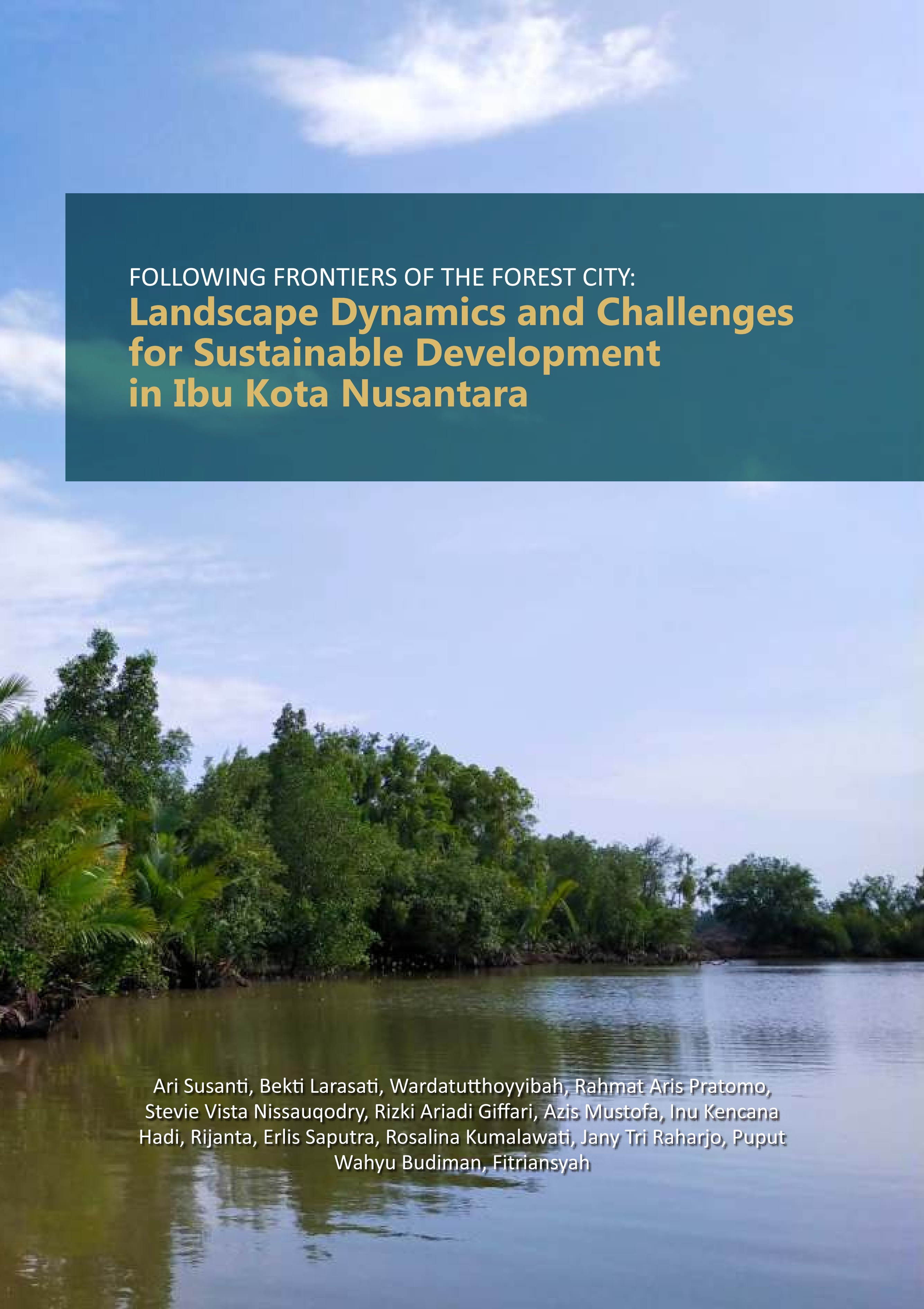

FOLLOWING FRONTIERS OF THE FOREST CITY:

Landscape Dynamics and Challenges for Sustainable Development in Ibu Kota Nusantara

Ari Susanti, Bekti Larasati, Wardatutthoyyibah, Rahmat Aris Pratomo, Stevie Vista Nissauqodry, Rizki Ariadi Giffari, Azis Mustofa, Inu Kencana Hadi, Rijanta, Erlis Saputra, Rosalina Kumalawati, Jany Tri Raharjo, Puput Wahyu Budiman, Fitriansyah

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Landscape and Fishpond in Babulu Laut
Photo credit: Ari Susanti

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Preface

In 2019, the Government of Indonesia (GoI) declared that the capital city was going to be moved from Jakarta to East Kalimantan, specifically to Penajam Paser Utara (PPU) and Kutai Kartanegara (Kukar) Regencies. This relocation intended to address Jakarta's severe social and environmental issues, including social inequality, traffic congestion, pollution, flooding, and land subsidence. The move aimed to decrease disparities between Java and the outer islands. The relocation also catalyzed redirecting migration flows within the country towards East Kalimantan and its surrounding regions. Furthermore, East Kalimantan provided available state lands for development, existing basic infrastructure, and relatively low risks of disasters and social conflicts.

The decision of the Indonesian Government to relocate the capital city has faced criticism, particularly regarding its potential impact on the ecology of Kalimantan. The Island is the second largest globally and plays a vital role in the ecosystem since it contains vast areas of tropical forests, including ecologically vulnerable peatlands. These forests are home to endangered endemic species and provide livelihoods for local and indigenous people. In response to these concerns, the Government adopted a forest city concept to balance natural landscape, biodiversity, and local livelihoods with modern city development. Law No. 3/2022 on Ibu Kota Negara (IKN) formalized the capital city relocation plans. However, concerns were raised about the broader impact of the new capital city beyond the designated areas of Penajam Paser Utara (PPU) and Kutai Kartanegara (Kukar) Regencies in East Kalimantan.

This book aims to describe the landscapes of East Kalimantan, specifically those of PPU and Kukar Regencies. It also proposes several alternative conservation strategies to facilitate a fair transformation towards inclusive and sustainable development and urbanization in the new city.

Authors

GLOSSARY

Forest City	The urban proposals combine infrastructures with local vegetation from the ecosystem in which the city is built. The city, dominated by forest vegetation in its ecosystem, has achieved integrated urban and rural development through its ecological constructions (Liaio, 2021).
Frontier	Area or source of unusually abundant natural resources and land relative to labor and capital. "transitional spaces where political authorities and social and environmental relations of the recent past are currently being challenged by new enclosures, territorializations, and property regimes" (Peluso and Lund, 2011 in Hein et al., 2016).
GoI	The Government of Indonesia
IKN	Ibu Kota Nusantara (the name of the new capital city in East Kalimantan)
Inclusive city	An inclusive city is a city that without prejudice to economic status, gender, race, ethnicity, or religion provides equal access to social, economic, and political opportunities for a wide variety of urban residents (Elias, 2020)
Indigenous communities/ people	"Distinct social and cultural groups that share collective ancestral ties to the lands and natural resources where they live, occupy or from which they have been displaced" (World Bank, 2022)

Transmigration	“The transfer of population in Indonesia from the islands of Central Java, Madura, Bali, and Lombok to the outer islands under government sponsorship”(MacAndrew, 1978).
Urbanization	“The process wherein urban living patterns supersede rural living patterns” (Murayama & Estoque, 2020); “the transformation of a lightly populated open country or rural areas into dense concentrations of people, characterized by the expansion of population from central cities and the migration of people from other areas” (Grolier, 1987)

ABBREVIATIONS

ALOS	Advanced Land Observing Satellite
ArcGIS	A family of client, server, and online geographic information system software developed and maintained by ESRI
BAPPEDA	Badan Perencanaan Pembangunan Daerah
BAPPENAS	Badan Perencanaan Pembangunan Nasional
BPS	Badan Pusat Statistik
BRIN	Badan Riset dan Inovasi Nasional (National Research and Innovation Agency)
BSN	Badan Standarisasi Nasional (National Standardization Agency)
CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
DAS	Daerah Aliran Sungai (Watershed)
GDP	Gross Domestic Product
GIS	Geographic Information System
GRDP	Gross Regional Domestic Product
IUCN	International Union for Conservation of Nature
Kemenristekdikti	Kementerian Riset, Teknologi, dan Pendidikan Tinggi (Ministry of Research, Technology, and Higher Education)
KLHS	Kajian Lingkungan Hidup Strategis (Analysis of Strategic Environment)
Kukar	Kutai Kartanegara
LMU	Land Mapping Unit
LPI	Largest Patch Index

MESH	The effective mesh size
MoEF	Ministry of Environment and Forestry
NP	Number of Patches
PD	Patch Density
PLAND	Proportion of Landscape occupied by a particular class of land cover
PPU	Penajam Paser Utara
RHL	Rehabilitasi Hutan dan Lahan (Land and Forest Rehabilitation)
SAR	Synthetic aperture radar
SDGs	Sustainable Development Goals
SPLIT	Splitting index
TIES	The International Ecotourism Society
UNWTO	World Tourism Organization of the United Nation
USDA	United States Department of Agriculture
VHR	Very High Resolution
WS	Wilayah Sungai (River Area)
WWF	World Wide Fund for Nature

1 Introduction

On 26th August 2019, President Joko Widodo of Indonesia announced the relocation of the country's capital from Jakarta to East Kalimantan, specifically Penajam Paser Utara (PPU) and Kutai Kartanegara (Kukar) Regencies. This decision was the culmination of a long-standing debate that began with the first president, Soekarno. President Widodo's declaration truly materialized the relocation, even though numerous leaders deliberated the matter over the years.

One of the primary reasons for relocating the capital city from Jakarta to East Kalimantan was overpopulation. Java Island is home to nearly 60% of the country's population, with Metropolitan Jakarta hosting over ten million people, a population density of 15,978/km^2, and an average annual growth of 0.64 in 2022 (BPS, 2023a). Jakarta is not only the capital city but also the center of businesses, finances, and trade. It hosts the most extensive airport and harbor to support these economic activities (Adyatama, 2019). However, this has created unintended consequences such as traffic congestion, pollution, and over-exploitation of resources

Bukit Bangkirai Landscape
Photo credit: Ikrima Barrorotul Farikhiyah

such as groundwater (BAPPENAS, 2019; Saputra, 2020), resulting in environmental degradation and more frequent disaster events, such as flooding (Varisk Maplecroft, 2021)BAPPENAS, 2019; Saputra, 2020). The chronic problems require systematic and structured solutions that involve collaboration with periurban and rural areas beyond Jakarta city boundaries. Therefore, the relocation of the capital city becomes necessary to address these issues.

East Kalimantan has become the destination for the capital city relocation because of its central location within the Indonesian archipelago. The development of the new capital city in this location stimulates economic development in the outer islands and reduces regional disparities (Farisa, 2021). Furthermore, East Kalimantan has become a favorite destination for migrants after West Java and Riau provinces(BPS, 2023b). The capital city relocation altered the national migration flow toward the city and its surrounding regions. Additionally, its stable geological formation resulted in a low frequency of seismic activities(Putri, 2022), making it a relatively low-risks location for natural disasters (Sapiie, 2019).

The choice to transfer the capital city to East Kalimantan was met with criticism primarily stemming from concerns about the region's fragile ecosystems and its extensive tropical rainforests. These forests are not only vital for global oxygen production but also serve as crucial habitats for endangered endemic species. East Kalimantan's old tropical rainforest is part of the Heart of Borneo (HoB), globally recognized as a biodiversity hotspot with significant biological diversity of around 15,000 flowering plants and 3,000 tree species, including 6,000 endemic species (WWF, 2017). The development of the new capital city and large-scale infrastructures to support the new city impacts the ecology of Kalimantan, specifically beyond the planned areas. In addition, the forests and their biodiversity are essential for the livelihood of local communities, specifically the indigenous people. The new city is also likely to attract spontaneous migrants seeking better opportunities, who might have better education and skills than the indigenous or local people. This situation has led to heightened tensions among various groups and poses disadvantages specifically to indigenous or local communities. Furthermore, uncontrolled migration leads to environmental degradation and other unintended consequences of the capital city relocation. The relocation did not address the complex problems in the current capital city Jakarta. This criticism stemmed from the evidence of previous mega-project impacts, such as new city developments for capital cities in South America and Africa (Browder and Godfrey, 1997; Saputra, 2020; Van Noorloos and Kloosterboer, 2018).

