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Pavan Kumar *Editors*

Towards Sustainable Natural Resources

Monitoring and Managing Ecosystem Biodiversity

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Foreword

Sustainable natural resources are one of the major challenges for ecosystem biodiversity. The monitoring of ecosystem biodiversity is in increasing demand in the international development sector, as the key role of biodiversity in securing livelihoods through the provision of basic goods and ecosystem services is more and more acknowledged. Many professionals working towards sustainable management of natural resources and nature conservation are confronted with the task of biodiversity monitoring yet have a background distant from biodiversity sciences.

Over the past several decades, the international and national research communities have developed a progressively clearer picture of how and why Earth's natural resource is changing and of the impacts of climate change on a wide range of human and environmental systems. Natural resources and their management form a critical interface between climate change and development. This book covers a huge range of strategies that can be applied to various sectors, from Forest Productivity to climate change threat on natural resources. Its aim, as with resource management itself, is to combine economics, policy, and science to help rehabilitate and preserve our natural resources. The book includes discussions of research needs in the natural resource as well as ecosystem biodiversity, areas of critical importance to conservation and sustainable development. Although specifically directed toward development agencies, non-governmental organizations, and decision-makers in developing nations, this volume should be of interest to all who are involved in the conservation of biological diversity.

I congratulate the editors, the contributors from different parts of the country and the publisher for bringing out a timely publication depicting climate impact on natural

resource management and hope that this important book shall serve as a reference for different institutions working in this area.

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Preface

Natural resources conservation, its monitoring and managing of ecosystem biodiversity is one of the dilemmas that mankind is confronted with currently both in the developed and the developing countries. The issues are of utmost seriousness for the latter, where majority of the population derives its livelihood from terrestrial ecosystems; more than one billion earn less than a dollar per day and live in abject poverty; more than 800 million suffer from chronic hunger and more than 3.7 billion suffer from micronutrient deficiencies. Ongoing climate change, land change systems, industrialization, unplanned urbanization, technological advancement, resource use conflicts, population increase, unscientific use of resource and over exploitation, political doldrums, loss of soil fertility and desertification have all put more pressure on these gifts of nature leading to their degradation and eventual loss leaving mankind deprived of these resources.

Despite unprecedented know-how in technology, allowing us to discover and visit planets and disclose the mysteries of the universe, we need to divert our attention from this compelling image of the abyss of space and instead focus on serious terrestrial issues about the conservation of natural resources and ecosystem biodiversity that still awaits a revolutionary invention. We cannot fail to be stirred by the utter isolation of our lonely planet, known as the only place to sustain life and ecosystems. It is not tough for us to comprehend that these resources of mother earth are of great significance to sustain life on earth. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. A sustainable economy is one that runs forever, where the rate of resource generated or recycled equals to or is smaller than the rate of consumption. Thus, to achieve a win-win situation, we need to think outside the box and act through more scientifically sound means by advocating holistic and integrated approaches in managing and monitoring natural resources and ecosystem biodiversity.

The overall objective of this book is to bring together a unified presentation for managing challenges emanating from accelerating exploitation of natural resource base and loss of ecosystem biodiversity. In addition to that, it aims to provide the ways that are truly sustainable—environmentally, economically, and

socially. A multidimensional interdisciplinary approach is required for sustainable use of natural resources with thematic linkages of economic, social, and environmental inter-relations which can provide the basic for human-wellbeing. To achieve sustainable development the Ecosystem Approach "a strategy for integrated management of land, water and natural resources that promotes conservation and sustainable use in an equitable way" should be used for natural resource management.

This book is a collection of peer-reviewed contributions from researchers in diverse fields. The book is truly interdisciplinary, with a research and application-oriented dimension. The whole book is divided into four sections. Part I explores the degradation assessment of forest ecology whereas Part II deals with the dynamics of land use and ecological services. Part III comprises nature conservation and biodiversity and Part IV explored the resource use and sustainability. The chapters in each section of this book are innovative and have practice-based experiences. Part I deals with tracing of transitions in tropical deforestation using Landsat time series, anthropogenic stress on forest diversity, forest vulnerability and status and conservation of agro-biodiversity. Here, the chapters of the section examine the broader issues associated with natural resources in economic systems and focus on the resource-related aspects of sustainability. Part II of the book takes into account the impact assessment of terrain attributes on Snow Cover area of northwestern Himalayas, land change systems and increasing population impacts on food security and river catchments and also evaluates the distribution of urban green spaces from urban sustainability approach. Such topics are critically important to the long term health of both ecological as well as economic systems. Similarly, Part III addresses various issues related to contaminated environments and their impacts. Part IV concludes with spatial accessibility to primary healthcare, artificial intelligence in agriculture sustainability, climate smart solution in catalyzing livelihood and sustainability and bio-physical environment in perspective of changing climate and sea level rise. The book proposes some pragmatic options for managing resources within these limits and provides an integrated approach which finally creates an enabling environment that offers hope of transformational change in the management of socio-ecological systems. Thus, this book aims to make available to the reader with ground information and examples to sustain localized approach, facilitating practitioners to illustrate an appropriate way of action.

