one layer, plant species such as *C. obtusa* and *C. japonica* occupied more than 60 % that understory was generally very poor in species abundance and diversity.

Correlative coefficients of environmental variables to the first two axes of PCA (Table 12.6) indicated that axis 1 (eigenvalue 0.79) was positively correlated with development of shrub layers. Axis 2 (eigenvalue 0.37) negatively correlate with herb layer coverage and species number. Figure 12.16 shows the distribution of vegetation by axis 1 and 2. Owing to axis 1, community distribution of *P. densiflora* is the most well developed community among other communities while plantation community is the poorest developed community. Because plantation is apparently managed by human tree layer can exist only one layer while, abandoned *P. densiflora* community has enough space for growth in other layer communities. Owing to axis 2, community distribution indicates which community can support the development of herb species and species number. Some of *P. densiflora*, *Miscanthus sinensis*, and clear cutting site community support it.

Cluster analysis and ordination of species abundance clearly distinguish the two vegetation types from the data, with most understory species less frequent and less abundant in the plantations. The ordination is strongly influenced by the variation in abundance of species.

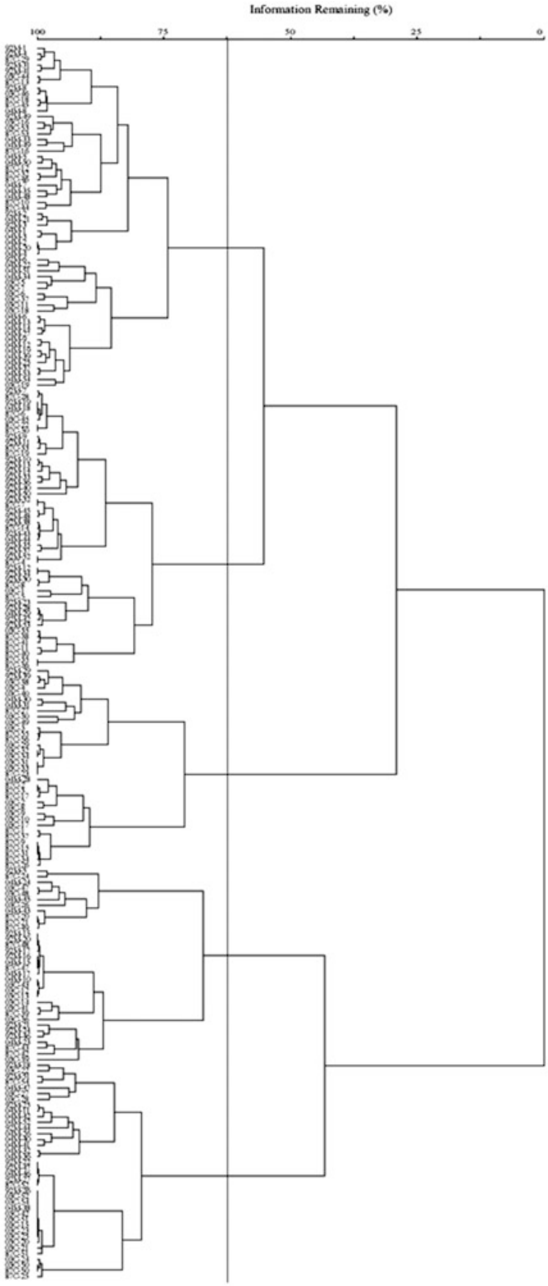


Fig. 12.15 Cluster dendrogram of 216 plots obtained by the cluster analysis using the Morisita's similarity index. *87* the year 1987, *92* the year 1992, *03* the year 2003, *04* the year 2004, *C* MK (Minamikata), *M* MW (Miwa-cho)

Table 12.6 Effect of the components in the PCA of Morisita similarity index and the correlation coefficients between axis 1 and axis 2 and environmental variables

	Axis 1	Axis 2
Altitude	0.078	0.103
Slope	−0.100	0.253**
Tall tree layer height	−0.133	0.128
Tall tree layer coverage	−0.295**	−0.015
Sub-tall tree layer height	0.125	0.030
Sub-tall tree layer coverage	−0.013	0.207
Shrub layer height	0.394**	0.053
Shrub layer coverage	0.345**	0.268**
Herb layer height	0.112	−0.057
Herb layer coverage	−0.174*	−0.508**
DBH	0.030	0.144
Number of species	0.202**	0.283**

*$p < 0.05$, **$p < 0.01$

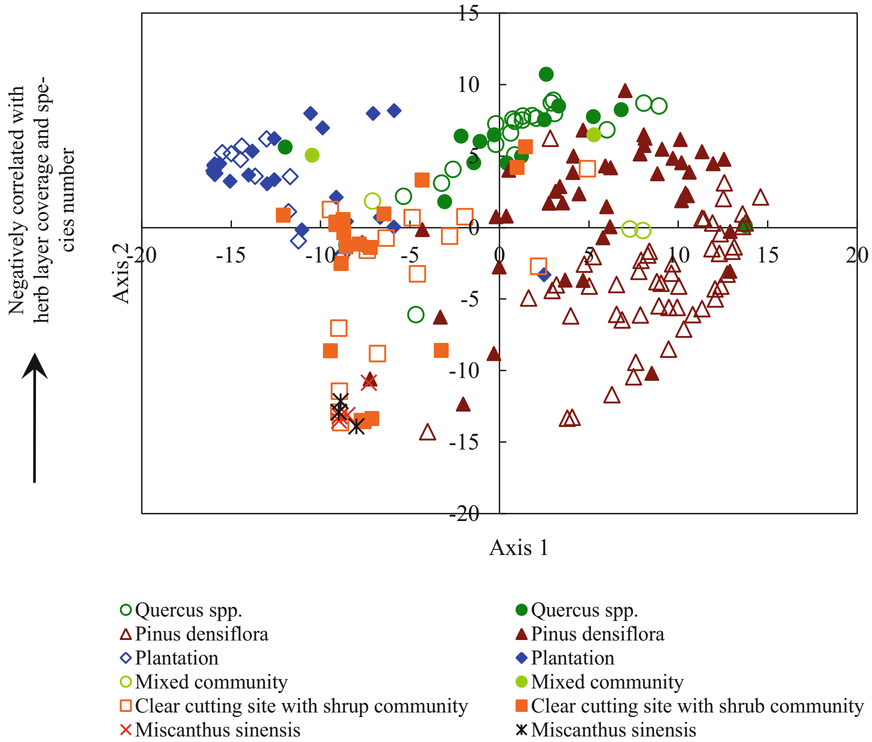


Fig. 12.16 Distribution of plots in relations to PCA axes *1* and *2*. *Open circle* was surveyed in 1987 and 1992 and closed one surveyed in 2003 and 2004

Table 12.7 The regression analysis between area-patch metrics and species diversity of given life-form and the value is the r square

Landscape indices	Landscape elements	Ph	Ch	H	G	Th
MPS (Mean Patch Size)	*Pinus densiflora*	0.265	0.574	0.292	0.254	0.349
	Quercus spp.	0.298	0.150	0.664	0.042	0.366
	Others in natural types	0.130	0.875	0.727	0.356	0.219
	Plantation	0.020	0.037	0.459	0.059	0.035
	Agricultural area	0.030	**0.973***	0.761	0.501	0.083
	Others in introduced types	0.454	0.298	0.004	0.876	0.378
	Grassland	0.035	0.441	0.024	0.765	0.015
PD (Patch density)	*Pinus densiflora*	0.394	0.162	0.019	0.063	0.428
	Quercus spp.	0.825	0.140	0.041	0.468	0.726
	Others in natural types	0.117	0.888	0.758	0.351	0.203
	Plantation	0.320	0.621	0.423	0.696	0.213
	Agricultural area	0.150	0.018	0.182	0.370	0.153
	Others in introduced types	0.179	0.097	0.066	0.558	0.162
	Grassland	0.870	0.032	0.261	0.172	**0.909***

*$p < 0.05$, **$p < 0.01$

Table 12.8 The regression analysis between edge metrics and species diversity of given life-form and the value is the r square