The Government of Indonesia (GoI) strategically incorporated the Forest City concepts into the development of the new capital city, Ibu Kota Nusantara (IKN), to seamlessly integrate rural and urban development while preserving the forest vegetation. The forest city construction in China contributed to around 1.17% CO2 reduction in Chinese cities (Liao et al., 2021). By strengthening the rural-urban linkages or landscape approach, both areas benefitted from improved employment, education, health services, environmental management, and civic engagement (Cattaneo et al., 2022). Using these concepts, the new capital city IKN becomes a national identity of Indonesia's commitments to climate change adaptation and mitigation (Sekretariat Kabinet Republik Indonesia, 2022) and its commitment to achieving Sustainable Development Goals (SDGs), particularly SDG 11 on Sustainable Cities and Communities (Government of Indonesia, 2019). The newly established city runs on green energy and incorporates smart technologies under Sustainable Development Goal 7. The planning considers climate measures and prioritizes the adaptive capacity of local communities (Sekretariat Kabinet Republik Indonesia, 2022). However, this mega project's impacts on areas beyond the planned development remain uncertain.

This book examines the dynamics of the landscape and the challenges for sustainable development in the new capital city and beyond through the lens of a socio-ecological system (SES). An SES is a complex system encompassing social and ecological components and their interactions (Mathias et al., 2020). The SES framework allows a deeper understanding of the relationship between humans and their environment, as well as systematic innovations to address complex issues (Caniglia and Mayer, 2021), such as the connections between rural and urban areas. These areas are not binary due to their numerous interactions, making it difficult to establish clear boundaries (Cattaneo et al., 2022). They are interconnected and interdependent spaces (Gebre and Gebremedhin, 2019) that evolve based on social, economic, and political factors (Deslatte et al., 2022; Xiao et al., 2017), playing a vital role in urban and rural development.

The flow of people, goods, capital, and ideas between urban and rural areas, as well as the spaces between them can create various linkages. These movements also establish connections among sectors and complementary functions between the areas (OECD, 2023). The linkages provide rural areas access to markets, employment opportunities, education and health services, and agricultural inputs. In contrast, urban areas can secure sustainable supplies of clean water, food, raw materials, renewable energy, and other ecosystem services, such as carbon sequestration. Ecosystem services have also become the most prominent manifestation of rural-urban linkages in academic discussions (Gebre and Gebremedhin, 2019; Niva et al., 2019; Xiao et al., 2017). Strengthening the integration and reciprocal connection between rural and urban areas can improve socio-economic performance, promote sustainable development and climate change adaptation and mitigation, and increase resilience for both (Baffoe et al., 2021).

Resilience epitomizes the capacity of a system to endure swift changes, unexpected shocks, or demanding stresses. It forms the fundamental essence of SDGs, permeating each goal as a guiding principle (Talubo et al., 2022). Discussions on urban resilience have increased as the world has become highly urbanized and faces threats such as climate change, pandemics, disasters, economic crises, and terrorism '(Bueno et al., 2021). Urban designs that enhance connections between rural and urban areas, such as forest city constructions, have been adopted to increase resilience, inclusiveness, well-being, and biodiversity (Endreny, 2018). Additionally, they contribute to achieving the SDGs and reducing Green House Gas emissions (Liao et al., 2021). In urban development, peri-urban areas often experience adverse impacts of urbanization, particularly in poverty alleviation and ecosystem preservation (Dolley et al., 2020). Adopting an SES or landscape approach that acknowledges spatial and temporal scales, as well as formulating policies for synergies between resilience and well-being can facilitate the development of SDGs in the age of climate change (Chaigneau et al., 2022). Based on these concepts, Figure 1 summarizes the theoretical framework for this book, which explores the landscape dynamic due to the interactions between social and ecological systems under specific social, economic, and political conditions. The ecological system often suffers negative impacts from development (Susanti, 2016) and frontier

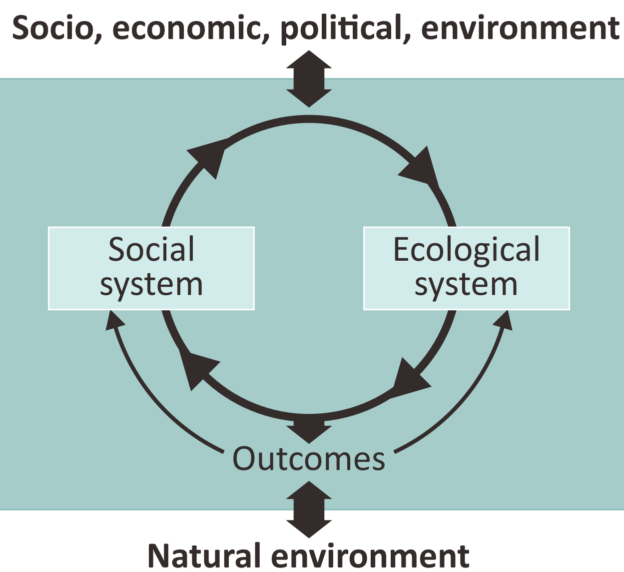


Figure 1. The Socio-Ecological Framework for Urban Development (Deslatte et al., 2022)

expansions, which provide feedback to the socio-ecological systems. Furthermore, the relocation of the capital city adds a layer of complexity to a landscape impacted by iterative and often simultaneous natural resource exploitation. This book focuses on the landscape dynamics and challenges for sustainable development resulting from these dynamics. For a detailed analysis, it uses examples from villages in the city development area (Pemaluan and Sepaku Villages), expansion areas (Teluk Dalam Village), and beyond the IKN development plan (Babulu Village). Meanwhile, data collection used direct observation and measurement, interviews, visits to related institutions, and online data collection. The analyses use hybrid or mixed methods, including reviews of technical documents and interview transcribes, as well as statistical and spatial analyses. The book commences by delving into an examination of landscape components, offering a concise historical account of frontier expansion and land-based or extractive industry activities. These activities have wielded substantial influence over the dynamics of the landscape, forging the present-day topography and exerting an impact on the province's progress towards achieving the 13th SDG indicator on climate action. The ongoing persistence of extractive activities and the exacerbation of climate change are escalating the potential risks and challenges associated with sustainable urbanization in IKN. Therefore, the book proposes alternative conservation strategies for an equitable transformation towards inclusive and sustainable development of new cities, fostering responsible urbanization practices.

2 Landscape Characteristics

The landscape formations are shaped by the interaction between nature and humans. Contemporary landscapes are the culmination of multiple factors, encompassing variations in abiotic conditions such as climate, topography, and soils. Additionally, biotic interactions play a significant role in creating spatial patterns within seemingly uniform environmental settings. The historical and current patterns of human settlement and land utilization contribute to shaping the landscapes. Finally, the dynamics of natural disturbance and succession also influence the overall composition and structure (Turner et al., 2001). The distribution of plants and animals is intricately tied to the landscape as each species possesses distinct habitat requirements. Moreover, the presence of these species contributes to the functioning of the ecosystem as a whole. This section characterizes the landscape of East Kalimantan and draws examples from the villages in the city (Pemaluan and Sepaku Villages) and expansion zones (Teluk Dalam Village), and beyond (Babulu Village) the IKN development plan.

Mangroves in Mentawir
Photo credit: Bekti Larasati

2.1 Topography

The East Kalimantan landscape is characterized by mostly undulated topography, with a smaller portion having a flat surface, and the average altitudes range from -4 meters to 2,103 meters above sea level (masl) (Topographic-map.com, 2023). The PPU, Kukar Regency, and the observed villages have similar landscapes, mostly undulating and hilly with flat to very steep slopes. Landform slope classification consists of <2%, 2-8%, 8-16%, 16-25%, 25-40%, and > 40%. Babulu Darat exhibits a hilly topography, with elevations ranging from 0 to 250 masl. Steep slopes predominantly characterize the landscape, showcasing various land uses including plantation forests, dry land agriculture, shrubs, secondary forests, and a smaller portion allocated to paddy fields. Moreover, the flat area with a slope of 2-8% harbors the paddy fields and dryland agriculture, which are situated in proximity to the residential area.

Sepaku Village has a hilly topography from steep to very steep slopes and an elevation of more than 500. The landscape with more than 40% slopes is primarily in plantation and secondary dryland forests, while 26-40% are plantation forests, shrubs, dryland farming, and mixed dryland farming. In addition, the area with a slope between 16-25% is mostly dryland farming, mixed dryland farming, and partly forest plantations. Transmigration, dryland farming, and a small fraction of plantation forests occupy the area with a 2-8% slope. Other villages have quite a varied topography, ranging from a slope of <2% to more than 40%. In Teluk Dalam, the peat soil and mangrove forest around the river have a slope of <2%. In contrast

Table 1. Landform Slope Classes of the Research Area (Source: Primary data 2021)

Village	Landform Slope Class				Area (ha)
	2-8% (flat)	16-25% (steep)	26-40% (very steep)	>40% (extremely steep)	
Sepaku	2,167.19	4,346.01	2,268.71	943.98	9,725.90
Teluk Dalam	926.88	15,563.60	5,653.76	0	22,144.24
Pemaluan	4,629.92	16,946.66	4,817.12	0	26,393.70
Babulu Darat	693.18	3,324.23	1,180.47	0	5,197.89
Babulu Laut	17.64	3,103.67	0	0	3,121.31

to the neighboring villages, Teluk Dalam comprises mining areas characterized by slopes ranging from 16-25% and 25-40%. The mining activities occupy a flat region adjacent to the river. Alongside the mining areas, the landscape encompasses plantations, dryland agriculture, and a small portion of swamp shrubs and secondary mangrove forests situated near the rivers within the areas exhibiting slopes of 16-25%. Pemaluan Village has a flat to hilly topography with an elevation of more than 500 masl. Meanwhile, the area near the river has primary and secondary mangrove forests dominating a steep slope of 16-25%. Other areas with hilly topography and steepest slopes are plantation forests and some shrubs. Furthermore, there are also plantations in the flat area with 2-8% slopes. The flat areas of Babulu are mostly aquaculture, mangrove forests, and rice fields, while the plantations and secondary forests are in the areas with steeper slopes.

2.2 Climate

East Kalimantan is characterized by a tropical climate and shares the same seasons as other Indonesian regions, specifically dry and rainy seasons. Based on the Oldeman climate type, the IKN area and its surroundings have C1 and B1 climate types. Climate type C1 has less than or equal to one dry month and 5-6 wet months. Climate type B1 is wetter than C1 which has less than or equal to one dry month and 7-9 wet months. The climate in Kukar Regency belongs to types C1 and B1 in the east and northwest parts. Based on the Schmidt-Ferguson climate type classification, Kukar Regency and the southern region fall into the categories of Type A (very wet) and Type C (rather wet) respectively. PPU Regency falls into the B1 of Oldeman climate type and C (rather wet) of Schmit-Ferguson climate types. Based on these classifications, the IKN area and its surroundings have relatively high monthly rainfall.

Table 2. Annual Rainfall and Number of Rainy Days in the IKN Area (Kementerian PPN/BAPPENAS, 2020)

Year	Rainfall Rate (mm/year)	Rainy days
2006	3,589	107
2007	2,196	97
2008	2,988	117
2009	2,229	113
2010	3,438	123
2011	2,326	98
2012	3,188	106
2013	2,705	103
2014	2,185	95

Table 2 indicates that the average annual rainfall in the IKN area and its surroundings was 2,760 mm/year. The trend of average annual rainfall from 2006-2014 fluctuated but decreased from 2012 to 2014. During the period, the highest and lowest average annual rainfalls were in 2006 and 2014 at 3,589 mm/year and 2,185 mm/year, respectively. The highest and lowest number occurred in 2008 and 2014, with 117 and 95 rainy days.

2.3 Surface and Groundwater

Mahakam is the largest river in East Kalimantan Province and has a crucial potential source of clean water for the region (Sutapa et al., 2022). Mahakam River also plays an essential role in the transportation of people and goods as it flows across the regions. Furthermore, the IKN lies within the River Area, a cross-provincial area covering 85,236 km^2, of which 93.84% is in East Kalimantan Province (Kementerian PPN/BAPPENAS, 2020). Table 3 indicates the watersheds in the IKN area and their water

Table 3. The Watersheds in the IKN Area and Estimation of the Size and Water Discharge (Kementerian PPN/BAPPENAS, 2020).