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Aligarh, India — Dr. Saleha Jamal
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Part I
Degradation Assessment of Forest Ecology

Chapter 1
A Perspective View of Sustainability of Natural Resources: The Governance Challenge

Aishwarya and Pavan Kumar

Abstract Due to the importance of natural resource management in sustainable development and conservation of the global ecosystem, natural resource monitoring has become increasingly crucial around the globe. The functional aspect of the dealing of climate impact on sustainable management of natural resources requires decision-making. Decision-making mandates the engagement of actors with differing interests. The operational aspect of resources use is influenced by actors' interest from social milieu, policy setting, market structure and its technological interface. The soil, water and forest as key base-dependent resources to maintain the resilience of ecosystem and social stability is established. The proposed chapter intended to develop a comprehensive framework to explore the rules of engagement and boundaries of actors' interest, to address the sustainable use of natural resources.

Keywords Climate change · Environmental issues · Sustainability · Sustainable · Natural resource

1.1 A Perspective View of Challenges

Protecting the Environment, and Ensuring Development: The goal of all actions to ensure sustainability is the environment. The tasks and components involved in maintaining the ecosystem, sustainably, demand the acquisition of measures that are realistic for areas of human activity. The idea is to achieve development in all areas, without, necessary for this, harming the environment. The Effect on the Legitimacy of Government Influence (Contradictory) on Science (2007) predicted Majla's future thinking. An increase of 0.74 °C in temperature is estimated from 1906 to 2005. In windy weather, there is an increase in temperature in the atmospheric air. In

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analogy, some degree changes are as follows: Surface air temperatures for the period 1901–2000 indicate a critical warning of 0.4 °C for 100 years; It is estimated that by the end of the twenty-first century, rainfall will increase by 15–31% and mean annual temperatures will rise from 3 to 6 °C; The rapid melting of snow with the intensification of monsoon can lead to flood disasters in the Himalayan region; A trend of 1 cm sea level rise per decade has been recorded along the Indian coast; The delta will be threatened by floods, erosion, and salt penetration.

Climate is the long-term average of a weather parameter. Due to the geographical arrangement of our country, the climate is different everywhere. Thus, India is divided into several agro-climatic zones, and the country's economic activities are highly dependent on climatic characteristics. There are a number of essential climate variables (ECVs) that are important for understanding and monitoring the global climate system and can best be observed from space-based systems (Schandl et al. 2013; Bentley et al. 2008) The problems associated with the natural environment and climate change are an understanding of the mutual physical, chemical, and biological processes that govern the total land system, the changes that occur in the system, and the way in which they are influenced by natural factors and human activities. Current key challenges to natural resource and environmental stability also cover the impact of climate change. Uncertainties associated with climatic shift have made substantial re-thinking in earth planetary systems. In this book, the editors attempt to promote strategies related to the adaptation, which in turn supposedly minimize the impact of climate change. Science, technologies, and adaptation strategies are the keys to climate change mitigation, which are the primary foci of this book.

Natural resources provide important ecosystem services to mankind which is essential not only for their life but also for their overall development. But unfortunately due to increasing population pressure and decreasing quantity of limited resources, immediate affordable management of these resources is necessary. This arrangement is even more important in a developing nation like India whose development lies in optimum exploitation of their natural resources. Ecosystem imbalance invites many natural calamities like floods, droughts, landslides, etc. The recent flood tragedy in Uttarakhand on June 17, 2013 is just one example of this imbalance (Akenji et al. 2015a, b; Jordan et al. 2010; Visseren-Hamakers et al. 2015). Despite being one of the most natural resource rich nations of the world, India has not been able to exploit its natural resources effectively and efficiently and some resources are still completely untapped. In this direction, the Government of India and the National Bank for Agriculture and Rural Development (NABARD) are upgrading and integrating the management of natural resources in India.

The beginning of industrial capitalism in the nineteenth century marked the beginning of the race for growth and industrialization in the industrial world. This resulted in uninterrupted exploitation of natural and material resources of the colonized countries by imperialist capitalism. Decolonization began after World War II, resulting in the independence of many colonies and placing democratization and economic development at the center of national policy. In the context of democratization, according to Partha Chatterjee, the Indian post-colonial state has adopted a representative form of government based on universal adult suffrage; Whereas, the basic objective of

planning development in India was accumulation and legalization. Industrialization was given priority in the economic development model, which led to the limitless and uninterrupted exploitation of nature. In the latter half of the twentieth century, the environmental crisis and problems related to displacement caused by industrial and growth were reflected in the competition of continuous industrialization and growth (Peters 1998; Ovadia et al. 2014; Ekhator et al. 2016). Therefore, in contemporary times, to achieve the universal goal of environmental protection, emphasis was given at the national and global level and many initiatives were also taken in this direction. A series of activities on these issues were started at the Human Environment Conference in Stockholm in 1972 under the leadership of the United Nations. As a result the United Nations Environment Program was launched; including issues such as promoting green economies and creating public awareness—which acts as a guide for environmental laws enacted by all countries for the protection of natural resources, ecosystem, and biodiversity. The United Nations Conference on Environment and Development (UNCED), 1992, also known as the Earth Summit or Rio Conference, was held in Rio de Janeiro, Brazil. The Agenda-21 passed by it reaffirms that committed and active participation of non-state actors is essential to achieve the ideal of sustainable development. The credibility of civil society is due to their responsible and constructive role. In the implementation of Agenda-21, recognition and participation of formal and informal organizations, mass movements, media, environmental research institutes, etc. have been ensured (Ezeani et al. 2017; Taverne et al. 2008; Bice et al. 2014).