Landscape indices	Landscape elements	Ph	Ch	H	G	Th
MPE (Mean Patch Edge)	*Pinus densiflora*	0.507	0.326	0.179	0.067	0.584
	Quercus spp.	0.180	0.256	0.796	0.003	0.248
	Others in natural types	0.173	0.819	0.621	0.327	0.267
	Plantation	0.011	0.135	0.558	0.001	0.001
	Agricultural area	0.766	0.215	0.248	0.001	0.845
	Others in introduced types	0.771	0.019	0.091	0.481	0.748
	Grassland	0.001	0.663	0.158	0.708	0.013
TE (Total Edge)	*Pinus densiflora*	0.202	0.294	0.823	0.001	0.278
	Quercus spp.	0.511	0.334	0.272	0.466	0.398
	Others in natural types	0.115	0.890	0.762	0.351	0.201
	Plantation	0.796	0.187	0.048	0.558	0.690
	Agricultural area	0.412	0.086	0.548	0.100	0.474
	Others in introduced types	0.505	0.011	0.348	0.247	0.538
	Grassland	**0.900***	0.025	0.227	0.182	**0.934***

*$p < 0.05$, **$p < 0.01$

12.4.4 Relationship Between Spatial Pattern and Life-Form

The relationship between spatial pattern and species diversity given each life-form was represented by regression analysis, the values are r square (Tables 12.7, 12.8, and 12.9). Regression analysis in between species diversity given life-form and patch-area metrics has a relationship significantly between Ch and agricultural area and between Th and grassland (Table 12.7). In other words, agricultural area was

Table 12.9 The regression analysis between patch shape metrics and species diversity of given life-form and the value is the r square

Landscape indices	Landscape elements	Ph	Ch	H	G	Th
AWMSI (Area Weight Mean Shape Index)	*Pinus densiflora*	0.001	0.771	**0.963***	0.281	0.023
	Quercus spp.	0.008	0.005	0.209	0.192	0.011
	Others in natural types	0.316	0.474	0.217	0.197	0.395
	Plantation	0.079	0.733	0.757	0.564	0.028
	Agricultural area	0.851	0.009	0.218	0.248	0.875
	Others in introduced types	0.766	0.095	0.013	0.638	0.706
	Grassland	0.244	0.762	0.727	0.209	0.353
AWMPFD (Area Weight Mean Patch Fractal Dimension)	*Pinus densiflora*	0.199	0.644	**0.940***	0.088	0.300
	Quercus spp.	0.552	0.001	0.037	0.022	0.515
	Others in natural types	0.364	0.166	0.016	0.075	0.397
	Plantation	0.368	0.382	0.019	**0.927***	0.292
	Agricultural area	0.753	0.068	0.032	0.599	0.705
	Others in introduced types	0.655	0.330	0.535	0.220	0.764
	Grassland	0.136	0.868	0.775	0.315	0.228

$^*p < 0.05$, $^{**}p < 0.01$

significantly related to shrub species and also grassland area was significantly related with annual herb species.

In edge metrics, TE has a significantly related with Ph, Th and grassland (Table 12.8). It shows that grassland vegetation as a representative species, *Miscanthsus sinensis*, has related with tree species and annual herb species in edge environment.

Pinus densiflora was significantly related with perennial herb species in both patch shape metrics (Table 12.9). Plantation also was significantly related with Geophytes life-form in AWMPFD.

12.5 Discussions

12.5.1 Changing Rural Landscape and Human Activities

From the results reveal that drastic social, economic, and technological development, especially those occurring after the 1970s, were responsible for changes in patterns of landscape, including alternations in the rural ecosystems (Fukamachi et al. 2001). The modern impacts of the energy revolution and introduction of chemical fertilizers, along with the economic boom which resulted in serious depopulation of the rural region, greatly altered the structure of rural landscape.

Changes of life styles and agricultural practices of the local residences were obvious, leading to modifications in the management system of rural forest changed to produce timber over organic resources for livelihood. Such alternations were responsible for the shift in values of agricultural and silvicultural products from self-support to commercial, and for having transferred the work force from man-power to mechanized agriculture (Jongman 2005; Nassauer 2005; Kim et al. 2006).

Farm household population continuously decreased after 1970 and agricultural area also decreased. These results explain the current socio-economic environments in Japanese rural landscape. Although human shifts to rural region, they do not work with agricultural activities therefore, increasing human population may not be directly influencing.

Abandoned agricultural field was widely observed in areas with difficult conditions for mechanized agriculture. The *Pinus densiflora* as a main landscape element decreased in area and patch number due to abandonment and pine wilt disease due to abandoned *P. densiflora* which is significantly related with human management (Kamada and Nakagoshi 1996; Hong 1998; Kume et al. 2003; Kim et al. 2006).

Natural disturbance such as pine wilt disease were strongly related to the patterns of rural landscape changes in both study areas. The 1905 outbreak of pine wilt disease in Kyushu and after 1920s, the disease caused considerable loss of pine trees moreover, an infection center of the disease was established in Kyushu, and it spread into surrounding areas (Mamiya 1988). In Chugoku region, includes Hiroshima prefecture, the disease also occurred around 1960s and was widespread in Hiroshima Prefecture where forests occupied by secondary vegetation mainly *P. densiflora*. Therefore, a log of dead pine and infected pine tree were cut down and tried with plantation for management of forest (Mamiya 1988; Kume et al. 2003). The plantation area and clear cutting site prepared for plantation increased in area and number of patch in this regard and also that influenced spatial heterogeneity.

Ownership and intensity of human activities also contributed to the changes in spatial heterogeneity and landscape structure (Nagaike and Kamitani 1999; Turner et al. 1996). Land ownership was considered an important causal factor, leading to alternations in pattern of land use type. Private forests became fragmented by cutting for pulpwood, and by small-scale, individual activities performed on conifer plantations that were subsidized by the government. That small scale plantation made a small patch in the matrix. In contrast, common forests located nearby roads were often cut down on large scales for conifer plantations, using the investment from external capital.

Spatial heterogeneity is important to the well-being of the ecosystems structure as well as function in landscape (Forman 1995; Pickett and Cadenasso 1995; Turner et al. 2001). Spatial heterogeneity increased in quantitative aspect. However, in qualitative aspect, landscape elements in natural types may be influenced by abandonment of human management while landscape elements in introduced types may be influenced by intensified human impacts.

In the results, landscape elements and land use type which responded to socio-economic factors over decades were, determined mainly by human impacts. The changes indicated that transformation of landscape patterns depended on different management regimes from the importance of each landscape elements, which also to the importance as commercial resources.

12.5.2 Relationship Between Spatial Heterogeneity and Vegetation Structure

Interpretations of modern vegetation must consider the importance of historical factors in addition to current environmental conditions (Motzkin et al. 1999). Natural and human disturbances may influence vegetation pattern and structure by directly altering the environment and resource distributions, creating opportunities for the establishment of new species or reducing populations of established species. A major challenge for ecological study is to evaluate the relative contribution of current environmental conditions and historical factors in determining vegetation patterns and dynamics.

After 1960s, abandoned rural vegetation landscape from the traditional rural forest managements and pine wilt disease strongly influenced vegetation pattern and structure in western Japan (Kamada and Nakagoshi 1996; Hong 1998, 2001; Fukamachi et al. 2001). Plantation was influenced by abandonment of traditional human managements and also pine wilt disease affecting economic purposes.

In order to cluster and ordination, vegetation composition and structure make a vegetation pattern which distinguished five types. Vegetation pattern was decided by coverage of herb layer, species number, and shrub layer development. In other words, vegetation pattern was mainly decided by understory development in both study areas dominated by *Pinus densiflora*. Traditionally managed *P. densiflora* forest was the best condition in this regards. Because traditional human activities such as tinning and collecting biomass have kept the sunlight condition which can easily reach into the understory. That is an apparently important for growth environments of the understory. Actually, plantation type was located by understory development which in ordination graph located to apposite position with *P. densiflora* position on the diagonal.