Name of Watershed	Size (hectares)	Water discharge (m^3/s)
Dondang	55,757.73	16.22
Mahakam	49,668.72	1,607.30
Manggar	2.82	3.86
Riko	1,322.41	12.83
Sanggai	89,141.20	12.83
Samboja	55,053.24	11.58
Wain	3,038.75	4.70

Table 4. Demand and Service Coverage of Clean Water in East Kalimantan by Regencies and Municipalities in 2021 (Dinas PUPR Provinsi Kalimantan Timur, 2022).

Regency/Municipality	Population (people)	Service coverage (%)	Clean water demand (liter/second)
Balikpapan	704,110	97.84	1,218
Penajam Paser Utara	185,022	49.90	297
Paser	280,250	66.80	577
Bontang	185,201	81.18	449
Kutai Timur	424,447	44.20	965
Berau	253,979	72.44	631
Samarinda	825,494	79.39	1,908
Kutai Kartanegara	741,950	56.64	1,750
Kutai Barat	168,348	72.19	299
Mahakam Ulu	35,171	13.89	49
East Kalimantan	3,803,972	70.78	8,141

discharge, while Table 4 shows the clean water demands and current services coverage of the clean water. Nearly one-third of the population needs access to clean water services. PPU and Kukar Regencies are among the lowest coverage of clean water services.

2.4 Soils and Underlying Sediments

Large areas of Central, East, and South Kalimantan are composed of sedimentary rocks, including sandstone and shale. Besides older formations in West Kalimantan, most sedimentary formations are relatively young and include cal and oil source rocks. The southern part of Borneo consists mainly of loosely consolidated sand and gravel terraces, often overlaid by young, superficial peat deposits and alluvial fans deposited by flooding rivers (MacKinnon et al., 1996). The study collected soil samples from 10 land mapping units (LMUs) that were distributed across the research area (Table 5). The soil analysis indicated that the dominant soil types were Alluvial and Red-Yellow Podzolic, followed by Latosol, Litosol, and Peaty Soil. In four villages, Red-Yellow podzolic becomes the dominant soil type. Pemaluan Village has a small part of Peat Soil, while Teluk Dalam has some areas with Peaty Soil types. Babulu Darat Village also has Latosol, Litosol, and Alluvial soil types, specifically near residential areas. Meanwhile, Sepaku Village has Latosol and Litosol soil types in 16-40% slope areas.

Table 5. The LMUs and the Soil Types (Primary data, 2021)

No	LMU	Soil Type
1	II.Al	Alluvial
2	III.Al	Alluvial
3	IV.Al	Alluvial
4	III.Kp	Red Yellow Podzolic complex, Latosol, Litosol
5	IV.Kp	Red Yellow Podzolic complex, Latosol, Litosol
6	V.Kp	Red Yellow Podzolic
7	II.Pd	Red Yellow Podzolic
8	III.Pd	Red Yellow Podzolic
9	IV.Pd	Red Yellow Podzolic
10	V.Pd	Peaty Soil

The Red Yellow Podzolic is classified as Ultisol by USDA soil types. Ultisols are deep, well-drained, red or yellowish soils, higher in weatherable minerals than Oxisol but still acid and low in native fertility (Sanchez, 1989). These strongly weathered soils form a high proportion of the Red-Yellow Podzolic soils typical of the rolling plains of Kalimantan (MacKinnon et al., 1996). Low pH becomes the primary problem of acid soils, followed by low organic matter levels. The addition of liming materials such as calcite, dolomite, steel slag, and fly ash has become the standard technique to overcome these problems. The choice of materials and their dosage will be applied depending on the soil properties, such as exchangeable Al, initial pH, organic matter, and soil texture, as well as the crops to be cultivated (Suwardi, 2019).

Alluvial is a new soil known as Entisol by USDA soil types. Entisol is soil with slight development in which the parent material primarily determines the properties. Some examples are soils in young alluvium with thin depositional layers at shallow depths, soils on hard rock, very wet mineral soils of marshes and lagoons, and deeply mixed by man (Grossman, 1983). One related reason is that Entisols are prevalent in areas with concentrated human habitation, such as in Babulu Darat Village, due to the tendency of people to gather around areas with accessible transportation routes such as rivers or oceans.

Peat soils are the most dominant organic soil developed through centuries under wetland conditions by accumulating decomposed and undecomposed plant residues (Osman, 2018). Peatland with the status of peaty soil or very shallow peat with a depth <50 cm is not categorized as peat soil. This is because the bulk density value is relatively high as a result of the low minerals and the C-organic content value. Table 6 summarizes the soil characteristics in the research areas.

Table 6. Soil Characteristics in the Research Areas (Primary data, 2021)

Location	Code	Texture	Organic matter	Salinity	Permeability	Permeability Class
Sepaku Village	TA/V Kp	Silt loam	0.62	10.99	0.237	Slow
	TA/IV Pd	Clay loam	1.89	9.12	0.498	Slow
	TA/V Pd	Silty clay loam	1.89	12.50	0.377	Slow
Pemaluan Village	TA/II Pd	Silt loam	1.31	5.82	3.525	Medium
	TA/III A1	Loam	1.93	34.06	0.378	Slow
	TA/IV A1	Silt	1.30	8.46	0.027	Very slow
Teluk Dalam Village	TA/III Pd	Clay loam	4.42	32.35	0.239	Slow
	TA/III S	Clay	5.16	45.34	0.663	Slightly slow
	TA/I S	Clay loam	2.52	80.18	4.246	Medium
Labangka Village	TA/II A1	Clay	5.16	41.11	0.323	Slow
	TA/III A1	Sandy loam	1.90	11.89	54.452	Very fast
	TA/IV A1	Silt loam	4.52	13.30	9.938	Slightly fast

2.5 Vegetations and Wildlife

East Kalimantan is located on the equator in a region experiencing high temperatures in the year and within the wettest part of the Indonesian archipelago. These conditions and the island's geological and climatic history have promoted speciation and high species diversity (MacKinnon et al., 1996). Lowland dipterocarp and partly mangrove become the most dominant vegetation in the IKN area (Kementerian PPN/BAPPENAS, 2020). Sundaland's extensive lowland dipterocarp forests represent the most crucial feature both ecologically and commercially (Robiansyah et al., 2021) and reach their highest species richness in Kalimantan. Dipterocarps, named after winged fruits, grow as tall trees with canopy heights commonly reaching 45 m and 60 m. Typically, several species of dipterocarp genera grow together, and around 609 or 42.5% of all endemic plant species of Dipterocarpaceae were identified in East Kalimantan. About 83 are Dipterocarpaceae commercial timber species (Sidiyasa, 2015).

Mangrove (or mangal) is the collective name for the tree vegetation colonizing muddy shores in the tidal zone from extreme high water to low tide. It occurs only on shores where sand bars, coral reefs, or islands break the vigor of the surf. The coastal/deltaic, estuarine or lagoonal, and island forms are the three main mangrove ecosystem types in Kalimantan (MacKinnon et al., 1996). Meanwhile, Indonesia is home to over 20% of the world's mangrove areas and possesses a higher number of species than other countries (Ilman et al., 2016).

Kalimantan has the region's finest and most extensive remaining dipterocarp and mangrove forests. These forests become the habitat for non-endemic and endemic species, both flora and fauna. Furthermore, the East Kalimantan Province hosts 107 and 219 species of flora and wildlife (Pemerintah Provinsi Kalimantan Timur, 2023). Several endemic species are hornbills, proboscis monkeys, orangutans, clouded leopards, and sun bears. However, logging activities and clearance for agriculture and other extractive industries pose significant threats to the habitat of these extensive lowland dipterocarp forests.

The GoI had set national regulations to protect these endangered plants and animal species by issuing the Minister of Environment and Forestry Decree No. P.106/Menlhk/Setjen/Kum.1/12/2018 on the protected plant and animal species. In addition, the International Union for Conservation of Nature

(IUCN) red list provides information on a global species' status of threatened species. The Convention on International Trading in Endangered Species of Wild Fauna and Flora (CITES) status can determine global animal trading. Appendix I of CITES also provides the prohibited list of species for international trading. The IUCN Red List consists of 179 species, of which 151 are classified as threatened, including 15 vulnerable, eight endangered, and six critically endangered *Dipteropcarpaceae* in East Kalimantan (Table 7). However, they are not on the CITES list or the nationally protected plant species mentioned above.

Black orchids, Bornean Ironwood and Tongkat Ali are other important endemic species of East Kalimantan. The black orchid is the mascot of the Province and grows only in limited locations. It is the most well-known and favored orchid species among local and international enthusiasts (Widians et al., 2018). Meanwhile, the Bornean Ironwood becomes the mascot of the East Kutai National Park. It can grow to a height of 50 m and a diameter of 120 cm with a massive crown and can survive up to 1000 years (Yudaputra et al., 2020). The Borneon ironwood was on the list of nationally protected species according to the Ministerial Decree of Environmental and Forestry No. 92/2018. According to the Ministerial Decree of Environmental and Forestry No. 106/2018, it is not on the list of nationally protected species. Furthermore, Bornean Ironwood is the most resilient variety of commercial wood for exterior construction, including poles and bridges. It is the strongest and heaviest wood in the world, also known as the Ironwood. The population has drastically decreased in its native habitat, mainly because of overexploitation to meet its high

Table 7. IUCN and CITES List of Endangered Species (Pemerintah Provinsi Kalimantan Timur, 2023)

No	Species Name and Scientific Name	Class	IUCNStatus	CITES
1	*Hopea rudiformis*	Dipterocarpaceae	Critical Endangered	-
2	*Shorea leptoderma*	Dipterocarpaceae	Critical Endangered	-
3	*Shorea hemsleyana*	Dipterocarpaceae	Critical Endangered	-
4	*Shorea macrobalanos*	Dipterocarpaceae	Critical Endangered	-
5	*Vatica cauliflora*	Dipterocarpaceae	Critical Endangered	-
6	*Vatica pentrandra*	Dipterocarpaceae	Critical Endangered	-
7	*Dryobalanops beccarii*	Dipterocarpaceae	Endangered	-
8	*Shorea brunnescens*	Dipterocarpaceae	Endangered	-
9	*Shorea domatiosa*	Dipterocarpaceae	Endangered	-
10	*Shorea pachyphylla*	Dipterocarpaceae	Endangered	-
11	*Shorea sagittata*	Dipterocarpaceae	Endangered	-
12	*Vatica endertii*	Dipterocarpaceae	Endengered	-
13	*Vatica globose*	Dipterocarpaceae	Endangered	-
14	*Vatica rotate*	Dipterocarpaceae	Endangered	-
15	*Dryobalanops keithii*	Dipterocarpaceae	Vulnerable	-
16	*Shorea collaris*	Dipterocarpaceae	Vulnerable	-
17	*Shorea confusa*	Dipterocarpaceae	Vulnerable	-
18	*Shorea smithiana*	Dipterocarpaceae	Vulnerable	-
19	*Shorea ferruginea*	Dipterocarpaceae	Vulnerable	-
20	*Shorea longiflora*	Dipterocarpaceae	Vulnerable	-
21	*Shorea mecistopteryx*	Dipterocarpaceae	Vulnerable	-
22	*Shorea mujongensis*	Dipterocarpaceae	Vulnerable	-
23	*Shorea obscura*	Dipterocarpaceae	Vulnerable	-
24	*Shorea polyandra*	Dipterocarpaceae	Vulnerable	-
25	*Shorea retusa*	Dipterocarpaceae	Vulnerable	-
26	*Shorea superba*	Dipterocarpaceae	Vulnerable	-
27	Upuna borneensis	Dipterocarpaceae	Vulnerable	-
28	Vatica badiifolia	Dipterocarpaceae	Vulnerable	-
29	Vatica sarawakensis	Dipterocarpaceae	Vulnerable	-
30	Black Orchid or Anggrek Hitam (*Coelogyne pandurata)*	Liliopsida	-	Appendix I
31	Bornean Ironwood or Pohon Ulin/Kayu Besi (*Eusideroxylon zwagerii)*	Dicotiledoneae	Vulnerable	Appendix II
32	Tongkat Ali or Pasak Bumi (*Eurycoma longifolia* Jack)	Magnoliopsida	-	-

demands. The Tongkat Ali or Pasak Bumi extract is a traditional aphrodisiac, anti-malaria, breast cancer prevention, insecticidal properties, and osteoporosis prevention (Mohd Effendy et al., 2012). Pasak Bumi can grow in various habitats, including coastal ecosystems, mixed dipterocarp forests, lowland forests, and Kerangas forests (Hidayati et al., 2021). Land degradation and conversion for urban development and agriculture expansions have threatened the habitat of this species and put their survival in potential danger(Fithria, 2020).