1.2 Policy Implementation

India has been striving to move forward on the path of sustainable development for a long time and has been incorporating its fundamental principles in its various development policies. Despite the recent worldwide economic crisis, we have been able to maintain a good rate of growth. Many development goals of India have been included in the Sustainable Development Goals. Many programs being implemented by our government are in line with the Sustainable Development Goals, including Make in India, Swachh Bharat Abhiyan, Beti Bachao-Beti Padhao, National Rural Drinking Water Program, National Health Mission, Pradhan Mantri Awas Yojana-both rural and urban, Prime Minister These include Gram Sadak Yojana, Digital India, Deendayal Upadhyaya Gram Jyoti Yojana, Skill India, and Pradhan Mantri Krishi Sinchai Yojana. We are working on multiple fronts to incorporate the Sustainable Development Goals into development policies, so as to fulfill the legitimate desires of our countrymen to live a better life that is compatible with the environment and our earth. The Central Government has entrusted the responsibility of monitoring and coordinating the implementation of the Sustainable Development Goals to NITI Aayog. The Ministry of Statistics and Program Implementation has been entrusted with the task of preparing the relevant national indicators. The identification of indicators from the Global List of Indicators proposed by the United Nations Economic and

Social Council by the Ministry of Statistics and Program Implementation that can be adopted for our National Indicators Framework is indeed a milestone. The decision taken by the Government of India to present its first Voluntary National Review (VNR) at the High Level Political Forum (HLPF) to be held in New York in July 2017 is an example of the importance India attaches to the successful implementation of the Sustainable Development Goals. There is a need to make more efforts by every individual and organization at the national, state, and local level to fulfill the aspirations of the people for overall development while preserving the environment.

1.3 Book Structure

This volume covers a huge range of strategies that can be applied to various sectors, from forest productivity to climate change threats on natural resources. Its aim, as with resource management itself, is to combine economics, policy, and science to help rehabilitate and preserve our natural resources. The overall objective of this book is to bring together a unified presentation for managing challenges emanating from accelerating exploitation of natural resource base and loss of ecosystem biodiversity. In addition to that, it aims to provide the ways that are truly sustainable—environmentally, economically, and socially. This book is a collection of peer-reviewed contributions from researchers of diverse fields. The book is truly interdisciplinary, with a research and application-oriented dimension. The whole book is divided into four sections, (A) Degradation assessment of forest ecology, (B) Dynamics of land use and ecological services, (C) nature conservation and biodiversity, and (D) Resource use and sustainability. The chapters in each section of this book are innovative and have practice-based experiences.

Section (A) deals with tracing of transitions in tropical deforestation using Landsat time series, anthropogenic stress on forest diversity, forest vulnerability and status and conservation of agro-biodiversity. The chapter first aims to investigate the causes of forest degradation and deforestation in East Kalimantan province. Primer of the issue is presented in Kiswanto et al., emphasizing the tracking transitions of tropical deforestation in East Kalimantan, Indonesia using time series Landsat images from 2000 to 2016. They investigated the causes of forest degradation and deforestation in East Kalimantan province, as one of the highest increases in primary forest loss in Indonesia. In Chap. 3, authors from Asian continent discuss Influence of anthropogenic activities on the diversity of forest ecosystems. Dar et al. discussed the forest resources of the country with a special focus on ecosystem services provided and the anthropogenic threats are exposed to. While Sajjad et al. presented indicator-based inherent forest vulnerability using multi-criteria decision-making analysis in the Darjeeling district of West Bengal. Sajjad et al. used twelve site-specific factors in Darjeeling district of West Bengal in India, namely, forest fragmentation, vegetation types, biological richness, disturbance index, temperature, rainfall, soil types, land use/land cover, geology, geomorphology, normalized difference vegetation index

(NDVI), and normalized difference water index (NDWI) for assessing their contribution to forest vulnerability. Uprising concerns in Agro-Biodiversity, Status and Conservation Strategies: An Indian Perspective as reported in singh et al., in this book, that capable agro-biodiversity is not only backbone of sustainable agriculture but also essential components of different farming systems, viz., Horticulture, Agro-forestry, Fisheries, Poultry, and other crops and cropping systems.

Second section deals with the Dynamics of Land Use and Ecological Services. Assessing the impact of terrain attributes on snow cover area distribution in Kashmir valley, Northwestern Himalaya as summarized by Islam et al., and also used MODIS (Moderate Resolution Imaging Spectro radiometer) snow product and ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) GDEM (Global Digital Elevation Model) data to examine snow cover area distribution in relation to the different topographic parameters in Kashmir Valley . Monitoring Land Use/ Land Cover Change Dynamics Using Remote Sensing and Geospatial Techniques in Rambiara Catchment, Kashmir Valley, India studied by Taufique and Khursheed. Khursheed et al. discussed the impact assessment of land use land cover dynamics and population growth on food security of Kashmir Valley, India in Chap. 8. The study aims to this chapter to assess the food security scenario in the Kashmir Valley with due attention on the fact whether there is any significant variation in the patterns of area under the staple food crops and any increment or decrease in the production of these cereals. Evaluation and distribution of urban green spaces in Kolkata municipal corporation: an approach to urban sustainability explained by Jamal et al. This study is an attempt to assess and evaluate the status and distribution of urban green spaces in Kolkata Municipal Corporation over the 30 years of time period.