Species life-form indicates the micro-climate, biomass allocation, litter chemistry, and different nutrient in habitat environments therefore we can imagine the habitat environments (Gill and Burke 1999). Life-form in terms of important ecosystem functions and consequent differences in plant responses, such as regeneration of habitation environments can be used as indicators for ecosystems (Motzkin et al. 1999; Walker and Langridge 2002). Woody vegetation has increased globally in grassland and savanna regions (Gill and Burke 1999). Woody species such as Ph (Phanerophytes) and Ch (Chamaephytes) increased in both study areas while herbaceous vegetation such as H (Hemicryptophytes) and G (Geophytes) decreased. Woody plants altered the soil characteristics primarily by changing site hydrology, slowly decomposing soil carbon, and decreasing soil temperature. Changes in the distribution of woody and herbaceous vegetation may potentially influence vertical patterns of ecosystem processes as well, since plant life forms differ in vertical biomass allocation patterns and litter chemistry. Moreover, these differences in biomass allocation between herb and woody plants may influence carbon, nutrient, and water cycling in rural vegetations.

Land cover (element) changes may be one of the most significant ways that humans influence ecosystem properties. Regression analysis between spatial pattern and plant life-form carried out for understanding that changing landscapes have influence on ecological functions. Agricultural area and grassland had significantly associates with woody plants and annual herbaceous plants in area-patch metrics and edge metrics. Agricultural area and grassland usually occupied by herbaceous plants moreover, herbaceous plants prefer the edge place better than inside of forest (Mou et al. 2005; Storch et al. 2005). Therefore, habitat environments in order to area and volume of edge in agricultural area and grassland may have influence especially, annual herbaceous plants. Patch shape of *P. densiflora* was significantly associated with species diversity of perennial herbaceous species. Patch shape can influence ecological processes. Human activities often simplify boundary shapes, changing complex shapes that may follow topographic variability of result from natural disturbance into straight lines (Forman 1995; Turner et al. 2001). Hardt and Forman (1989) compared patch boundaries of three shapes, convex, concave, and straight, and found that the density of colonizing three was 2.5 times greater in areas with concave boundaries. In addition, there was greater evidence of browsing on the vegetation adjacent to convex boundaries. These results suggested that the convex boundary shape would result in more rapid rates of succession.

12.5.3 Management Strategy for Rural Forest Landscape Conservation

Landscape is a unified system of man and nature. Mosaic patterns of landscape can be caused by natural and anthropogenic disturbances (Forman 1995). Both the natural and anthropogenic disturbances induce new patches in landscape mosaics creating a heterogeneous landscape. The heterogeneity of landscapes influences many ecosystem processes and biological responses (Turner et al. 2001). Human impacts on landscape heterogeneity are considerably more intensive compared with the effects of natural disturbances (Baker 1995), being able to change natural ecosystems to man-mediated ecosystems in the short-term.

Traditional human activities in rural landscape have not only made the unique cultural landscape but also ecological different ecosystem with urban and forest. In both study areas, *Pinus densiflora* was a traditional cultural landscape and also have ecological function as a habitat (Mou et al. 2005). However, according to changing socio-economic environment, that has been abandoned therefore, *P. densiflora* forest, which needs traditional human management, got disappeared. In addition, pine wilt disease has the widespread damage in both study areas. These human and natural disturbances strongly affect the rural landscape ecosystems.

Plantation was carried out to remove the damaged *P. densiflora* from pine wilt disease in broad areas. Plantation area and clear cutting site getting increased and then they brought Sasa species as a dominant species which usually suppress vegetation regeneration (Ida and Nakagoshi 1994). They got wide spread in both study areas as a dominant species and coverage of the understory was more than 70 %. In addition, dead pine trees left the forest fell to the understory and disturb understory species.

Abandoned human management and pine wilt disease made severely destruction to pine forest as a habitat. These anthropogenic and natural disturbances control the density, frequency, and intensity of disturbance. Moderate human disturbances support diverse species or habitat while human disturbance in both study areas is extremely abandoned and intensive disturbance (Hong et al. 1995; Hong 1998; Motzkin et al. 1999). Finally, for sustainable rural landscape, firstly in plantation, when tried for plantation should consider the understory vegetation and also dead pine trees need to be removed from the forest. Secondary, moderate human disturbance is recommended here.

This may be concluded that human management, particularly in secondary forests in rural areas which control forest succession, is constantly required to maintain the heterogeneity of vegetation and landscape structure over the course of time. In rural regions, developing counties are affected by intensive land use and developed countries are affected by abandoned land. However, depending on the management strategies as a cultural diversity of rural landscapes will lead either to degraded rural landscapes or sustainable rural landscapes over time.

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Chapter 13
Geo-ecological Similarity and Biocultural Diversity – A Case Study in Shinan Dadohae Archipelago in Korea

Sun-Kee Hong

Abstract Comparing geographically neighboring islands is necessary to explore the significance of their ecology and culture. However, when research is made into neighboring islands, the scale of space to which the comparison shall be made may be very dependent upon the research fields. Neighboring islands are different in many ways but also the same in many ways. In some cases, their differences serve as complements to the other isles. The archipelago in Shinan-gun is mostly made up of tidal islands, which neighbor each other. Exploring ecological and cultural homogeneity and heterogeneity of the islands is helpful to understand the identity of the islands and the communication among them. This research is aimed to compare ecological characteristics, bio-cultural diversities, and geographical and topographic similarities of Haui-myeon and its neighbor Sinui-myeon, located in Shinan-gun, and to analyze the heterogeneity and homogeneity of the two islands.

Keywords Archipelago • Ecological geography • Island cultures • Southwestern Korea • Tidal-flat island

13.1 Introduction

In researching the culture of islands, investigating into the geographical characteristics, the arrangement, the type of island, and the connection between islands is regarded as a basic pre-survey to analyze and infer their ecological and cultural connections in the future. According to the Theory of Island Biogeography, geo-ecological characteristics of an island are defined by the distance between the island and the mainland, the island's size, and the distance between islands (MacArthur and Wilson 1967). It cannot be said that the 'Theory of Island

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Biogeography' explains ecological characteristics and biodiversities of all islands across the world, but it may be said that the definition is based on the most basic principle of fundamental attributes of an island (Campbell 2009; Hong 2011a). It has not been clearly verified that the theory is applicable to ecological and cultural characteristics of islands. However, seeds of bioculture created while being dependent upon the ecosystem and biodiversity of islands are spread through various methods and channels to neighboring islands (Maffi 2007; Lee et al. 2010; Hong 2012). Research needs to be conducted into the ecology and culture of the archipelago in southwestern Korea, with a focus on the number of islands and the connection between islands. It is meaningful for researchers to make an investigation into individual islands, and it is interesting to compare ecological and cultural characteristics of islands since their mutual homogeneity and heterogeneity are interrelated (Browaeys and Beats 2003). In fact, with the exception of several islands such as Ulleungdo, Jejudo, and Heuksando, most islands in Korea are located near the mainland, with many forming groups of islands, and a number of islands having a tidal flat (tideland).

An island community is connected with a tidal flat or a sand-hill so that it is known as a "land-bridge." It is a strip of land that appears to be in connection with land by means of ebb and flow, and it is surrounded by a tidal flat so that it is considered a religiously sacred place in worshiping the sea (Ex.: Mont Saint Michel in France; Modo of Jindo in Korea). It is also sometimes used as a major stronghold because access to it is difficult (http://en.wikipedia.org/wiki/Tidal_island). Across the world, islands of such a type are developed in Korea, France, UK and others (Gillespie and Clague 2009; Hong 2011a). Tidal islands are characterized by the fact that they have temporal landscape under the influence of ebb and flow, so that islands may be revealed by a tidal flat or a sand-hill. A tidal island may be also defined as an 'island which has developed tidal flat' or 'island of tidal flats'. So, it seems necessary from the standpoint of comparative humanities that research should be made into each isle and the connection between islands in the western sea and southern regions of the Korean peninsula. It may also be meaningful to propose policies for future development of islands since connecting and developing neighboring islands will contribute to synergy development of neighboring individual islands, which lack resources. This thesis is intended to investigate and analyze the characteristics of ecological resources and landscape of Haui-myeon and Sinui-myeon in Shinan-gun, where the two islands share their border in a narrow watercourse of a tidal flat, for the purpose of understanding homogeneity and discriminations of their ecological geography.