Table 8 includes animal species that are protected at the national level and are also listed as endangered species on the IUCN and CITES lists. In addition to the mentioned species, there are others that the national level legally protects, but their low risk of extinction lists them as Least Concern (LC). Some of these species include *Microhierax fringilarius, Aviceda jerdoni, Elanus caeruleus, Haliastur indus, Nisaetus cirrhatus, Ictinaetus malaiensis, Accipiter trivirgatus, Spilonis cheela, Ixobrychus eurhythmus, Ardae sumatrana, Ardae alba, Rhyticeros undulatus, Anthracocerus albirostris, Platysmurus leucopterus), Aethopyga siparaja, Loriculus galgulus, Rhipidura javanica, Gracula religiosa, Muntiacus muntjak, Prionailurus bengalensis, Trugulus napu.* Figure 2 shows several pictures of the animal species.

The East Kalimantan provincial Government also mapped the high-conservation value regions as part of the wildlife protection management strategies and Biodiversity Management Master Plan 2020 (Pemerintah Provinsi Kalimantan Timur, 2023). The map indicated that the HoB had

Table 8. IUCN and CITES List of Endangered Animal Species (Pemerintah Provinsi Kalimantan Timur, 2023)

No	Species Name and Scientific Name	Class	National Protection Status	IUCNStatus	CITES
1	Orangutan (*Pongo pygmaeus)*	Mammalia	Protected	Critical Endangered	Appendix I
2	Greater Green Leafbird or Burung Cica-Daun Besar (*Chloropsis sonnerati)*	Avifauna	Protected	Endengered	-
3	Proboscis Monkey or *Bekantan (Nasalis larvatus)*	Mammalia	Protected	Endangered	Appendix I
4	Bornean Gibbon or Owa Kalawat (*Hylobates muelleri*)	Mammalia	Protected	Endangered	Appendix I
5	Lesser Adjutant or Bangau Tongtong (*Leptoptilos javanicus*)	Avifauna	Protected	Vulnerable	-
6	Long Tailed Parakeet or *Betet Ekor Panjang* (*Psittacula longicauda*)	Avifauna	Protected	Vulnerable	-
7	Malayan Sun Bear or *Beruang Madu (Helarcos malayanus)*	Mammalia	Protected	Vulnerable	Appendix I
8	Bornean Clouded Leopard or *Macan Dahan (Neofelis nebulosa)*	Mammalia	Protected	Vulnerable	Appendix I
9	Sambar Deer or Rusa Sambar (*Rusa Unicolor*)	Mammalia	Protected	Vulnerable	-
10	Lesser Fish-Eagle or Elang Ikan Kecil (*Ichthyophaga humilis*)	Avifauna	Protected	Near Threatened	Appendix II
11	Oriental Darter or Pecuk-Ular Asia (*Anhinga melanogaster*)	Avifauna	Protected	Near Threatened	-
12	Black Hornbill or Kangkareng Hitam (*Anthracoceros malayanus*)	Avifauna	Protected	Near Threatened	Appendix II
13	Rhinoceros Hornbill or Rangkong Badak (*Buceros rhinoceros*)	Avifauna	Protected	Near Threatened	Appendix II
14	Red-Crowned Barbet or Takur Tutut (*Psilopogon rafflesii*)	Avifauna	Protected	Near Threatened	-

become the concentrated habitat for endangered species, specifically primates, carnivores, and birds. The relocation of the capital city from Jakarta to East Kalimantan Province necessitates significant infrastructure construction. This human-induced disturbance has a severe impact on wildlife habitats in the region (Spencer et al., 2023). To minimize the adverse effects of relocation activities on the environment, it is necessary to implement a suitable risk mitigation plan.

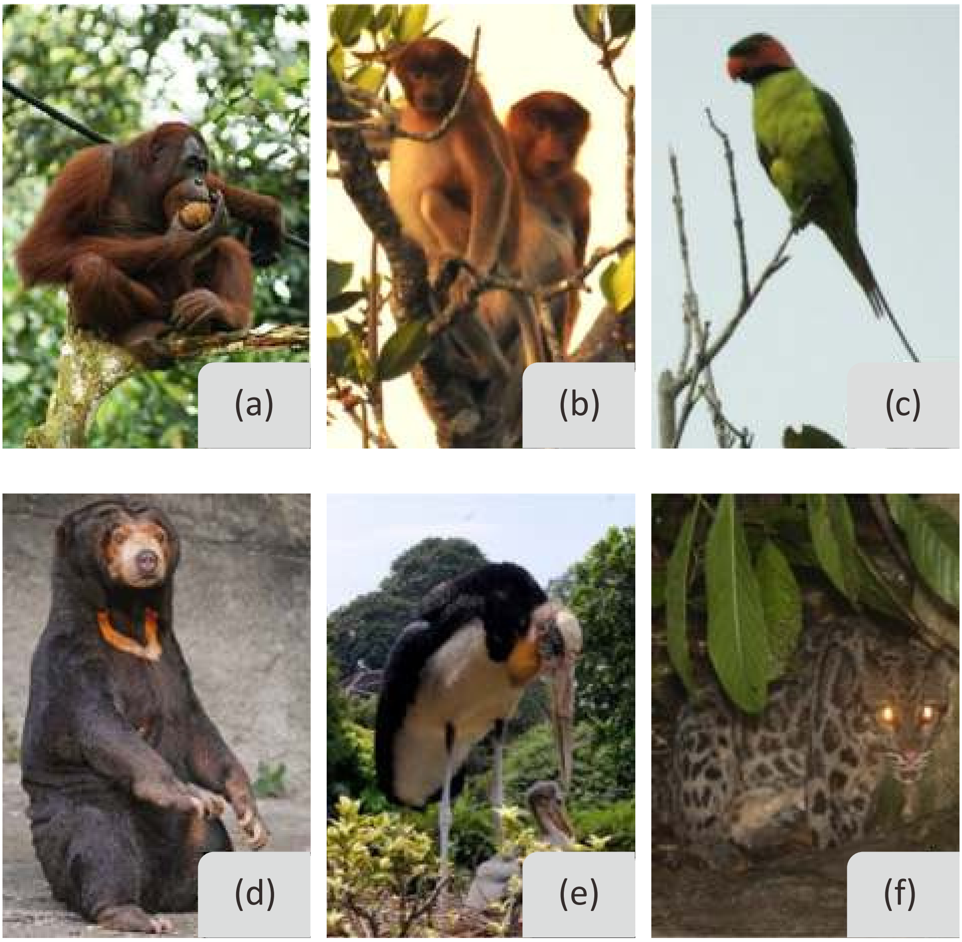
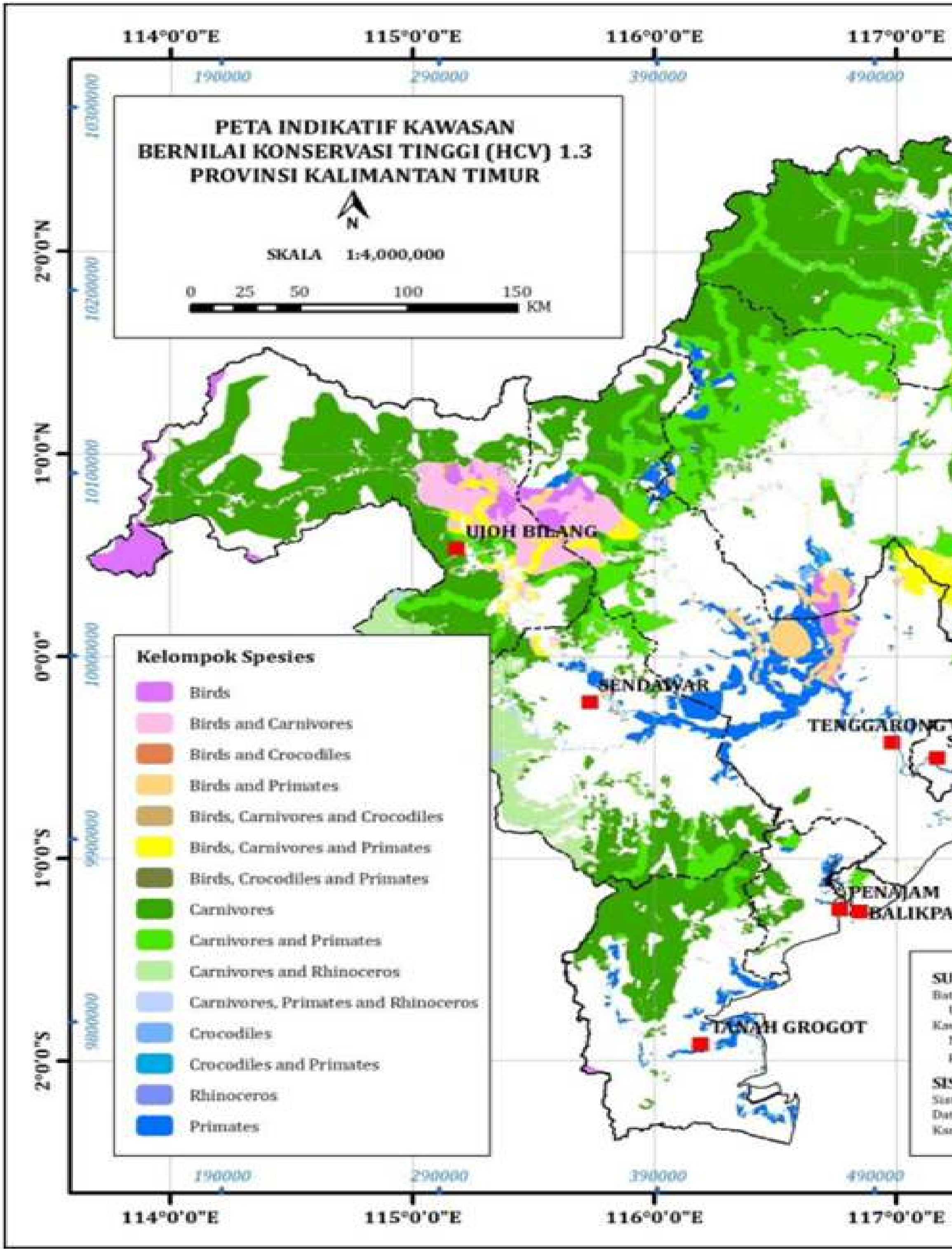