Nature conservation and biodiversity discussed in Sect. 3. Nabi and Dar studied the bioremediation: microbial and plant assisted remediation of contaminated environments while Dar et al. explained the conservation of biodiversity in India: current status and future strategies. This chapter is therefore aimed to provide a complete picture of the status of biodiversity of the country with special insights about the species richness, the pressures they face, and various strategies in place for their conservation. Himshikha et al. assessed the various biodiversity management activities such as in situ and ex situ conservation approach, socio-economic and eco-development initiatives, social forestry programs, implementation of indigenous-community oriented policies, conservation of localized plant communities and restoration of green forest cover has demonstrated strong potential to restore regional diversity in the influence of anthropogenic activities on the biological diversity of forest ecosystem. Rather et al. revealed the assessment of environmental impacts of pesticides: evidence from meta-analysis. This would allow stakeholders; especially farmers gain enough information about the state of their land and options for sustainable use in agriculture, livestock production, or aquaculture. The study also reveals that many human diseases grow by the use of pesticides in the farmlands. The meta-analysis also shows that the various components of the environment like soil, water, and air are extensively overblown by the frequent use of pesticides.

Last Sect. 4 deals with the resource use and sustainability. Tali et al. studied the enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary Healthcare in HD Kote, Mysore (India). It's helpful for the policymakers to identify the inaccessible areas and also demarcate the service area of healthcare centers. Such steps will be helpful to improve the accessibility to healthcare in terms of improving the number of facilities and also improve the road network in an area. Role of artificial intelligence in agriculture sustainability, an example from India was discussed by Rafi et al. Rejith et al. examined the climate change and sea level rise scenario on the bio-physical environment. This study analyses the shoreline changes of Kerala using Landsat images of 1990 and 2000 of pre-monsoon time in order to assess the most vulnerable coastal stretches. Singh et al. explained the Proline: A key player to regulate biotic and abiotic stress in plants while Jamal and Kumar conclude the entire volume in toward sustainable natural resources: conclusion part. This book provides an insight about the natural resources, as they are the strategic component in the climate systems. Some case studies are presented in this book, or in previous publications, it appears that the complexity of Sustainability of natural resources is far greater.

References

Akenji L, Bengtsson M, Briggs E, Chiu A, Daconto G, Fadeeva Z, Fotiou S, Gandhi R, Mathews C, Metternicht G et al. (2015a) Sustainable consumption and production: a handbook for policymakers (Global Edition). United Nations Environment Programme: Nairobi, Kenya

Akenji L, Bengtsson M, Salem J (2015b) Sustainable consumption guide for policymakers: debunking myths and outlining solutions (Asia Edition). United Nations Environment Programme: Nairobi, Kenya

Bentley M (2008) Planning for change: guidelines for national programmes on sustainable consumption and production. United Nations Environment Programme: Nairobi, Kenya

Bice S, Moffat K (2014) Social licence to operate and impact assessment. Impact Assess Proj Apprais 32:257–262

Ekhator EO (2016) Public regulation of the oil and gas industry in Nigeria: an evaluation. Annu Surv Int Comp Law 21:43

Ezeani EC, Nwuke C (2017) Local content and the marginal fields programme: challenges for indigenous Participation in the Nigerian oil industry. Oil Gas Energy Law J OGEL 15:1–20

Jordan A, Lenschow A (2010) Policy paper environmental policy integration: a state of the art review. Environ Policy Gov 20:147–158

Ovadia JS (2014) Local content and natural resource governance: the cases of Angola and Nigeria. Extr Ind Soc 1:137–146

Peters BG (1998) Managing horizontal government: The politics of co-ordination. Public Adm 76:295–311

Schandl H, Heyenga S, Hosking K, Akenji L, Bengtsson M, Bhattacharya TR, Foran T, Gandhi R, Guo F, Walker P et al. (2013) Capacity building and policy needs assessment for sustainable consumption and production. United Nations Environment Programme: Nairobi, Kenya

Taverne B (2008) Petroleum, industry and governments: a study of the involvement of industry and governments in the production and use of petroleum. Kluwer Law International: Alphen aam den Rijn, The Netherlands. ISBN 978-90-411-2663-4

Visseren-Hamakers IJ (2015) Integrative environmental governance: enhancing governance in the era of synergies. Curr Opin Environ Sustain 14:136–143

Chapter 2
Tracking Transitions of Tropical Deforestation in East Kalimantan, Indonesia Using Time-Series Landsat Images from 2000 to 2016

Kiswanto, Martiwi Diah Setiawati, Iwied Wahyulianto, and Satoshi Tsuyuki

Abstract We investigated the causes of forest degradation and deforestation in East Kalimantan province, as one of the highest increases in primary forest loss in Indonesia. Here we used satellite-based observation of Landsat images to quantify the loss of primary and secondary forest and its transition between 2000 and 2016. We found that among the three types of forest in the region (i.e., dryland, swamp, and mangrove), mangrove experienced the highest forest loss (i.e., 26.7% of total mangrove forest) followed by a swamp (16.75%) and dryland forest (11.9%). Furthermore, this region has experienced forest degradation and deforestation of about 0.5 Mha and 0.88 Mha within 16 years of the study period. Forest degradation mainly occurred in the primary forest, while rapid deforestation was primarily in the secondary forest where logging activities were the main drivers. The other main drivers of deforestation were aquaculture, which contributes about 26.4 thousand ha of mangrove forest loss, and estate cropland, which contributes about 177.6 thousand ha and 2.2 thousand ha of dryland forest and swamp forest, respectively. Mining, agriculture, and infrastructure development were the other drivers of deforestation. Furthermore, no evidence showed the land use transition from the secondary forest into primary forest or non-forest land use type into secondary forest. This information

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will be beneficial to local authorities when designing a policy for avoiding negative impacts on deforestation.