13.2 Landscape Geography

The archipelago in southwestern sea was generated about 7,000 years ago when valleys and low lands were submerged and mountain peaks and hills were isolated due to rising sea level. The southwestern sea in Korea is characterized by a ria-type coast and by the fact that the topography of islands is much transformed by means of a repetition of natural erosion and artificial reclamation (Hong et al. 2010a, b). In Korea, Jeollanamdo Province accounts for 65 % of the total islands, most of which have an extensive tidal flat and very dynamic seascape since they are transformed by oceanic tides. In Korea, the only county which borders on the sea and made up of islands is Shinan-gun, Jeollanamdo Province. Shinan-gun has a group of islands including 11 administrative districts, including Jido-eup, Aphae-eup, Jeungdo-myeon, Imja-myeon, Jaeun-myeon, Amtae-myeon, Palgeum-myeon, Anjwa-myeon, Jangsan-myeon, Sinui-myeon, Haui-myeon, Docho-myeon, Bigeum-myeon, and Heuksan-myeon (Terms of each 'Eup' and 'Myeon' are corresponding to 'village' and 'sub-county' in English. Moreover, 'Myeon' is corresponding to 'do' and same terminology with 'island' in English). All nine administrative districts border on the sea and may be geographically and broadly divided into coastal islands, open-sea islands, and inland-sea islands (Fig. 13.1).

Speaking in more detail, each of the archipelago islands has inland sea and open sea due to the geographical characteristics of the islands. In this paper, I classify all the islands of the archipelago according to their regional scale. From the standpoint of their history and culture, the islands are also divided into Jaeun-Amtae-Palgeum-Anjwa, Bigeum-Docho, Jeungdo-Aphae, and Imjado comprising lower and upper islands. In this paper, the islands are not geographically divided simply for ecological geography purposes but also for the purpose of knowing the meaning of the lives of island residents, including their transportation and culture. On the whole, it may say that, excluding Heuksan-myeon, almost all of the islands are located on the inland sea or adjoining seas. After all, the inland sea and open sea on the south-western coast are characterized by their close relationship with the surrounding environment, including the tidal flat. Islands on the inland sea have an arc-form arrangement of Jaeundo, Amtaedo, Palgeumdo, Anjwado, and Jangsando; and islands on the open sea include Bigeumdo and Dochodo. Hauido and Sinuido are located at the lower end of the group of islands and partially sit both on the open sea and inland sea.

As Fig. 13.1 shows, it may be said from the standpoint of landscape connectivity (Forman 1995), that the topography of Shinan-gun well represents evolutional and geographic characteristics of islands since a throng of islands are developed in such a manner that their homogeneous ecosystem may be regarded as a group. Jido-eup, Aphae-eup, Jeungdo-myeon, and Imja-myeon are connected with the inland and form a boundary (Group 1), while Ja-eun-myeon, Amtae-myeon, Palgeum-myeon, Anjwa-myeon, and Jangsan-myeon form another boundary (Group 2). Bigeum-myeon, Docho-myeon, Haui-myeon, and Sinui-myeon have a relatively wide surface touching the open sea, and form the last boundary (Group 3). The landscape of the islands is characterized by the scene that the open sea protects islands on the inland. Groups 1, 2, and 3 of the islands are ecologically and geographically divided, and also directly and indirectly influenced by the landscape matrix called a tidal flat and by ocean currents. In contrast, Heuksan-myeon islands (Heuksan Archipelago) on the open sea are far away from the influence of a tidal flat (Group 4). Bigeum-myeon, Docho-myeon, Haui-myeon, and Sinui-myeon belonging to

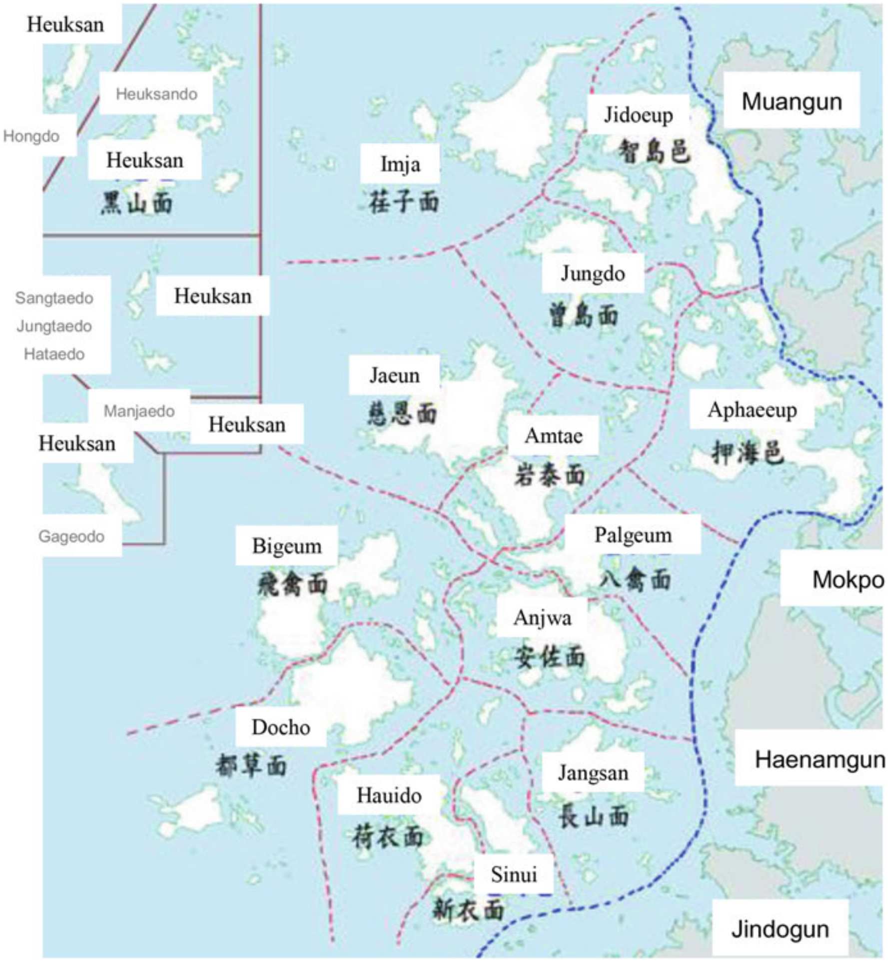

Fig. 13.1 Administrative of Shinan-gun, Jeollanamdo Province (The homepage of Shinan-gun http://www.shinan.go.kr/)

Group 3 border on the open sea, but each of them is differently influenced by a tidal flat depending upon the direction and geographical position for them to face the sea. Nevertheless, like the other groups of islands in Shinan-gun, it appears that Bigeum-Docho and Haui-Sinui have very high geographical connection and ecological connection.

13.3 Landscape Structure and Major Biocultural Elements

The geographical strengths in Shinan-gun include agriculture using tidal flat deposits, which contain a lot of organic matter. On this island, agricultural products are well protected from damage caused by diseases and harmful insects, so that sound agricultural products may be cultivated. However, difficulties in production and smooth distribution of sound agricultural products include such meteorological conditions as typhoons and an increase of transportation and logistical costs. Meteorological characteristics have varied influence on the use of land in Shinan-gun. However, a warm and wet oceanic climate is subservient to the growth of crops; yet an oceanic climate has double influence since it often leads to such low pressure climate as typhoon. Of course, such meteorological characteristics are not contributory to the production of crops on all the islands in Shinan-gun.

Considering the landscape matrix and topographic similarity of a tidal flat, comparison of the two islands Sinui-myeon and Haui-myeon finds that they have a different and heterogeneous landscape. Figure 13.2 shows the characteristics of land use types including agriculture and salt industry (sun-dried salt), which are representative primary industries in Shinan-gun. Concerning agriculture, compared to Sinui-myeon, Haui-myeon more excellently uses the land to produce rice and has a relatively wider area of fields (Institution for Marine and Island Cultures 2011). In contrast, the area of farms for producing sun-dried salt is wider at Sinui-myeon. In Haui-myeon, salt farms are distributed in east and south coastal regions, which include tidal flat; In Sinui-myeon, salt farms are distributed throughout the island including Sangtae-ri, Jungtae-ri, and part of Hatae-ri. In the case of Jungtae-ri at Sinui-myeon, Sangtae and Hatae have been reclaimed so that salt marsh on a tidal flat surrounding the island has turned into a salt farm; also, abandoned salt farms are used as shrimp farms or other uses in some parts of the island (Institution for Marine and Island Cultures 2012). According to Table 13.1, which shows a comparison of the quantities of sun-dried salt produced at each ‘eup (corresponding to ‘village’ in English)’ or ‘myeon (corresponding to ‘sub-county’ in English)’ in Shinan-gun, Sinui-myeon is overwhelmingly more predominant in the salt industry population, production area, and quantities since salt farms have been formed by means of tidal flat reclamations.