Figure 2. (a) Orangutan - Photo credit: Wikipedia,(b) Proboscis Monkey, Photo credit: Iqbal Nur Ardiansya, (c) Long Tailed Parakeet - Photo credit: Iqbal Nur Ardiansyah, (d) Malayan Sun Bear - Photo credit: Wikipedia, (e) Lesser Adjutant, Photo credit: Wikipedia, (f) Bornean Clouded Leopard - Photo credit: Wikipedia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Birds and Carnivores
Birds and Crocodiles
Birds and Primates
Birds, Carnivores and Crocodiles
Birds, Carnivores and Primates
Birds, Crocodiles and Primates
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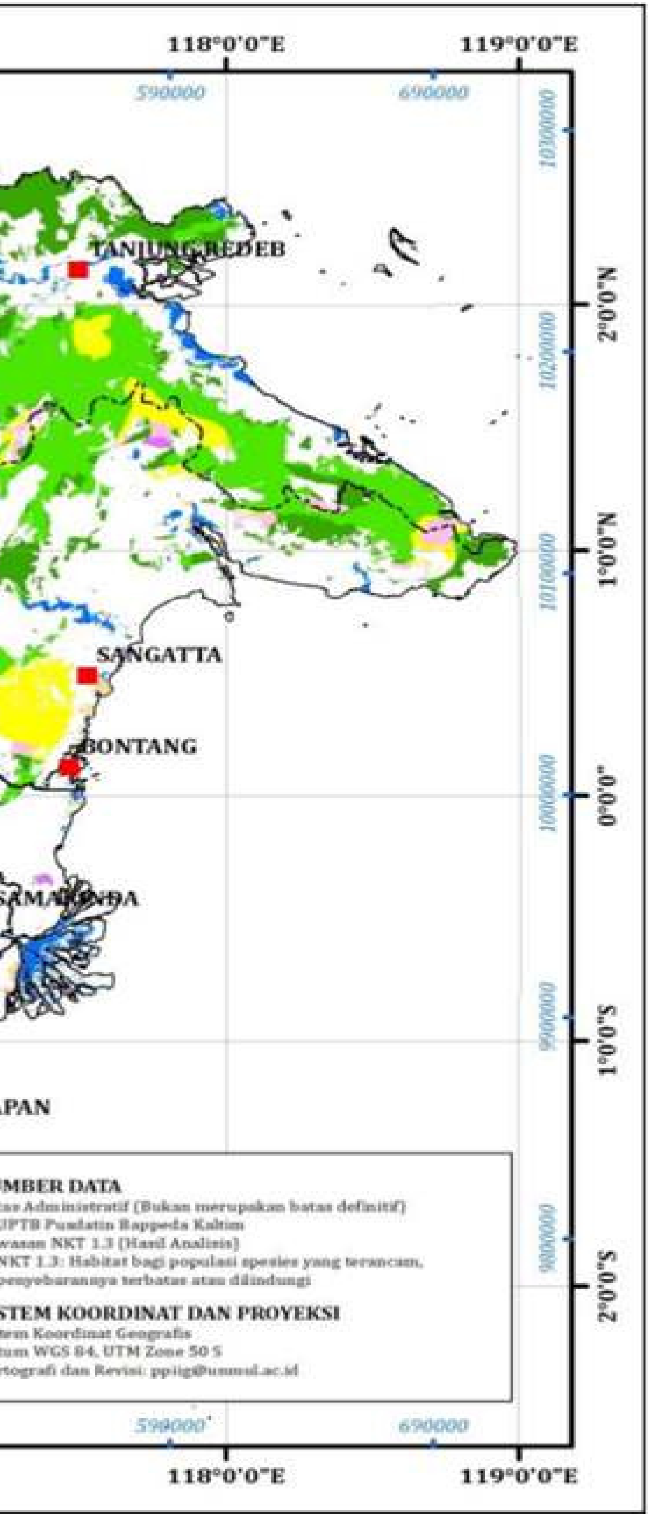


Figure3.
Map of High Conservation Value Areas Based on Species' Class (Pemerintah Provinsi Kalimantan Timur, 2023)

3 Resources-Based Economic Activities and Landscape Dynamics

3.1 Historical Frontier Expansion and Resources-based Economic Activities

Resources-based development is the main economic activity in the frontier regions. It involves exploiting natural resources for extractive industries and contributing significantly to the global economy. The European exploration and conquest of the New Worlds from 1500 - 1914, which followed the classic pattern of frontier expansion, has resulted in successful resource-based economic developments. This pattern can be divided into four phases. Initially, there was exploration and small-scale extraction of natural resources. A transportation network was developed to support large-scale extractive industries. Subsequently, agricultural land development and the establishment of permanent settlements took place. In the final phase, industrialization and urbanization subjected the frontiers to the depletion of once relatively abundant natural resources (Barbier, 2010).

Many regions have advantages from the expansions, and the process of economic development has created new frontiers of

Coal Mining in Teluk Dalam
Photo Credit: Ikrima Barrorotul Farikhiyah

natural resources. Frontier expansion in the tropics has continued with increasing intensity, mainly to fulfill the global demands for food, fuel, and fibers (Bourgoin et al., 2020). It has a different pattern of frontier expansion involving horizontal and vertical that simultaneously co-occur in most lower-middle-income countries. This new pattern insignificantly contributed to the economic development of these countries in the long run. This can be attributed to the isolation of the resource-based sector from the rest of the economy, the lack of infrastructure to accommodate public scientific knowledge, and the necessity for reinvestment in more dynamic economic sectors to stimulate diversification (Barbier, 2010).

Indonesia has become one country that depends highly on resources-based activities for its economic development, reflected in its income structures. Even though the manufacturing sector has dominated 19.25% of the Indonesian economy in the last five years (2017-2021), agriculture, forestry, and fishing still become substantial contributors to the national income, counted around 13.28%. Within this sector, estate crops, have a prominent contribution to the national income, followed by fishing and food crops. Even though agriculture's contribution has increased, forestry and fishing have decreased. In addition, mining and quarrying also have been increasing their contributions to the national income in 2021 with 4.00% growth (BPS, 2022a). This structure indicates that the resources-based economy has dominated the national income.

East Kalimantan becomes one of Indonesia's provinces with the highest regional income. Therefore, the frontiers have been experiencing iterative expansion with various intensities and types of extractive activities as the region lies on abundant natural resources (Goh, 2020). Toumbourou et al. (2022) discovered that distinct forms of extractive activities, despite initially appearing as independent processes, exhibit significant overlap and coexistence both temporally and spatially. These activities mutually reinforce one another, thereby facilitating the sustainability of extractive practices and constricting resource accessibility for diverse community groups. For example, local people, such as Dayak, Paser, and Kutai tribes, have been harvesting forest products, practicing shifting cultivation and managing forest gardens or simpukng for their subsistence (Mulyoutami et al., 2009). These community activities collided with the Western exploitation that began during the Dutch colonization seeking oil, gas, other valuable mining, and timber exploitations (Bock, 1985). Furthermore, the mining industries have flourished, attracting investors and contributing significantly to the region. The government also facilitated the development of industrial forests and oil palm plantations to stimulate the development of the outer islands. The support included infrastructure and labor mobilization through the transmigration program (Susanti and Maryudi, 2016).

The longitudinal data indicate that extractive industries dominate the sectoral contributions to regional incomes of East Kalimantan Province despite its efforts to transform and achieve a Green Economy (Table 9). Mining and quarrying have become the highest contributor, and their contribution tends to increase. Meanwhile, mining products such as charcoal and oil have been

Table 9. The Sector's Contribution to GDP from 2000 to 2020 of East Kalimantan Province (BPS, 2022a)

No	Sector	Year					
		2000	2005	2010	2015	2020	2022
1	Agriculture, Forestry, and Fishing	6.9%	5.3%	6.0%	6.5%	7.0%	6.6%
2	Mining and Quarrying	34.8%	42.6%	47.4%	50.0%	47.2%	46.6%
3	Manufacturing	42.4%	36.6%	25.1%	20.2%	19.9%	19.7%
4	Electricity, Gas, and Water	0.2%	0.3%	0.3%	0.1%	0.1%	0.1%
5	Construction	2.4%	2.2%	2.8%	7.0%	7.5%	7.9%
6	Trade, Accommodation, and Food Service Activities	6.4%	5.8%	8.2%	5.6%	6.6%	6.9%
7	Transportation and Communication	3.4%	3.3%	3.7%	4.1%	4.6%	4.9%
8	Financial and Bussiness Activities	1.9%	1.7%	2.3%	1.7%	1.7%	1.8%
9	Services	1.7%	2.2%	4.2%	4.9%	5.4%	5.5%
		100%	100%	100%	100%	100%	100%

the main focus of the manufacturing industries as they have down streamed these products, and the contribution from 2000 to 2022 tends to decrease. Agriculture, forestry, and fishing have firm contributions with minor fluctuations. Trade, Accommodation, and Food Service Activities also had a similar pattern, while construction and services showed an increasing contribution from 2000 to 2022, specifically starting in 2015 (BPS, 2022a).

At the regency level, the PPU Regency experienced significant economic growth from 1.28% in 2028 to 14.49 in 2022. The construction (24.11%), mining and quarrying (22.62%), and agriculture, forestry, and fishing (19.41%) sectors became the main contributors to its regional income. The GRDP of Kukar Regency grew from 2.16% in 2018 to 3.31% in 2022. The Kukar Regency has been highly dependent on the mining and quarrying sector, contributing around 69% to the GRDB. The agriculture, forestry, and fishing sectors contributed around 11%, and the manufacturing sector with 7% contribution (BPS Kabupaten Penajam Paser Utara, 2023). The high economic growth in the PPU Regency is related to the relocation of the capital city, such as the development of roads, bridges, and dams to support urbanization in the region. The capital city relocation has added a layer to the dynamic landscape in East Kalimantan in general and PPU and Kukar Regencies in particular.

3.2 Landscape Dynamics

The long-term extraction of resources and the development of the new capital city IKN are causing changes in the landscape dynamics. Previous research factored human disturbances to separate the intact from the degraded primary forest using Geographic Information System (GIS)-based fragmentation analysis. The analysis used Landsat 5 and 7 data (Margono et al., 2014) and employed a two-step supervised classification technique using per-pixel classification and a decision tree algorithm (Broich et al., 2011). It suggested that the primary forest cover loss in Kalimantan Island increased from 2001 to 2012, with 17.63% of the total intact and degraded primary forest covers (Margono et al., 2014).

The longitudinal data of vegetation cover in East Kalimantan Province showed that from 2013 to 2020, there was a slight decrease in the percentage area of primary forests, while the area occupied by secondary forests experienced fluctuations. Furthermore, between 2015 and 2017, there was a significant decline in the percentage area of secondary forests. In addition to the low-land dipterocarp forests, the mangrove forests emerged as vital ecosystems. However, they also faced deforestation between 2015 and 2018 (MoEF, 2021, 2020, 2019, 2018, 2017, 2016). The mangrove forests consisted of 96.17%, 3.11%, and 0.71% of dense, moderate, and sparse mangrove forests, respectively (Ditjen PDASRH, 2021).

The low-land Dipterocarp and Mangrove forests in East Kalimantan are crucial carbon reservoirs (Kusumaningtyas et al., 2019; Ray et al., 2011). Moreover, the mangrove forests are also the habitats of Bekantan (Proboscis monkey) and other endemic species living on Kalimantan Island (Bismark, 2010). The alterations in forest cover and subsequent loss can have adverse impacts at both local and global levels. These impacts encompass an increase in the frequency and intensity of flood events (Bradshaw et al., 2007), a decrease in precipitation (Smith et al., 2023), pest and diseases outbreaks (Brancalion et al., 2020; Chakrabarti, 2021; Ellwanger et al., 2020) biodiversity loss, and climate changes (Denryanto and Virgianto, 2021). Research on deforestation suggested that agricultural expansion had become the main driver of forest cover changes in the last decades –(Bismark, 2010; Koh and Ghazoul, 2010; Margono et al., 2014; Susanti, 2016). However, between 2018 and 2020, the area percentage of secondary forests increased due to the forest and land rehabilitation programs, as shown in Figure 4. The forest and land rehabilitation become annual activities for the Provincial Forestry Service in collaboration with its partners (Dinas Kehutanan Provinsi Kalimantan Timur, 2023).