Keywords Forest transitions · Tropical forest · Forest degradation · Deforestation · East Kalimantan · Remote sensing

2.1 Introduction

Over the past five decades, the loss of primary forest in Indonesia is among the highest in the world (Tsujino et al. 2016; Austin et al. 2019). Moreover, Kalimantan Island as home to the most Indonesia's carbon-rich peatlands has been particularly affected in fire occurrence (Margono et al. 2014). For example, in 1997–1998 and 2015, this island has experienced extreme peatland burning and caused severe toxic haze that affects serious human health impact and the economy both on local and regional scales (Koplitz et al., 2016). Also, deforestation and peatland fire contributed about half of the total annual carbon in Indonesia and creates a big challenge to achieve national green house gasses reduction by 29% by 2030 (Nikonovas et al. 2020).

However, policymakers have limited knowledge to design forest conservation policies that effectively address the drivers of deforestation and responsible prosecute for forest loss (Austin et al. 2019; Henders et al. 2018; Luttrell et al. 2013). For instance, all level government officials (i.e., district, provincial, and national) are involved in the decision-making process for spatial planning, land use allocation, and permit for land development (García-Llamas et al. 2016; van Oosten et al. 2014), but often has conflict interests. These varied conditions at local scales show that land cover does not change spatially (Margono et al. 2016; Tsujino et al 2016), but also temporally and portrayed as a series of transformations. Thus, it is important to obtain and analyze local temporal and spatial variability of land cover change with an accurate assessment to help in understanding landscape dynamics(Clavero et al. 2011; Metzger 2002; Rawat and Kumar 2015), measuring forest cover change (Leblois et al. 2017; Margono et al. 2016; Singh et al. 2017), supporting the government policy to effectively employ specific tropical forest conservation intervention (Kubitza et al. 2018).

Several countries have conducted a forest transition analysis (Barbier and Tesfaw 2015; Kuemmerle et al. 2015; Kull 2017; Mather 2007, 2005; Mather and Needle 1998; Meyfroidt et al. 2010; Rudel et al. 2010, 2005) by using land use trends for their territory. Derived from historical studies of forests (Agus et al. 2013; Kim et al. 2014; Setiawan et al. 2015), transition approach asserts forest change in predictable ways because of various causes, including urban growth (Kukkonen and Käyhkö 2014; Patel et al. 2015), industrialization (Islam and Sato 2012), agricultural intensification (Tsujino et al. 2016; Vijay et al. 2016), emerging forest scarcity (van Straaten et al. 2015), land use displacement (Meyfroidt and Lambin 2011), forest plantations (Holt et al. 2016), and their effects on carbon budget (Kuemmerle et al. 2015).

This study was conducted to characterize the land cover change transitions, which contribute to deforestation through annual land cover changes of Landsat imageryin East Kalimantan from 2000 to 2016. The definitions of forest, deforestation, and forest degradation used in this study refer to the regulation adopted by the Government of Indonesia (FAO 2010; MoEF 2015; MoF 2009). This study has provident useful to define which forest cover type where replaced with other types in a certain period (Carlson et al. 2013; Gaveau et al. 2016). Besides, we quantified and schematically presented land cover changes within 16 years' period and evaluate the East Kalimantan green policy intervention to land cover transition.

2.2 Materials and Methods

2.2.1 Study Area

The study area was conducted in East Kalimantan Province with coordinate between 2°33' N and 2°25' S and between 113°44' E and 119°00' E (Fig. 2.1).

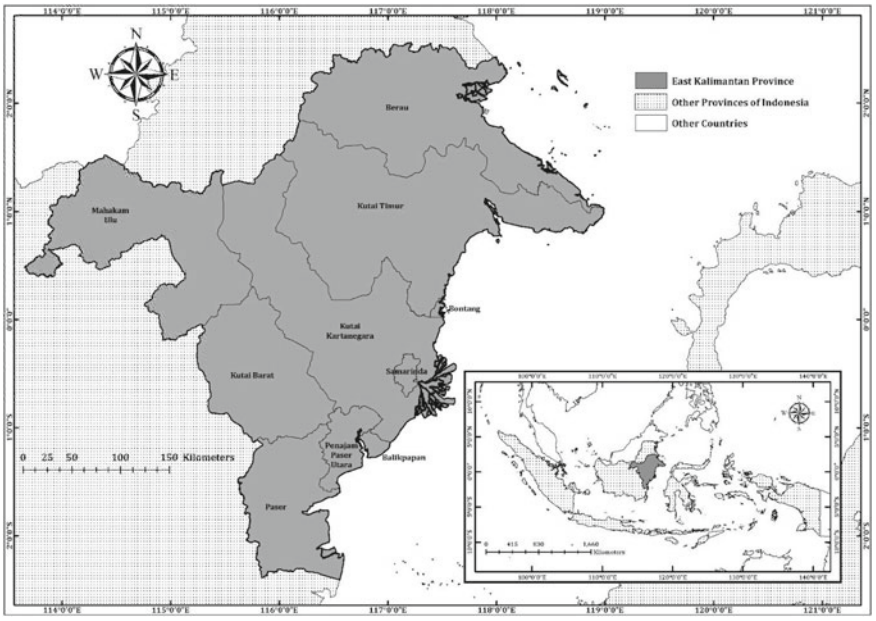

Fig. 2.1 The study area in East Kalimantan Province is part of the island of Borneo. This area is bounded by Sarawak (Malaysia) to the northwest, the Celebes Sea to the northeast, Makassar Strait to the southeast, North Kalimantan to the north, South Kalimantan to the south, Central Kalimantan to the southwest, and West Kalimantan to the west. *Source* Kiswanto et al. 2018