13.3.1 Vegetation

According to temperature conditions set up by Yim and Kira (1975), most subtropical and temperate evergreen forests of islands located on the west and south seas in Korea are divided by the isopleths of coldness index −10 °C month (Yi and Kim 2010). In general, southwestern sea regions, where subtropical and temperate evergreen forests are distributed, have a warm climate, abundant resources, a high population density, and mostly play a central role in politics, economy, and

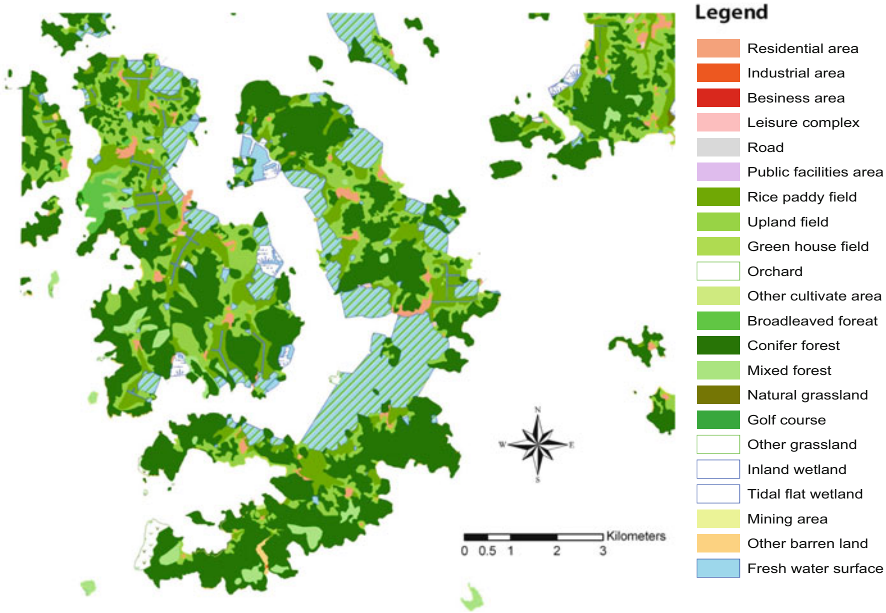

Fig. 13.2 Land use map of Sinui-myeon and Haui-myeon

industry. Subsequently, many regions have been uniformly developed by local residents and governments, and natural vegetation remains intact almost nowhere in the region.

Considering the features of creature communities, potential natural vegetation in Shinan-gun mainly includes evergreen broadleaf forests, which comprise bramble, Japanese Evergreen Oak, *Castanopsis cuspidate* var. *sieboldii*, and silver magnolia. However, due to such human interventions as fire, lumbering, cultivation, and grazing, most of extant evergreen forests have been destroyed and evergreen needle-shaped leaf forests including *Pinus thunbergii* are primarily distributed. Moreover, such deciduous broadleaf trees as *Platycarya strobilacea*, *Mallotus japonicus*, *Carpinus turczaninowii*, *Quercus serrata*, and chestnut tree stand along with or in the neighborhood of *Pinus thunbergii* and others; herbaceous plants and communities of *Pueraria thunbergiana* including *Miscanthus sinensis* and arrowroot are distributed in a wide area. It seems that hornbeam and *Magnolia officinalis* communities, which are considered as potential natural vegetation in this region, will develop into climax communities in compliance with geographical conditions of the region and continuously retain their status. According to climate and geographical conditions, if human intervention is stopped, it is expected that evergreen needle-shaped leaf trees will give way to evergreen broadleaf trees via deciduous broadleaf trees, or directly to evergreen broadleaf trees in this region where *Platycarya strobilacea*, Japanese green alder, chestnut tree, oak tree and others stand together with *Pinus thunbergii* community and *Pinus thunbergii*

Table 13.1 Sun-dried salt production in Shinan-gun (Data of 2010, unit: person, ha, ton)

	No. of Laborer (person)		Area (ha)				
Administrative	Permitted no.	Operated no.	Permitted no.	Operated no.	Remained salt in 2009 (ton)	Production (ton)	Sale (ton)
Shinan-gun	945	846	2,434.4	2,162.5	46,366	203,602	198,404
Jido-eup	87	84	298.4	292.6	788	28,730	25,988
Jeungdo	37	32	274.6	268.0	4,524	17,032	17,209
Imjado	46	46	143.6	143.6	350	9,805	9,336
Jaeundo	9	2	42.0	6.0	9	130	107
Bigeumdo	221	217	429.9	425.8	4,037	44,823	42,038
Dochodo	104	102	247.8	243.0	23,538	20,852	28,172
Hauido	79	72	144.9	132.8	619	11,440	10,456
Sinuido	239	237	470.1	466.5	10,313	57,170	51,796
Jangsando	21	6	53.2	16.6	–	873	494
Anjwado	23	1	61.1	1.6	51	88	98
Palgeumdo	19	14	54.1	43.9	1,995	1,616	2,068
Amtaedo	14	11	46.9	40.8	142	2,240	2,036
Aphaedo	46	22	167.8	81.3	–	8,803	8,606

communities. *Castanopsis cuspidata* var. *sieboldii*, *Carpinus turczaninowii*, and others may be regarded as potential natural vegetation in this region; most of the *Pinus thunbergii* community, *Pseudosasa japonica* community, grasslands, and others are not potential natural vegetation but substitutive communities in this region. Therefore, it appears that values for preserving plant communities are relatively low but their values are high when the plants are considered as a foundation of the transition stage for forming evergreen broadleaf forests or as a community to protect the coast.

Excluding Heuksan-myeon, *Pinus thunbergii* (Korean black pine) is dominant in the vegetation of tidal islands including Haui-myeon and Sinui-myeon in Shinan-gun. The vegetation is not a natural forest, but secondary woods which are artificially influenced or planted (Hong et al. 2006; Kim and Hong 2009). *Pinus thunbergii* communities are intensively distributed in most low lands which are 0–100 m above the sea level. 100–150 m-high low lands are divided, according to the direction and degree of their slope, into *Pinus thunbergii-Quercus serrata* community and *Pinus thunbergii-Carpinus turczaninowii* community. As the fertility of soil increases, more *Quercus serrata* trees tend to be planted; as the surface area of bedrock gets greater, *Carpinus turczaninowii* Hance communities multiply. In reality, Shinan-gun does not have a suitable kind of tree that can replace *Pinus thunbergii*, which has been widely used as firewood since the 1950s. Compared to the black pine tree (*Pinus thunbergii*), the pine tree (*Pinus densiflora*), a wild plant in Korea, has such a physiological trait that it can endure sea winds well, which contain salt. Consequently, *Pinus thunbergii* is still favored for restoring and planting forest in Shinan-gun according to meteorological conditions such as oceanic climate and typhoon. In addition to *Pinus thunbergii*, such tall plants are often seen as *Carpinus turczaninowii*, *Albizia julibrissin*, *Juniperus rigida*, *Platycarya strobilacea*, *Styrax japonicus*, *Ficus oxyphylla* and *Kalopanax pictus*. Also, the Microphanerophytes or shrub layers comprise such various plants as *Eurya japonica*, *Quercus serrata*, *Symplocos tanakana*, *Viburnum dilatatum*, *Lespedeza bicolor*, *Smilax china*, *Kalopanax pictus*, *Meliosma oldhamii*, *Viburnum dilatatum*, *Meliosma myriantha*, *Rhus succedanea*, *Hedera rhombea*, *Juniperus rigida*, *Ligustrum obtusifolium*, *Lindera obtusiloba*, *Sorbus alnifolia*, *Zanthoxylum schinifolium*, and *Pittosporu tobira*.