	2013	2014	2015	2016	2017	2018	2019	2020
Primary Forest	32.00	31.90	32.50	31.50	31.80	31.80	31.28	31.50
Secondary Forest	33.60	32.80	35.10	33.30	31.00	30.80	31.56	33.30
Non Forest	31.90	33.40	30.50	32.70	35.00	35.30	34.34	31.90

Figure 4. The Percentage of Forest Areas in East Kalimantan from 2013 to 2020 (MoEF, 2021, 2020, 2019, 2018, 2017, 2016)

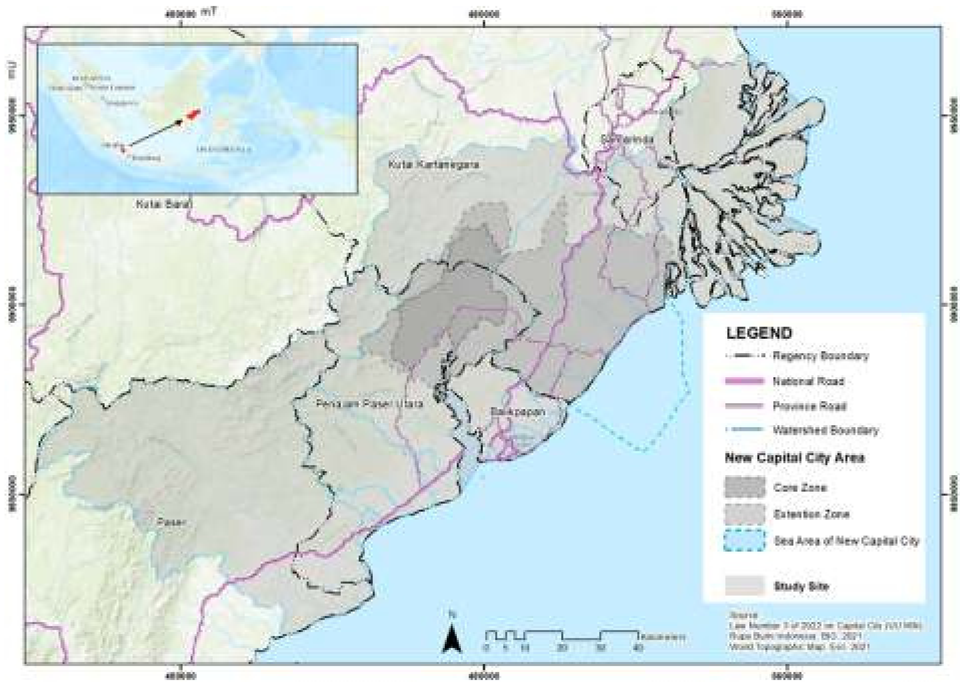


Figure 5. The IKN aArea and Its Surrounding Watersheds

The analysis of land cover change conducted between 2000 and 2020 in the planned area of IKN and its surrounding watershed also revealed a similar trend. Furthermore, it covered around 1,234,422.2 hectares of 32 watersheds acquired from BAPPEDA PPU Regency (Figure 5) and used Landsat 8 and 5, obtained on 03 April 2020 and 27 March 2000, respectively. The land cover classification also used auxiliary data, such as industrial forest plantation and mining maps acquired from the East Kalimantan Provincial Forestry Service, and an oil palm plantation map from Estate Crop Service, to facilitate the interpretation. Meanwhile, the identification of land cover classes used Random Forest Algorithm in Google Earth Engine. The evaluation was performed manually in ArcGIS Pro 3.1.0 by comparing the concept with the actual land cover in 2020 using ground check data and very high spatial resolution (VHR) images of 2020. The reference for Land Cover Classification was the Indonesian National Standard (Standar Nasional Indonesia - SNI) provided by the National Standardization Agency of Indonesia (Badan Standardisasi Nasional)(BSN, 2014).

The analysis demonstrated an overall classification accuracy of 0.82 (Congalton and Green, 2019), with a kappa statistic of 0.78. During the period between 2000 and 2020, there was a decrease in the extent of secondary dryland forests and mangroves, while the areas occupied by oil palm plantations, mining activities, settlements, and fish ponds experienced an increase. In addition, a significant area of changes from forest to non-forest occurred inside and outside the plantation concessions. The deforestation in the northern

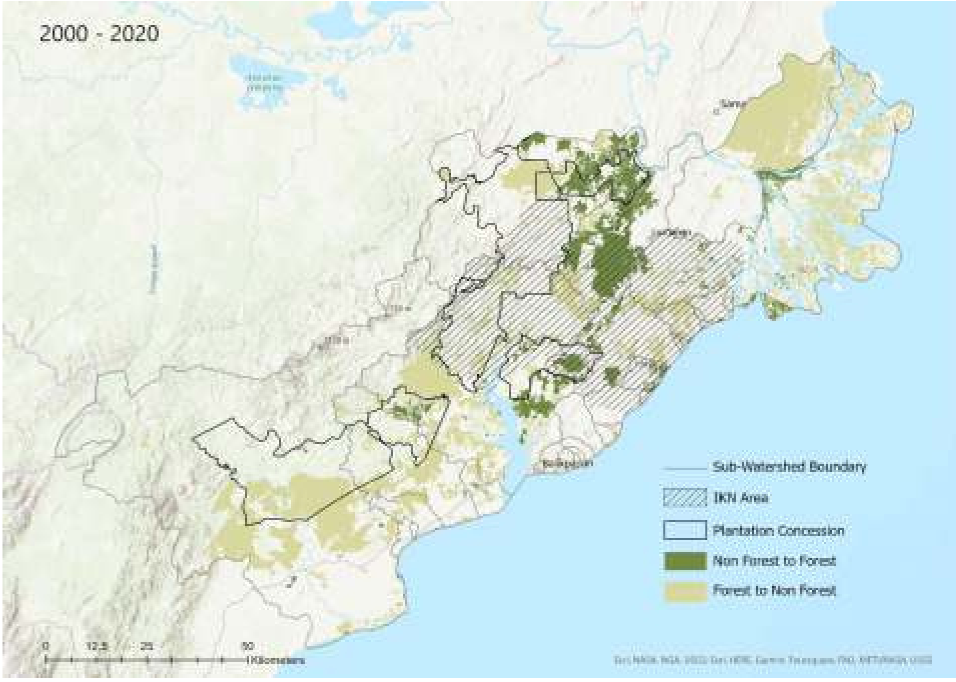


Figure 6. Land Cover Change Detection in the Research Area

area relates to the changes of mangroves to fish ponds (Figure 6). These patterns are similar to the previous research on deforestation in East Kalimantan from 2000 to 2016 (Kiswanto et al., 2022).

The conversion of forest cover into other types has resulted in landscape and habitat fragmentation. The fragmentation index of the mangrove forests, which served as crucial habitats for Proboscis monkeys, was estimated between 2000 and 2020 using Fragstat v4.2 software. The analysis focused on several indices, including PLAND, NP, PD, LPI, and SPLIT. The Percentage of Landscape (PLAND) index measures the proportion of the landscape occupied by a specific land cover class (Cushman and McGarigal, 2008). Furthermore, the Number of Patches (NP) index indicates the degree of fragmentation, in which a higher value shows a greater degree of fragmentation (Narmada, 2021; Pyngrope et al., 2021). The Patch Density (PD) index is also the ratio between the number of patches and the total landscape area (Cushman and McGarigal, 2008). The Largest Patch Index (LPI) indicates the increase or decrease of the largest patch size (Mengist et al., 2022; Narmada, 2021). A lower value of the MESH index reports a higher degree of fragmentation (Jaeger, 2000). Meanwhile, a low SPLIT or splitting index value indicates lower fragmentation (Su et al., 2014).

The PLAND index indicated that mangroves occupied around 9.64% of the landscape in 2000, declining to 5.55% in 2020. In 20 years, the region experienced around 4% of the loss. The increasing NP, PD, and SPLIT indices from 2000 to 2020 indicate that the mangrove forests were increasingly fragmented. In contrast, settlements' NP and PD indices decreased from 2000 to 2020, indicating a consolidation of the areas. The decrease in the LPI and MESH indices indicated an increasing fragmentation of mangrove forests from 2000 to 2020 (Table xx). The indices indicated that the mangrove forests have experienced massive fragmentation in the last 20 years. Furthermore, secondary dryland forests, mixed agriculture, mining, and paddy fields also experienced fragmentation. Previous research suggested that forest fragmentations lead to biodiversity loss (Bogaert et al., 2011; Jha et al., 2005; Liu et al., 2019), specifically wildlife communities (Jati et al., 2018), and increasing probability of fire events (Armenteras et al., 2013; Maillard et al., 2020). Considering the significant role of secondary dryland or mangrove forests, the governments should pay extra attention to the ecosystems in developing the new capital city IKN to prevent further losses.

Table 10. The Fragmentation Iindex Values of the Research Area between 2000 and 2020

Sector	Year	PLAND	NP	PD	LPI	MESH	SPLIT
Secondary dryland forest	2000	41.93	337.00	0.03	30.19	114,894.88	10.74
	2020	31.38	154.00	0.01	22.34	65,157.45	18.73
Mangrove forest	2000	9.64	785.00	0.06	0.75	372.80	3,311.21
	2020	5.55	1,084.00	0.09	0.58	123.42	9,889.26
Pulpwood plantation	2000	9.93	18.00	0.00	5.90	5,091.05	242.47
	2020	11.15	314.00	0.03	4.89	4,937.21	247.21
Oil palm plantation	2000	2.36	200.00	0.02	1.17	218.27	5,655.62
	2020	16.92	877.00	0.07	11.62	16,788.81	72.70
Shrub/ grassland	2000	14.07	1,156.00	0.09	5.77	5,746.09	214.83
	2020	5.69	4,165.00	0.34	1.86	451.28	2,704.57
Mixed agriculture	2000	10.34	56.00	0.00	4.13	2,703.87	456.54
	2020	10.39	1,696.00	0.14	2.01	1,191.60	1,024.27
Paddy field	2000	2.26	216.00	0.02	2.06	523.34	2,358.74
	2020	2.31	1,975.00	0.16	1.00	127.29	9,588.53
Fish pond	2000	1.63	1,024.00	0.08	0.30	15.40	80,176.16
	2020	5.14	663.00	0.05	0.57	144.05	8,472.65
Mining	2000	1.62	80.00	0.01	1.23	202.14	6,106.67
	2020	2.39	552.00	0.05	0.30	33.64	36,284.80
Bare land	2000	0.26	600.00	0.05	0.01	0.08	15,318,827.91
	2020	2.22	2,635.00	0.22	0.10	5.10	239,240.64
Settlement	2000	1.37	931.00	0.08	0.31	16.37	75,398.72
	2020	2.04	745.00	0.06	0.69	71.81	16,995.52
River	2000	4.57	252.00	0.02	2.85	1,188.60	1,038.56
	2020	4.59	317.00	0.03	3.06	1,327.14	919.66
Lake	2000	0.03	10.00	0.00	0.01	0.03	47,082,801.32
	2020	0.21	315.00	0.03	0.03	0.19	6,548,821.61

4 Challenges for Sustainable Development

4.1 Achievement of Sustainable Development Goals indicators

In 2015, the UN General Assembly agreed that there were 17 Sustainable Development Goals for 2030 to guide global public policies in promoting sustainable development. The 193 UN member countries have ratified the SDGs and committed to complying with the goals (UN, 2023). As a UN member state, Indonesia also adopted SDGs and institutionalized the concept in its development plans (BAPPENAS, 2023). The SDGs have significantly affected the understanding and communication about sustainable development. However, there is still more to be carried out on the institutional impacts of these goals (Biermann et al., 2022).

In Indonesia, the assessment of SDGs achievement occurs at national, provincial, and regency levels. The country is in the 82nd rank out of 163, with a 69.2 index score. It has achieved the 4th, 6th, 8th, and 12th goals, and moderately improved its performance for the 1st, 2nd, 3rd, 5th, 7th, 9th, 10th, 13th, and 16th goals. However, it

Erosion in Teluk Dalam
Photo credit: Desta Wahyu Ramadhan

stagnates in achieving the 11th, 14th, 15th, and 17th goals (sdgindex.org, 2022). An assessment of the relative position of SDGs indicator achievement between the provinces indicated that East Kalimantan had achieved higher compared to the national average for several goals. These included the 1st, 2nd, 4th, 6th, 7th, 8th, 9th, 10th, 11th, and 16th goals. However, it achieved below the national average for the 3rd, 12th, and 17th goals. The achievement of the 13th goal on climate action still has major challenges (BPS, 2020), specifically related to extractive economic activities in the province.

Despite the occurrence of disasters such as landslides, floods, forest and land fires, extreme weather events, and tidal waves or abrasion, the region's relatively low risk of disasters was considered a meaningful factor in selecting it as the location for the new capital city, IKN. Compared to other potential locations, East Kalimantan offers a better overall safety profile and a reduced likelihood of severe and frequent natural calamities (Abberger et al., 2002). These forest and land fire events have often been induced by massive clearing, especially peat drainage for establishing plantations (Syaufina, 2018). The fire incidents ravaged vast expanses of land, encompassing tropical forests, and gave rise to transboundary haze issues, economic repercussions, and loss of life (Varkkey, 2015). These events posed a formidable obstacle to the realization of SDG 13, which focuses on climate action (Susanti et al., 2022). Moreover, they exacerbated the Eco-environment Vulnerability Index (EVI), particularly in mining, coastal, and urban regions (Kurniawan et al., 2022).

4.2 Disaster Events

In 2021, East Kalimantan experienced 46 landslides, 36 floods, 29 forest and land fires, seven extreme wethers, and one tidal wave or abrasion. These disaster events affected more than 86,000 people, almost 100 causalities, and four fatalities (BPS, 2022b). PPU and Kukar Regencies, as documented in (BPS, 2022b) have encountered comparable disaster incidents. Furthermore, Kukar Regency shows a greater vulnerability to forest and land fires compared to PPU Regency (Kumalawati et al., 2023). Floods are the most prominent disaster event and affected more than 14,000 inhabitants in 2021 (BPS, 2022b). Vegetations facilitate water absorption and reduce surface flows and run-offs into rivers and streams. The removal reduced the soil's ability in absorbing water, increasing the risk of floods. Climate change intensifies and increases the frequency of extreme weather events, such as heavy rainfall, increasing the risk of floods (Tabari, 2020) and challenging the sustainability of the relocation of the new capital city (Shimamura and Mizunoya, 2020).