As the third-largest province in Indonesia with the total area of 12.73 Mha, East Kalimantan has a land area of 12,62 Mha and inland water of 112,802 ha (BPS 2020), which consists of seven districts and three cities. As one of the target province for reducing carbon emissions, this region is a leading member of the GCF (Governors Climate and Forests Task Force) and has been selected as the focal province for Indonesia's efforts to reduce deforestation through the Forest Carbon Partnership Facility's Carbon Fund and the Green Growth Compact (East Kalimantan 2013). Since 1950, however, East Kalimantan was designated as one of the target provinces for a transmigration program. Until now, there are 224 transmigration areas in this province where 12, 12, and 2 of them became a village, sub-district capital, and district capital (KDPDTT 2015). Since the economy is highly dependent on natural resources, some demands systematically encourage the conversion of natural forest to accommodate the regional development program. The study area had significant logging, oil palmplantation, and agricultural expansion (Elmhirst et al. 2017). Moreover, the coal mining site is omnipresent and more than 630 open-pit coal mines are abandoned (JATAM 2019). Van der Laan et al. (2018) and Verstegen et al. (2019) reported that land use changed in about one-third of Mahakam Ulu and Kutai Barat between 1990 and 2009, bringing about a 9% decline in forest area due to rapid land development. Moreover, in the National mid-term development plan 2020–2024, the capital city of Indonesia will be moved to East Kalimantan to equalize the community welfare between regions (Indonesia 2020).

2.2.2 Land Cover Map

This study was supported by 16 years of land cover maps in East Kalimantan using Landsat imagery visually interpreted from 2000 to 2016 and previously published sources (Kiswanto et al. 2018). We used this method because the forest type varies in the study area, and the cloud cover is persistent even in the dry season. Also, visual interpretation can be systematically validated by checking the high-resolution satellite imagery or comparing images to several ancillary spatial data sets (i.e., forest concession, cropland, and mining licenses), or completing ground surveys to capture additional valuable information. In contrast to the digital image interpretation that produced a pixel of the image, the result of visual interpretation is a polygon of land cover. This method was also conducted by previously published papers such as Gaveau et al. (2016), Gaveau et al. (2018), Kiswanto et al. (2018).

2.2.3 Definition

Our interpretation of forest excludes shrubland, estate cropland (i.e., oil palm, rubber), agricultural land, young forest regrowth, and non-vegetated areas. Moreover, we classified forest into seven main classes; primary dryland forest, primary

swamp forest, primary mangrove forest, secondary dryland forest, secondary swamp forest, secondary mangrove forest, and plantation forest. The definition of each class was referred to the Indonesian National Standards (Kiswanto et al. 2018; BSN 2014, 2010). In this paper, deforestation is defined as the land conversion of each forest cover class into non-forest cover classes that have only occurred one time in particular areas. Furthermore, forest degradation is defined as the change of each primary forest into the secondary forest and from the secondary forest into the plantation forest.

2.2.4 Annual Deforestation and Forest Degradation

Similar to land cover change analysis, deforestation and forest degradation were analyzed by comparing polygon by polygon of each forest cover class annually. We identified as deforestation if a polygon changed from forest to non-forest in each year, and identified it as forest degradation if a polygon changed from primary to secondary forest, or from secondary forest to a plantation forest at the same time. Accumulation from all forest cover classes each year is shown in annual deforestation and forest degradation.

2.2.5 Forest Transitions

We identified the change of forest cover annually, accumulated into each received land cover class and assessed the frequency of change. The result was shown as the changing flow from one class of forest cover to each land cover class based on the total area in each class and the frequency of change that shows as the first change, the second change, etc. as described in the supplementary materials (Figs. A.1–A.7). The first change means that one of the forest cover classes directly changes to another class. The second change, the third change, and so on reflect the repeated change throughout analysis after receiving additional land from the first change. Analysis of forest transitions would be finished in 2016 as the end period of analysis. The transitions of the forest cover were performed using a chord diagram created in R version 3.5.3 software, to visualize the interrelated data among the entities around the circle. This type of diagram was applied for regional studies (Abel and Heo 2018), social network analysis (Jalali 2016), medical studies, and multidisciplinary studies.

2.3 Results

2.3.1 Forest Cover Changes

The forest covered in the study area reduced 11% in extend between 2000 and 2016 (Fig. 2.2). This change equates to the total forest loss of 0.88Mha over the 16 years' study period. Both deforestation and forest degradation threaten its biodiversity and ecosystem services, including in the study area. As shown in Fig. 2.3, the study area experienced deforestation and forest degradation, which showed an annual consistent acceleration trend (Fig. 2.3). Moreover, our study found that the annual deforestation rate was larger (i.e.,0.05Mha/year) than the annual forest degradation rate (0.03Mha/year). Also, by conducting simple linear regression from Fig. 2.3,

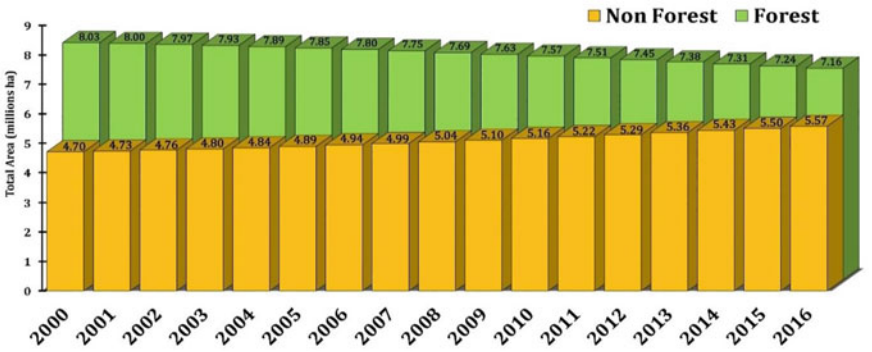

Fig. 2.2 The total area of forest and non-forest in East Kalimantan from 2000 to 2016. Orange color indicates a total non-forest area (i.e., shrubland, estate cropland, mining, bare ground, mix agriculture, settlement, transmigration area, aquaculture, open swamp, wet shrubland) in million hectares and green color indicates total forest area (i.e., primary forest, secondary forest, and plantation forest) in million hectares. *Source* Authors