13.3.2 Maeul, Traditional Villages and Sacred Spaces

Maeulsup (traditional village woods) do not simply have biological importance but serve as a cultural device and an ecological space wherewith to confirm the identity of island villages (Hong and Kim 2007). Maeulsup may be divided into various kinds and uses, and each has different ecological and cultural functions. Maeulsup on tidal islands in Shinan-gun are classified into several functions (Hong et al. 2010a, b). First, as a protective forest aimed at protecting a village. It is also called '*wooshil*' and it protects the safety of arable land, buildings, men, and livestock from sea winds. The second function is a fish-provision forest. According to former research on this type forest, I requests that the term of "Fish-Provision Forest" should be disused. The term began to be used by Japan during the Japanese colonial rule in Korea, as is attested in '勿巾防潮魚付林.' However, it is confirmed that, in fact, no Korean woods have such ecological functions as the Japanese definition of them implies. Only it is recognized that woods formed beside rivers or coasts not only function as a fish-provision forest but also have ecological-engineering meanings for the purpose of water quality improvement, protection against wind, and prevention of the loss of soil. It appears that the term began to be used in 1908 during the Japanese colonial rule of Korea when Forest Order was issued (Hong 2011c). It is belt-type woods mainly developing along the coast and it serves as a space that provides a shady shelter to a coastline, regulates the loss of soil, provides a refuge for fish gathering to the coast, and offers a home for the growth of young fish. However, an ecological investigation needs to be further conducted to determine if it serves as a proper place for fish to spawn, as its name implies. The third function is as a sacred place such as divine trees or shrine woods. This is a cultural device in which island resident's wish for a big catch and/or safe voyage. Values of biological resource of such shrine woods and old-large trees are increased so much in recent times that they are designated as a gene-protecting forest. At all times, *Maeulsup* composed of secondary forest, shrine woods, and old-large trees have existed together with other land use.

The form of a village and the arrangement of woods may be decided according to the residents' traditional recognition of nature and topography (such as *Fengshui* theory, *see* Hong 2007, 2011c). Yet, to the village residents who add transcendent meanings to woods while seeking oneness with nature and wishing for abundance and safety, gigantic trees on islands may serve as an important sacred place or a representative cultural complexity (Browaeys and Beats 2003), which has complex functions (Hong et al. 2010b). To island residents, unlike sacred places on land or forest regions, the sea is a very important resource and, at the same time, a dangerous space where they pray for a safe voyage and a large haul. In modern days, all island wood on the inland sea in Shinan-gun are used as lumber and firewood and, in fact, there are very few evergreen broadleaf forests which maintain oceanic climate features of the archipelago and have potential natural vegetation. Nevertheless, village woods, shrine woods, and old-large trees are among representative forests and cultural resources in Shinan-gun, which will be richly developed in the future. The old-large *Zelkova* tree on Okdo at Haui-myeon and the old-large nettle tree on Gido at Sinui-myeon are rare gigantic trees and shrine woods in this region. An old-large *Zelkova* tree stands at Okdo-ri, Haui-myeon. The gigantic tree, whose diameter is more than 50 cm, is surrounded by *Camellia japonica*, *Castanopsis cuspidata* var. *sieboldii* and other evergreen tall trees. It is very peculiar that, only in this place on Okdo, evergreen broadleaf trees grow intensively. Meanwhile, along with the nearby 'shrine rock,' a shrine tree cloth upon the old big tree (*Celtis sinensis*) on Gido, which is a subsidiary isle at Sinui-myeon, is considered a sacred place.

It is assumed that these old-big trees on the two islands have survived people's abuse of them as firewood, as is explained above, since the trees have been considered by the village residents to be a meaningful and sacred place. It is very significant that both of the trees have not survived on the main isle, but have on a subsidiary island. It is probable that, if they stood on the main isle, they should have been felled and used as a site for constructing a church under the influence of a religion. As islands are quickly urbanized, cultural assets like old-large trees or shrine woods are removed by religion or development (Hong 2011c). However, local residents understand more than the biological significance of woods (including gigantic trees) on a subsidiary island, and that they know well that landscape should be preserved and woods should no longer be misappropriated as firewood.

13.3.3 Tidal Flat and Inlets

Okdo of Haui-myeon is located at the center of the Diamond Islands (The name is given because nine administrative districts of Jaeun, Amtae, Palgeum, Anjwa, Jangsan, Sinui, Haui, Docho, and Bigeum in Shinan-gun stand together in the form of a diamond. Okdo stands at the center of the sea rout, and the watercourse called 8-inlet estuary goes from Okdo to the nine districts) in Shinan-gun. Therefore, it has been a center of marine transportation and logistics since a long time ago. Okdo is called an '8-inlet estuary' since it is connected to nine inhabited islands such as Jaeun, Amtae, Palgeum, Anjwa, Jangsan, Sinui, Haui, Docho, and Bigeum (National Research Institute of Maritime Cultural Heritage 2012). From each inlet of Okdo, you can board a ship to a neighboring district. So, Okdo had a Japanese military observatory even before Japanese colonial rule. There is also a sea route between Haui-myeon and Sinui-myeon. However, this sea route is so narrow that ferry boats would frequently come and go between the two districts. Okdo produces "Okdo common octopus", which is recognized as the most delicious among common octopus produced at Haui-myeon. Perhaps, it is not only because Okdo is surrounded by tidal flat, but also because Okdo has a very excellent tidal flat ecosystem that is connected via a waterway to neighboring inhabited islands and has seawater in which there are affluent nutriments. Sinui-myeon mostly consists of tidal flat from which common octopi and others are abundantly caught. Excluding Wolhang-ri tidal flat on Hataedo, most of the tidal flat have tide embankments for establishing salt farms, farm lands, and breeding grounds, and the embankments have an influence on the circulation of a tidal flat ecosystem. Like most of islands in Shinan-gun, Sinui-myeon is surrounded by tidal flat, the representatives of which includes eight of them at Yumi-ri, Pido, Noeun-ri, Wonhang-ri, and Ta-ri, Sangtaeseo-ri (Fig. 13.3).

Fig. 13.3 Tidal flat area near Gido at Sinui-myeon, Shinan-gun (Photo by Shinan-gun)

13.4 Ecosystem Service of Biocultural Elements

The topographic form of Haui-myeon and Sinui-myeon has very similar characteristics, as if they were separated from one island. Like the other islands comprising Diamond Islands in Shinan-gun, Haui-myeon and Sinui-myeon are administratively divided from each other but they are almost the same in terms of their geographical and geological characteristics. When it comes to their concrete features, the islands have various differences; as a whole, however, these two are mutually complementary. Their characteristics are broadly classified from the standpoint of geography, topography, ecosystem service, and landscape aesthetics (Hong 2011b).

First, they are geographically and topographically complementary. Haui-myeon has well-paved coastal roads, and Sinui-myeon has not only a well-developed national road number 2, which connects Sangtaedo to Hataedo, but coastal roads as well. Also, transportation is very convenient because well-constructed county roads connect villages with villages. Recently, a land bridge has been constructed to connect Sinui-myeon with Haui-myeon. Communications and exchanges between Sinui-myeon and Haui-myeon will be conducted more quickly and smoothly with the help of the bridge.

Second, they are complementary in terms of ecosystem services. A representative of landscape resources at Haui-myeon is agriculture; spacious farmland, which is similar to agricultural villages on the mainland, is well established. At Sinui-myeon, there are many salt farms, which predominantly utilize a tidal flat. All of the historical and practical features of tidal flat, salt, and reclamation are much better represented by Sinui-myeon than Haui-myeon. '*Mosil*' Road (ecological tracking road including mountain road and village road) which has been constructed recently in Shinan-gun plays an important role as an unpaved tracking road, and Sinui-myeon and Haui-myeon also have similar roads in woods, which are not yet completed but filled with images of the islands.