The analysis of water inundation in the IKN area used the rectified Landsat 8 OLI data from 2013 and 2021. The data can distinguish between water and land based on the differences in the backscatter properties of these surfaces and allow the identification of water bodies, even in areas with or without vegetation. The analysis employed the Otsu thresholding method to separate pixels into two classes based on the gray-level intensities. The analysis also applied post-processing steps to refine the segmentation, such as morphological operations or

Table 11. Water Inundation in Each Watershed Around the IKN Area

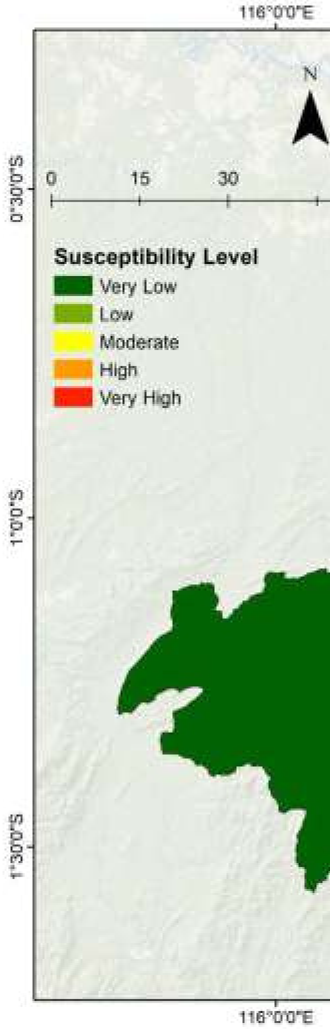
No	Watershed	2013	2015	2018	2020	2021
1	AMBARAWANG	1.516	0.061	0.874	1.603	0.269
2	BATAKAN	11.312	10.999	6.967	10.609	10.232
3	BATAKAN DS	14.519	14.951	4.594	19.977	10.762
4	DAMAI	17.395	21.459	8.578	50.300	11.884
5	JEMBAYAN	126.069	574.495	161.043	216.821	446.612
6	KLANDASAN ULU	17.504	15.985	3.818	49.790	13.196
7	LAMARU	3.709	4.699	3.680	5.023	2.151
8	MAHAKAM DS - A	86.517	105.004	198.789	241.206	21.655
9	MAHAKAM DS - B	27,613.497	27,190.574	25,182.626	30,438.246	27,976.926
10	MAHAKAM DS - C	1,041.279	1,675.823	1,881.121	2,010.675	2,142.942
11	MAHAKAM DS - D	207.431	517.527	350.639	386.325	481.176
12	MANGGAR	276.628	359.894	376.866	276.519	95.652
13	MANGGAR DS	15.927	15.130	13.168	12.310	10.973
14	PM - A	18.151	22.245	17.178	29.106	8.165
15	PM - B	1.429	1.406	4.781	0.850	625.277
16	RIKO MANGGAR	465.781	468.724	499.635	441.770	24.565
17	SAMBOJA	65.200	97.940	124.589	118.761	0.307
18	SAMBOJA DS	1.186	0.400	0.864	1.230	75.142
19	SAMBOJA KUALA	58.254	136.325	255.549	235.102	49.567
20	SAMBOJA KUALA DS	13.545	0.061	0.207	124.223	2.987
21	SELOKAPI	0.092	41.797	80.315	10.228	21.949
22	SENIPAH DS - A	1.225	11.939	15.153	4.830	3,146.682
23	SENIPAH DS - B	4.810	7.668	8.402	24.816	0.652
24	SENIPAH DS - C	27.823	27.564	12.626	3,477.045	9.770
25	SEPINGGAN DS	1,825.279	2,839.298	3,132.752	5.949	11.019
26	TELAKE	12.052	8.087	1.588	25.308	85.551
27	TELAKE DS - A	37.309	55.149	26.553	31.515	84.347
28	TELAKE DS - B	6.195	32.350	2.145	157.328	38.153
29	TERITIP	89.017	143.682	116.197	99.812	0.269
30	TUNAN	474.001	109.926	91.376	38.647	10.232
31	TUNAN DS - A	62.530	39.737	27.241	1.6031	10.762
32	TUNAN DS - B	1.516	0.061	0.874	0.609	11.884

Table 12. Water Inundation Susceptibility in Each Watershed Around the IKN Area

No	Watershed	Susceptible Area				
		Very Low	Low	Moderate	High	Very High
1	AMBARAWANG	597.229	2.656	0.241	0.099	0.126
2	BATAKAN	750.856	0.876	0.685	2.925	6.549
3	BATAKAN DS	533.739	1.650	3.059	5.986	3.279
4	DAMAI	2,907.462	4.471	4.426	3.858	5.918
5	JEMBAYAN	135,917.422	127.741	46.420	29.617	24.873
6	KLANDASAN ULU	696.720	1.430	1.680	8.569	3.727
7	LAMARU	1,797.494	1.464	1.107	0.989	0
8	MAHAKAM DS - A	5,119.148	64.255	60.725	48.797	6.141
9	MAHAKAM DS - B	118,681.588	6,713.048	7,023.214	7,986.152	7,982.563
10	MAHAKAM DS - C	87,584.610	779.935	539.903	455.625	347.439
11	MAHAKAM DS - D	60,757.780	175.954	80.627	42.989	46.420
12	MANGGAR	9,571.192	137.271	140.264	70.470	51.725
13	MANGGAR DS	2,063.372	1.700	1.341	1.762	9.530
14	PM - A	1,481.489	4.009	9.480	2.719	5.343
15	PM - B	875.850	1.718	0.133	0.001	0
16	RIKO MANGGAR	175,861.878	175.910	116.730	83.257	63.492
17	SAMBOJA	6,294.366	32.231	36.100	31.672	17.659
18	SAMBOJA DS	490.999	0.372	0.121	0.197	0
19	SAMBOJA KUALA	43,437.584	99.857	72.315	16.597	7.097
20	SAMBOJA KUALA DS	480.488	0.043	0	0	0
21	SELOKAPI	10,043.944	46.231	36.626	10.784	0.995
22	SENIPAH DS - A	331.581	0	0	0	0
23	SENIPAH DS - B	6,322.159	8.049	2.112	0.236	0
24	SENIPAH DS - C	337.307	1.405	2.779	3.902	0
25	SEPINGGAN DS	445.088	2.524	3.443	9.474	10.688
26	TELAKE	385,990.086	860.270	827.047	895.238	934.783
27	TELAKE DS - A	561.825	2.718	3.817	1.520	0.053
28	TELAKE DS - B	2,742.002	17.237	10.697	11.278	0.955
29	TERITIP	685.126	8.114	7.378	3.271	0
30	TUNAN	60,545.878	34.828	27.075	29.495	53.128
31	TUNAN DS - A	8,313.620	31.859	27.626	26.474	28.591
32	TUNAN DS - B	9,638.186	17.885	14.671	13.702	4.730

speckle filtering. Furthermore, the binary images showed the identified water extents. The merging of these images using a logical OR operation created the composite image that showed the water body extent over the entire time series. Comparing the longitudinal composite maps identifies the occurrence of seasonal water bodies. This stage may involve statistical methods to detect changes in water body extent or compare the time series to other sources, such as rainfall or river flow data, to identify the causes of changes (Chen and Zhao, 2022; Hu and Wang, 2022; Pan et al., 2020; Tran et al., 2022).

Based on the analysis in Table 11, water inundation spread over the entire Watershed Area in 2013, 2015, 2018, 2020, and 2021. The highest and lowest annual accumulation of water inundation in the entire period was in Mahakam DS – B and Ambarawang Watersheds, with an area of 138,402 Ha and 4.323 Ha. Within the five investigated years, 2020 had the most significant annual accumulated water inundation area of 38,558.136 Ha. In the watersheds around IKN, five water inundation susceptibility levels were determined by factoring in the frequency (Table 12). There were also areas with very high susceptibility levels, such as in Mahakam DS - B Watershed covering 7,982.56 Ha (Figure 7).



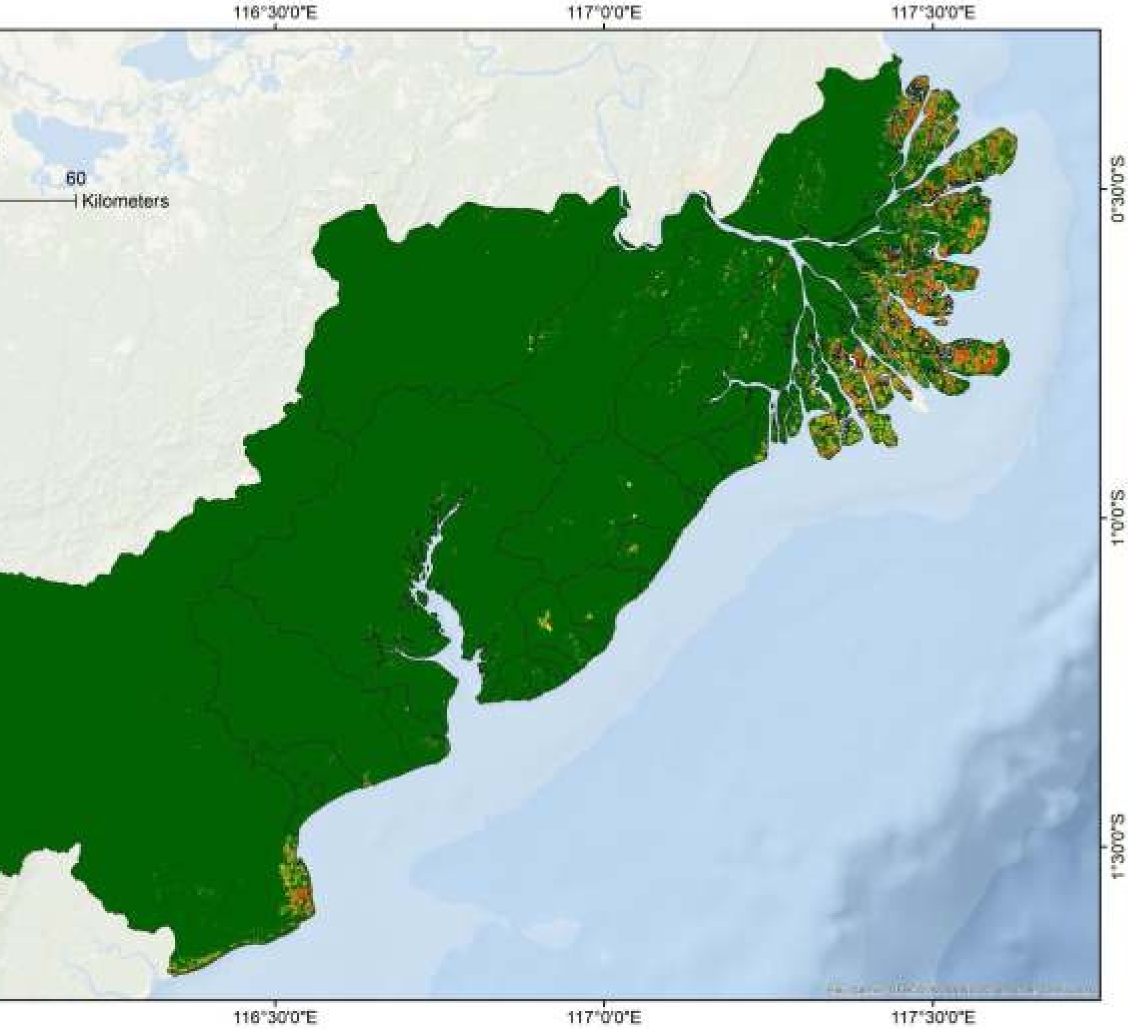


Figure 7. Water Inundation Susceptibility Map of Watersheds Around the IKN Area

5 Toward Sustainable Landscape Transition

5.1 Efforts for Sustainable Landscape Transformation

The world is changing to address the severe environmental degradation caused by unsustainable economic development models. Furthermore, Nations have exhibited a growing awareness regarding the detrimental environmental consequences to embrace progressively sustainable development paradigms (Rosato et al., 2021). The SDGs emerged to support sustainable development to improve the quality of life of people without exploiting natural resources that exceed their capacity. The transition from reliance on natural resource extraction to non-extractive practices represents a significant shift in efforts aimed at contributing to SDGs. The preservation of forests and vegetation assumes pivotal significance in the realization of SDG 15 (Life on Land) and also contributes significantly to the attainment of SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 17 (Partnerships for the Goals) .