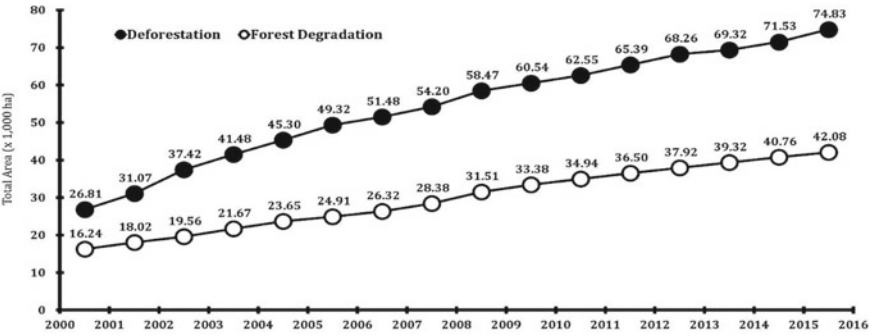

Fig. 2.3 Annual deforestation and forest degradation in East Kalimantan from 2000 to 2016

increasing 1 ha-degraded forest could increase deforestation area by 1.7 ha with the correlation value as 0.99. As a result, the potential of the total forest loss will be double if we assumed no green policy implementation.

2.3.2 *Transitions of Primary Forests*

The transitions of the primary dry land forest, swamp forest, and mangrove forest in the study area were assessed using the chord diagram. As shown in Fig. 2.4, the first outer circle colors expressed the entity name for each forest type (i.e., primary, secondary, shrubland, etc.) and the inner line diagram showed the transition direction among entities, for example, from primary forest to primary forest, from primary

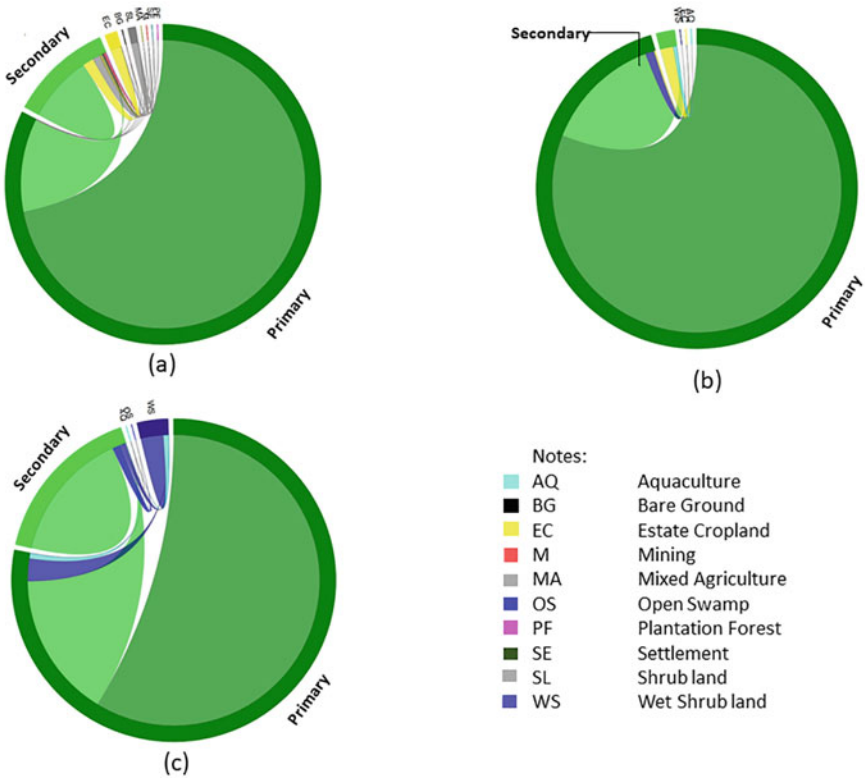

Fig. 2.4 Forest transition in **a** primary dryland forest, **b** primary swamp forest, **c** primary mangrove forest, from 2000 to 2016 in East Kalimantan province. Figure 2.4 used the chord diagram to simplify the transition forest matrix. The first outer circle colors expressed the entity name (i.e., primary, secondary, estate cropland, etc.) for each forest type and the inner line diagram showed the transition direction among entities. *Source* Authors

forest to secondary forest, etc. and more detail transition stages of each type of forest can be seen in the appendices (Figs. A.1–A.3).

Primary dryland forest was 2.5 Mha in 2000 and approximately 87.23% of primary dryland forest remained unchanged, while 12.75% changed to other classes (Fig. 4a). The analysis showed that the main threat of forest degradation in East Kalimantan was exposed as the direct change of primary into secondary dryland forest as shown in the green outer line with the light green direction in Fig. 4a. However, the degraded primary dryland forest to secondary dryland forest continuously deforested to the non-forests land cover type (Fig. 4a; light green outer line with predominantly yellow and gray directions). Also, estate cropland was identified as the main threat of deforestation in primary dryland forest (12%) while other causes were mining (3.93%), mixed dry agriculture (2.83%), settlement (0.08%), transmigration (0.06%), and pure dry agriculture (0.06%).