Third, they are complementary in terms of landscape aesthetics. Different characteristics of Haui-myeon and Sinui-myeon are mutually complementary since the former has such landscape elements as rice paddies, village woods, and large rocks while the latter has a tidal flat, salt farm, and setting sun. Ecological tourism resources of these two islands can be coordinated and supplemented. The colors (sea, soil, and wood), flavors (grass flavor and pine tree flavor) and sounds (bird sounds, wind sounds, and wave sounds) of the islands can be utilized to make their images. After a land bridge was constructed between Sinui-myeon and Haui-myeon, it was necessary to develop an ecological culture tourism program covering Haui-myeon. It seems to be advisable that the program should be developed in such a way that it may be an "ecological health exploration road program," which utilizes such unpaved ways as mountain roads and village roads. It is recommended that the program should include multi-purpose ecological exploration routes which make use of historic relics, farm lands, and village woods at Haui-myeon, photos of salt farms and neighboring ecological environments at Sinui-myeon, habitats of salt plants or marshy land plants (eg. *Nymphoides peltata* communities), and other wild plants.

Theory of Island Biogeography explains geographical homogeneity and heterogeneity including biogeographic differences of islands simply by considering the physical separation and adjacency of the islands including the size of, distance between, and closeness of them. However, for Korean islands where tidal flat are major landscape elements, such biogeographic principles need be reconsidered. As a whole, almost all the islands in Shinan-gun are separated or connected by 'tidal flat' which have an ecosystem different from land ecosystems and have an ocean landscape background (matrix) peculiar to islands. It is said from the standpoint of regional ecology that the landscape or characteristics of a region are not decided by the attributes of landscape or system of the region, but by the background (surroundings) of the system (Hong 2012). Consequently, after all, ecological and cultural attributes of such geographically neighboring tidal islands as Bigeum-Docho, Jaeun-Amtae, and Sinui-Haui are decided by 'tidal flat or sand hills', which are the surroundings and background of the islands. It is conceived that these ecological attributes may be also connected to the island identity (or islandness) and that similar ecological attributes and cultural characteristics of individual islands play a role in forming a cultural complex of the islands (Browaeys and Beats 2003).

It may be considered that, as for the archipelago in Shinan, ecological and geographical characteristics have triggered cultural homogeneity and heterogeneity of the islands, including the presence of tidal flat and/or the difference in tidal ebb and flow. Furthermore, on tidal islands in Shinan-gun, cultural characteristics of local residents who have been adapted to their environments are homogenized since they have very similar and homogeneous landscape and natural resources, including the distance between islands, physical characteristics of their geography, tidal flat life, vegetation, and oceanic life.

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Chapter 14
Development and Vision of Island Biocultural Diversity Initiative

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Abstract Island and coastal areas worldwide have long been recognized as unique and fragile ecosystems, harboring an abundance of often endemic biodiversity. They are now increasingly recognized as unique and fragile *biocultural* systems, harboring a great diversity of human cultures that are highly adapted to the island/coastal ecosystems, through close interaction with the local environment for material and non-material sustenance: from food and shelter to connection with deities, ancestors, and other spiritual forces thought to reside in nature. This close interaction with and adaptation to the natural world, along with respect for the spiritual forces of nature, is reflected in the languages and traditional knowledge systems of island/coastal communities, and has allowed such communities to use natural resources wisely and live sustainably often for hundreds or even thousands of years. However, rapid change is severely affecting island/coastal biocultural systems. From climate change and sea level rise, to loss of fishing grounds and coral reefs, to marine pollution and rampant development, the biocultural diversity of island/coastal areas is increasingly at risk. Along with the loss of unique biodiversity and ecosystems, comes the loss of the uniquely adapted island/coastal cultures,

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and of the languages and traditional knowledge systems developed by island/coastal communities. The loss of island/coastal biocultural diversity is a major threat for the vitality of the whole web of life on Earth. In recent year, United Nations and other major international organizations, such as CBD, UNEP, UNESCO, IUCN, and others have begun to recognize the links between biodiversity and cultural diversity, and to embrace the idea that the conservation of biodiversity is interrelated and interdependent with the maintenance of cultural diversity. Because of the uniqueness and value of island/coastal biocultural system, it is now time to devote special attention to their predicament, and to take action to prevent further damage and to preserve and restore sustainable relationships between people and nature in island/coastal areas. This should be done by taking into account and drawing from the wealth of traditional environmental knowledge developed by island/coastal communities. This was the central goal of several activities carried out by a group of researchers, conservationists, and representatives of island/coastal communities at the 5th World Conservation Congress (Jeju, Korea, September 2012). The group submitted a resolution titled “Strengthening Biocultural Diversity and Traditional Ecological Knowledge in Asia-Pacific Island Regions”, which was approved by the ICN Member Assembly (IUCN Resolution 5.115). Furthermore, the Island Biocultural Diversity Initiative was also launched at the WCC.

Keywords Bioculture • Island Biocultural Diversity Initiative • Traditional ecological knowledge • South Korea

14.1 Necessary of Networking

The rapid change wrought to the long-enduring island ecosystem occasioned by the change in fishing grounds caused by climate change on islands and coastal areas, as well as excessive human activities and maritime pollution, can be taken as a sign that the balance between man and nature, a balance which includes everything from simple biodiversity and landscape diversity to cultural diversity, has declined. Biocultural diversity has emerged as part of the dynamic process created by the interactions between biodiversity, cultural diversity and traditional knowledge amidst complex ecosystems (Hong et al. 2013). Humans have long used the surrounding landscape and bioorganisms as their life resources. Whenever necessary, they have established their control over existing species in order to develop new ones. The use of biodiversity became the background which facilitated cultural diversity such as unique food and housing culture. The relevant ecological knowledge has been diffused beyond adjacent areas to reach the national level.

Local languages and dialects have proven to be very susceptible to Westernization, and as a result many have rapidly become extinct. The indigenous knowledge regarding the use of natural resources can be regarded as facing a crisis similar to that confronting biodiversity, the latter having been driven out by reckless energy development and land use. This initiative has as its main goal the development of means to preserve declining indigenous knowledge as historical materials. Much as has been the case in the past, the future survival of man will greatly depend on biodiversity. The eco-cultural flexibility and sustainability evident in the relations between biodiversity and cultural diversity has been used as the basis for a harmonious coexistence model for ecosystems which can support the existence of mankind in the future. International organizations such as the IUCN, UNEP, UNESCO, and CBD have recognized the importance of the mutual relationship between biodiversity and cultural diversity. They have routinely used the term 'bioculture' to conceptualize, from an anthropological standpoint, human life's ability to adjust to various biological environments. Meanwhile, scholars have interpreted and used the concept of 'bioculture' in a more broadened manner.

The UNEP GEO-4 (2007) included human cultural diversity, which it regards as having influenced the ecosystem and the diversity of bioorganic species, in its definition of the concept of biodiversity. Meanwhile, based on the Main Line of Action on Biodiversity and Cultural Diversity, UNESCO organized specialists meetings in Aichi (April 2004), Japan and Paris (September 2007), France. Article 8j of the CBD highlighted the importance of traditional knowledge with regards to the sustainable use and conservation of biodiversity. For its part, the IUCN's Fourth World Conservation Congress (WCC) included a conference on 'biodiversity and indigenous residents.' In the aftermath of the conference, the IUCN program for 2009–2012, which called for the recognition of the importance of the cultural diversity linked to nature and cultural value, as well as the importance of the indigenous residents and indigenous knowledge through which such relationships are connected, was approved. Based on the vision that the world is a mixture of biodiversity and cultural diversity, the IUCN's Commission on Environmental, Economic and Social Policy (CEESP) has implemented related programs. As part of celebrations marking the International Year of Biodiversity, the CBD, along with UNESCO and economists, jointly organized a conference on the topic of Biological and Cultural Diversity for Development in 2010. In their capacity as essential indicators needed to discuss about the earth's environment and the sustainability of economic society, biodiversity and cultural diversity have gained international interest. The suggestions made in this initiative are designed to foster discussions about the development of biocultural diversity and the eco-cultural characteristics of a maintenance mechanism based on the ecological knowledge needed to use the biodiversity in island-coastal areas whose ecosystems have been weakened by climate change and the development process. At the same time, by organizing a cooperative network with domestic and international organizations and diffusing the contents of the initiative to the world, it is also designed to suggest an initiative for the World Conservation Congress (WCC) that revolves around the establishment of a conservation strategy for the biodiversity in island-coastal areas.