Mangroves in Babulu Laut
Photo credit: Ikrima Barrorotul Farikhiyah

The landscape of East Kalimantan has been subjected to significant changes due to the extractive activities of different actors in different forms, intensities, scales, times, and spaces. The recent addition of the mega urban development for the new capital city IKN has added complexity to these dynamics. Despite the considerable economic gains and advancements achieved through these landscape dynamics, it is important to acknowledge their significant toll on forest ecosystems. These ecosystems, essential for economic stability, livelihood systems, resilience, and biodiversity, have been adversely impacted. In response, governments and their collaborative partners have diligently pursued measures to enhance resilience and work towards the achievement of SDGs . The development of the new capital city, IKN, must promote sustainable landscape transformation to support urbanization in the IKN and beyond the planned areas. This is specifically important because East Kalimantan Province has committed to the transformation toward the Green Economy.

The planned development areas have adopted the Forest City concept to improve environmental quality and preserve social inclusivity . The Forest City strategically includes peri-urban and rural areas in city planning to minimize adverse impacts of urban development and strengthen reciprocal productive rural-urban linkages. In addition, agroforestry techniques have become alternatives for the rehabilitation of degraded lands. The landscape has a multi-functionality used to strengthen the linkages between rural and urban areas. Creating an agroecosystem landscape increases biodiversity and carbon stocks, improves wildlife habitats and ecosystem functions , and increases rural households' resilience . Meanwhile, restoring degraded lands, specifically peatlands, can reduce the risk of fire and other environmental-related disasters, create conservation corridors , maintain biodiversity gene banks for future purposes, and contribute to Nationally Determined Contributions (NDCs) for GHG emissions reduction.

The improved landscape stimulates low-carbon economic activities, such as ecotourism. The enhanced landscape holds the potential to catalyze low-carbon economic activities, notably in the realm of ecotourism. Furthermore, ecotourism characterized by responsible travel to natural areas, encompasses practices that actively conserve the environment, promote the well-being of local communities, and incorporate elements of interpretation and education . Based on Indonesian Presidential Decree Number 63 in 2022, the concept becomes one of the driving clusters in developing the new capital city to accomplish the IKN super hub. Ecotourism development at IKN focuses on the natural environment and traditional culture in natural areas to educate and raise awareness of tourists on the importance of conservation. In line with these ideas, nature-based and wildlife ecotourism are good ways to support national policy.

Ecotourism allows tourists to learn about the importance of biodiversity and conservation. Even though mass tourism only focuses on economic benefits and tourist satisfaction, it also increases tourist awareness of conservation and biodiversity. Ecotourism can provide alternative funding sources for conservation efforts, such as establishing protected areas and monitoring endangered species (SDG 15). Furthermore, it provides the experience of being in direct contact with nature, and even in wildlife activities, tourists can meet the animals in their habitat. Tourism can play a significant role when sustainably managed in fragile zones, conserving and preserving biodiversity and generating revenue as an alternative livelihood for local communities. Sustainable tourism development and its impacts at the community level can contribute to national poverty reduction goals, promote entrepreneurship and small businesses, and empower less favored groups, particularly youth, and women (SDG 1). The local communities' involvement in ecotourism management can reduce the dependency on extractive activities and enhance environmental protection and conservation. Successful long-term implementation of community-based tourism also requires significant community involvement and collaboration. However, climate change challenges tourism activities, specifically in tropical countries , due to intensified change-related disaster risks, such as floods, sea level rise, storms, extreme weather, and coastal erosion.

5.2 Implications for Wildlife Conservation

Wildlife is highly reliant on resource availability in the natural world. Additionally, it needs shelter, nesting sites, food, water, and a breeding location. The relocation and development of the new capital city lead to increased human activities, induce ecological disturbances and create human-wildlife conflicts (Distefano, 2005; Meijaard et al., 2011). The land cover change analysis indicated increasing lowland and mangrove forest fragmentations between 2000 and 2020. The forest fragmentations also limit the home range of wildlife (Rybicki and Hanski, 2013) which leads to a decrease in species' resource diversity (Turner et al., 2001), increases competition for the remaining resources, creates stress, and decline in fitness or quality of life (Burke and Nol, 1998). Meanwhile, inbreeding depression may develop due to less genetic variation in a small population, leading to local extinction of species populations.

Acknowledging the landscape system and planning appropriate wildlife conservation could avoid extinction, specifically for species facing a high risk of extinction due to habitat disruption (Fahrig, 2003). The Proboscis monkey and Orangutan have become threatened species in East Kalimantan. The estimated habitat was 3,521 km^2, of which up to 45% (1,579 km^2) were inside oil palm plantations, logging concessions, and industrial forest plantations (Wardatutthoyyibah et al., 2019) The estimation of East Kalimantan's Orangutan habitat was around 22,695 km^2, where 59% (13,359 km^2) were inside the logging concessions and oil palm plantations (Wich et al., 2012).

These wildlife habitats were outside of conservation areas. Therefore, the GoI regulated the conservation by establishing Essential Ecosystem Areas (KEE) to safeguard species outside of protected areas. Protected areas outside of conservation areas such as ecological reserves, natural conservation areas, and game reserves classified KEEs. These areas played a crucial role in sustaining the continuity of life by actively engaging in efforts to conserve biodiversity for the welfare of society and the overall quality of human existence. The primary objective of KEEs was to establish connections between areas with significant biodiversity values through the implementation of corridors. To promote wildlife preservation, the local government actively promoted the involvement of local communities, NGOs, and private sector participants. The participation was vital in ensuring the successful conservation of wildlife. Furthermore, the regulations on KEEs were governed by the Directorate General of Nature Resources and Ecosystem Conservation (Dirjen KSDAE). These included the Dirjen KSDAE Regulation No.P8/KSDAE/ SET.3/KUM.1/11/2016, which provided guidelines for determining wildlife corridors as essential ecosystems. The Director General of KSDAE Regulation No. P.5/KSDAE/SET/ KUM.1/9/2017 offered technical guidelines for determining high conservation value areas outside of Nature Reserve Areas, Nature Conservation Areas, and Game Reserves.

East Kalimantan has 12 and two KEEs in the planning stages and operational stages. The Wehea and Mesangat-Suwi Wetland KEEs in East Kutai to Berau Regencies have been established and are currently in operation. The

Mangrove Forest Ecotourism in Mentawir Village
Photo credit: Bekti Larasati

Wehea-Kelay KEE covers around 532,143 ha and is crucial habitat for Orang Utan, as stated in the East Kalimantan Governor Decree No. 660.1/K.214/2016. The KEE development plan involves the participation of various stakeholders, including the local government, central government, and private sectors. These private sectors include five logging concessions, one industrial plantation, two oil palm concessions, and one traditional organization responsible for overseeing protected forests. The Mesangat-Suwi Wetland KEE preserved the habitat of Proboscis monkeys *(Nasalis larvatus)* and Siamese crocodiles *(Crocodile siamensis)*, as stated in the Governor Decree No. 522.4/ K.672/2020.

The Ministry of Environment and Forestry proposed IKN's north and south sides wildlife corridors in PPU and Kukar Regencies. The corridor on the north side connects the Bukit Soeharto Grand Forest Park and several production forests. On the south side, the development plan links the Wein River Protected Forest, and Bukit Soeharto Grand Forest Park with different land cover types, including secondary forests and shrubs. To establish wildlife corridors above the highways, it is necessary to conduct a reclamation of the ex-mining areas and create canopy crossings. However, governments should anticipate the potential of illegal poaching, as the development of roads and public facilities may expose wildlife habitats. The necessity for heightened public awareness and consistent monitoring of protected species in the vicinity of the new capital city has attained a sense of urgency.

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Erlis Saputra

Erlis Saputra was born on 1 October 1980 in Pekanbaru, Riau province, Indonesia. He completed his doctoral degree from the Department of Human Geography and Spatial Planning at Utrecht University, the Netherlands. Since 2007, he has been a lecturer in the Department of Development Geography, Faculty of Geography, Universitas Gadjah Mada, Indonesia, where he focuses on and teaches urban geography, spatial theory, small city and archipelago development, and spatial and regional planning.

His passionate interest in the issues of human geography, development, and planning, means that more than working only on campus is needed for him. So in 2005, he co-founded the Institute for Regional Development Studies (IReDS), a development NGO. This organization has allowed him to combine theoretical perspectives, primarily developed in the academic environment, with empirical work in the field. His interest continues to grow in line with several issues he encountered during his research on tourism geography. In 2012, he co-founded Indonesia Tourism Watch (ITW), a tourism-based NGO. The combination of his position as a lecturer, his growing interests, and his activities in NGOs has led to many opportunities to work on projects and research with, for instance, the central and local governments of Indonesia, private sectors in development and resources exploration fields, international, national, and local NGOs, and local communities. He published in several peer-reviewed journals, books, and conference proceedings.

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Rosalina Kumalawati was born in Bantul Regency on May 4, 1981. She graduated from the Faculty of Geography, Regional Development Planning Study Program in 2003. She obtained a Master's degree from Physical Geography, Faculty of Geography, UGM in 2005. She completed education at the Doctoral level in Regional Development Planning for Disaster Mitigation from the Faculty of Geography UGM in 2014. Her research interest has been in Regional Development Planning since 2002 through BPKS UGM and PSBA UGM. From 2015 until now, he is still actively writing about disasters. In 2016, she cooperated with several agencies to conduct research related to disaster mapping. In 2017, she was involved in research and community service with the Peat Restoration and Environment Agency. Now, Rosalina Kumalawati is still active as a lecturer at the Geography Study Program, FISIP ULM Banjarmasin, South Kalimantan. She published Bunga Rampai Penginderaan Jauh (ITB, 2012), Pengelolaan Bencana Lahar Gunung Api Merapi (Ombak, 2014), Penginderaan Jauh Pemetaan Daerah Rawan Bencana Lahar Gunung Api Merapi (Ombak, 2014), Modul Pelatihan Pembangunan Infrastruktur Pembasahan Gambut Sumur Bor Berbasis Masyarakat (BRG, 2017). From 2021 to 2023, there will be collaborative research with the South Asian-European Joint Funding and Cooperation Indonesia-The Netherlands, BPN, and Word Bank.

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Puput Wahyu Budiman

Puput Wahyu Budiman is an Urban and Regional Planning Researcher at the Research and Development Agency of East Kalimantan. He graduated with a Bachelor of Engineering from the Faculty of Engineering, Brawijaya University, Malang, followed by a Master's Degree in the Department of Architecture and Planning at Gadjah Mada University (UGM), Yogyakarta. He has a wealth of research and development experience in the fields of Urban and Regional Planning, Sustainable Settlement and Geography Information System. His research interest is finding the living concept in the traditional settlement, spatial Housing patterns in local Communities, the relationship between human and their environment, and indigenous Community in living. He uses deductive and inductive approaches, mixed methods (qualitative and quantitative), and other tools to understand better the broader context of local, urban, and regional planning. As a planner and researcher, he focuses on finding the spatial concept in the local community to enrich the knowledge of sustainable development concepts.

Fitriansyah

Fitriansyah is a lecturer in management and business at the Faculty of Economics, Business, and Politics at Muhammadiyah University, East Kalimantan, Indonesia. He graduated with a Bachelor of Engineering from the Faculty of Industrial Engineering, Islamic University of Indonesia, Yogyakarta, followed by a Masters Degree in Management at Gadjah Mada University, Yogyakarta. Doctoral degree in Management Science obtained at the University of Mulawarman Samarinda. In addition, he obtained the Engineer Profession from the Faculty of Engineering, Mulawarman University, Samarinda. He has a wealth of teaching, research, and development experience in human resource management, finance, information systems, and governance, especially research related to job passion and talent. Apart from being a lecturer, he is also a bureaucrat or state civil servant and currently serves as Head of the Regional Research and Development Agency of East Kalimantan Province.

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