Primary swamp forest in the study area was 26.85 thousand hectares in 2000 and 85% of it remain unchanged while 15% changed into other classes (Fig. 4b). Also, the degradation of swamp forest was dominated by the change of primary swamp forest into the secondary swamp forest (~13%). Moreover, the main driver of deforestation in the primary swamp forest was estate cropland, which contributed about 1.7% of the total loss in the primary swamp forests, while fishpond/aquaculture triggered about 0.4% of total loss in primary swamp forests.

The primary mangrove forest was 57.1 thousand hectares in 2000 and remained unchanged at 75.3% (Fig. 4c). Similar to dryland and swamp forests, the significant loss in primary mangrove forest was caused by the degradation of primary forest (~18.6%). Furthermore, the main cause of deforestation in primary mangrove forests was forest conversion into wet shrubland (~3.3%) and aquaculture (0.8%). This finding has the same agreement with Thomas et al. (2017), which stated that the primary driver of mangrove loss from 1996 to 2010 in Mahakam delta in Kalimantan Island was fish pond/aquaculture. Among three types of forest, mangrove forest remains the highest ratio of primary forest loss followed by swamp forest and dryland forest.

2.3.3 Transitions of Secondary Forests

The transitions of the secondary dryland forest, swamp forest, and mangrove forest in the study area are shown in Fig. 2.5. Among three types of forest, mangrove forest has experienced rapid changes in the secondary forest followed by dryland forest and swamp forest. Furthermore, all types of secondary forest experienced rapid land conversion with predominantly change into dry and wet shrubland.

The secondary dryland forest in East Kalimantan was about 4.76Mha in 2000 and 83.8% of it remained unchanged in 2016 (Fig. 5a). However, about 3% was degraded into plantation forest and 16.2% were deforested into dry shrubland (9.4%) which mainly by logging and estate cropland (3%) (Fig. 5a). Other causes of deforestation were also represented by the conversion of secondary dryland forest into mining

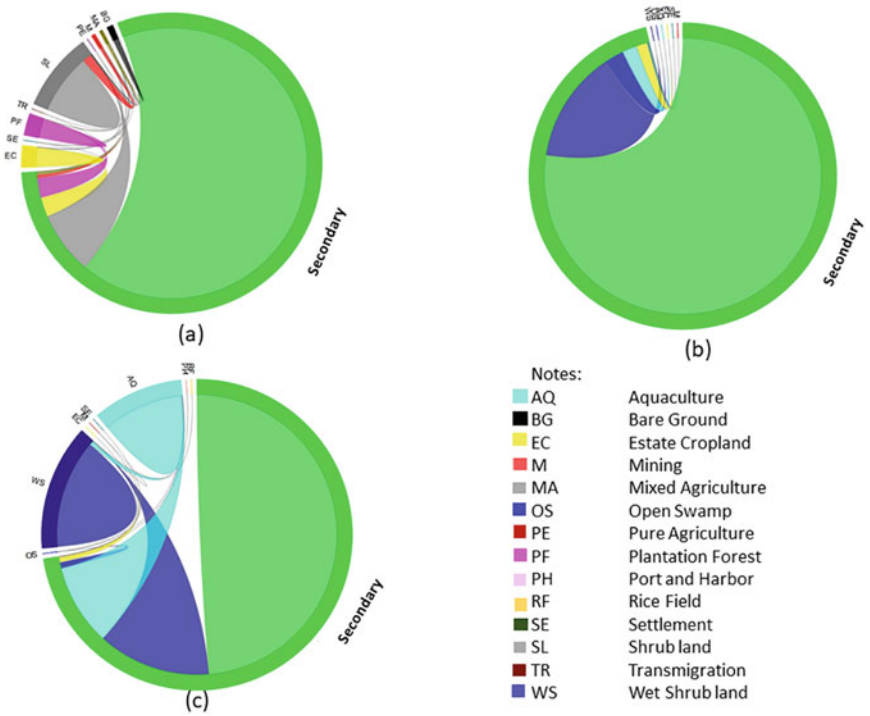

Fig. 2.5 Forest transition in **a** secondary dryland forest, **b** secondary swamp forest, **c** primary mangrove forest, from 2000 to 2016 in East Kalimantan province. The transition can be breakdown into two main stages: (1) the transition from the secondary forest into the non-forest type and plantation forest and (2) transition from a non-forest type into a non-forest type. For a detailed number please refer to the appendices (Figs. A.4–A.6) *Source* Authors

(0.5%), mixed dry agriculture (0.43%), settlement, transmigration, and pure dry agriculture. The secondary swamp forest in East Kalimantan was about 131 thousand hectares in 2000 and 80.57% of it remained unchanged. The land conversion of swamp forest was dominated by the change of secondary swamp forest into wet shrubland (13.6%), followed by open swamp (2.4%), aquaculture (1.8%), estate cropland (1.3%), settlement (0.3%), and mining (0.03%) (Fig. 5b). About 23% of the total secondary mangrove forest was identified as the forest loss and 77% remained unchanged. Similar to other forest classes, deforestation in secondary mangrove forests mainly caused by the conversion into wet shrubland (20.7%) followed by an open swamp (1.1%), estate cropland (1%), aquaculture, mining, settlement, and port harbor (Fig. 5c).