14.2 Islandscape

Islands have never drawn as much attention at the global level as is currently the case. Islands not only constitute a link to the mainland, but also represent the basis of biological resources and human life. While a ‘small island’ may be inhabited, the surrounding sea areas are nevertheless home to numerous biological and energy resources. Citizens the world over have increasingly focused their attention on the important hubs known as seas and islands. Contrary to terrestrial ecosystems, islands boast unique ecosystems created by differing biodiversity, a denouement which is turn is dependent on oceanic climate, or the presence of warm or cold currents (MacArthur and Wilson 1967). Islanders have lived their lives based on the unique geographical characteristics and biological resources created by differing sea currents and the ebb and flow of the tide. As such, island spaces have provided the foundation for the complex ecological knowledge pertaining to the relationship between terrestrial and sea areas. The process through which people have adapted to and sustainably used the resources available to them amid limited spaces and poor environments, as well as the traditional knowledge created during the adaptation process, are regarded as the prototype and driving force for the creation of biocultural diversity. However, more efforts should be made to develop and study the traditional ecological knowledge of local residents who have used biological resources in a sustainable manner as a means to respond to rapid changes in the global environment such as global warming (Fig. 14.1).

14.3 IUCN Resolution 5.115 and Island Biocultural Diversity Initiative

Recent changes in the ecosystem have included changes in fishing grounds caused by climate change at the global level, increased sea levels, excessive development, marine pollution, and natural disasters. Small islands in the Asia-Pacific area have experienced a decline not only in terms of biodiversity, but also with regards to local cultures. International organizations such as the IUCN, UNESCO, and CBD have been cognizant of the mutual relationship between the biodiversity and the cultural diversity of islands. They have used the term ‘*bioculture*’ to facilitate the conceptualization of the characteristics of human life’s efforts to adjust to various biological environments (Maffi and Woodley 2010). The academic sector has interpreted and used this term in a more broadened manner. The sustainability of islands is only possible when the ‘biosphere’ that constitutes the environmental ecosystem of islands and ‘culture’, which represents the human social system, coexist and show a balance between one another. However, discussions regarding the evaluation of, and indicators for, the sustainability of islands in the Asia-Pacific area that includes Korea have remained limited. Given the fact that we have reached the point in time where it has become necessary to improve the life environments of

Fig. 14.1 Island has been important role for creating new academic disciplines as well we culture and civilization (Photo by SK Hong)

islands vulnerable to global climate changes such as rising sea levels occasioned by the changes in marine climates, changes in agricultural and fishery areas base caused by changes in the island environment, and natural disasters such as earthquakes and tsunamis, efforts should be focused on the conservation of the ecosystems of islands and coastal areas, the establishment of an economic basis for island residents, and the actualization of a qualitative economic system. The biological and cultural resources possessed by the Dadohae constituting the representative island area on the Korean peninsula located in the western and southern areas of Korea must be conserved and used in order to improve the quality of life of island residents and share the ecological values with the global world (Hong 2012). The 5th IUCN World Conservation Congress (WCC) held in Jeju in September 2012 discussed the conservation of biodiversity and the sustainable use of cultural resources in islands-coastal areas that are highly vulnerable to climate change and development process. The <*Strengthening Biocultural Diversity and Traditional Ecological Knowledge in Asia-Pacific Island Regions*> was introduced and accepted to IUCN (Resolution 5.115, see Table 14.1). In addition, the <Island Biocultural Diversity Initiative> was launched as part of the workshop held during the IUCN World Conservation Congress (WCC) (Fig. 14.2).

Table 14.1 IUCN Resolution 5.115 titled "Strengthening biocultural diversity and traditional ecological knowledge in Asia-Pacific Island Regions"

TITLE: Strengthening Biocultural Diversity and Traditional Ecological Knowledge in Asia-Pacific Island Regions

RECOGNIZING that the rapid change seen in island ecosystems of the Asia-Pacific region, occasioned by the change in fishing grounds due to climate change and natural disasters such as mega-earthquakes and tsunamis, as well as due to excessive fishing activities and marine pollution, is leading to the decline of biocultural diversity;
RECALLING that Article 8j of the CBD highlights the importance of traditional knowledge with regards to the sustainable use and conservation of biodiversity and that IUCN has implemented related actions based on the idea that biodiversity and cultural diversity are interlinked;
CONSIDERING the need to advance discussions and actions about conservation models based on traditional ecological knowledge relevant to the wise use of biodiversity in island-coastal areas whose ecosystems are weakened by climate change and over-exploitation of resources, and where associated traditional cultures are affected by such changes in ecosystems;
CONVINCED that the establishment of specialist groups in IUCN Commissions would be a very useful step to advance the conservation of biocultural diversity in island-coastal areas of Asia-Pacific regions;

The IUCN World Conservation Congress at its 5th session in Jeju, Republic of Korea, 6-15 September 2012:

1. **CALLS ON** members of the United Nations, including IUCN members in Asia-Pacific countries, to support activities of conservation of biocultural diversity and traditional ecological knowledge in island-coastal regions based on its uniqueness and scarcity;
2. **ENCOURAGES** IUCN members, local governments and NGOs that have perceived the importance of traditional ecological knowledge in the wise use of biological resources in island and coastal areas to engage in supporting the preservation of traditional knowledge and biocultural diversity;
3. **REQUESTS** the Director General to:
(a) promote the creation of a consultative body responsible for preparing a proposal for a convention or other international instruments to State members within the United Nations for the conservation of biocultural diversity and traditional ecological knowledge in island-coastal regions, and to invite IUCN member countries to engage in its promotion and support;
(b) work with IUCN Commissions in the creation of an Islands Specialist Group within IUCN Commissions that will be responsible for advancing the conservation of biocultural diversity and traditional ecological knowledge in island-coastal regions and provide support for the activities of related research institutes and NGOs;

In addition, the World Conservation Congress, at its 5th Session in Jeju, Republic of Korea, 6-13 September 2012, provides the following guidance concerning implementation of the IUCN Program 2013-2016:

URGES IUCN Members, Commissions and the Director General to work together for the establishment of an "Asia-Pacific Island Biocultural Diversity Initiative" which, led by specialists on the policy and practice of the conservation of island-coastal biocultural diversity including scientists specializing in humanities, operates in conjunction with related organizations such as the CBD and UNESCO.

Sponsors: **The Ecological Society of Korea**
Co-Sponsors:
Nature Policy Division, Ministry of Environment, Korea
Korea Association for Conservation of Nature (RK)
TerraLingua (Canada)
Tonga Community Development Trust (Tonga)
Small Fishers Federation (Sri Lanka)
Endorsement:
Korean Society of Environment and Ecology (RK)
Korea Environmental Education Network (RK)
Korea National Park Service (RK)
The Christensen Fund (USA)

Fig. 14.2 Workshop for launching <Island Biocultural Diversity Initiative> during 5th IUCN (World Conservation Congress 2012, Jeju, Korea)

14.4 Goal

Biological organisms and culture have different attributes. However, human civilization has developed in a manner that has been dependent on nature, with the two developing a fatefully dependent relationship in which man cannot exist without natural resources. The term of 'biocultural diversity' was created to denote coexistence between man and nature. As such, there can be no denying that man and nature have existed in a mutually dependent relationship, and have interacted with one another and complemented each other within the ecosystem. However, the time has come for the government, researchers, citizens and specialists to fully comprehend that this connectivity has declined amid the rapidly changing global environment, reckless development, and the decrease in biodiversity. As evidenced by a look at human history, man's future survival will be greatly dependent on biodiversity (Hong et al. 2013). The eco-cultural flexibility and sustainability stemming from the mutual relationship between biodiversity and cultural diversity will be used as a harmonious coexistence model featuring an ecosystem that can support man's continued existence. On 2014, CBD-COP12 will be held in Korea. We hope that our activity of <Island Biocultural Diversity Initiative> will be expanded to global network with cooperation of IUCN members during CBD-COP12 in Korea.

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