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SIPA
Sustainable Infrastructure Programme in Asia

A Report Synthesis

Road Impact Study on Ecosystem Services in RIMBA Ecosystem Corridor

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Road Impact Study on Ecosystem Services in RIMBA Ecosystem Corridors


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FOREWORD

In the last five years, people in the central Sumatra have been cheering up the newly constructed toll roads that they perceive to be a potential economic growth. The section of toll road connecting two important cities in Riau Province (Dumai-Pekanbaru)—and also the other sections between Jambi and Palembang (some section are under construction)—is believed to give a hint that the Government is determined to put the linear infrastructure into the list of National Strategic Project. Being in charge of the toll road building, the Ministry of Public Works and Public Housing (PUPR) and Agrarian and Spatial Planning/National Land Agency (ATR/BPN) have received a feedback— to be taken into account for ecosystem studies for the development of toll road infrastructure in the central Sumatra corridor containing— stakeholders' concern for wildlife habitat, including WWF Indonesia. The planned toll road sections seemed to be a delicate issue at the beginning as some of them pass through elephant and tiger habitat areas, yet eventually, it can be overcome— thanks to the decision that they made to build some animal bridge facilities through which wildlife still manage to make cross-section mobility. This approach is known as nature-based solutions (NbS).

NbS is a mechanism for mitigating the risks of road construction against natural disasters, animal-human conflict, building fragility due to harsh ecosystems, and disruption of people's access to natural resources for their daily needs. During a development planning process, NbS - such as building bridges that accommodate the movement of animals, is an important approach in accommodating the needs of development and conservation of natural resources.

Once the government decides to build an infrastructure facility, it must involve an environmental impact analysis (AMDAL) document. This means that there must be a feasibility study from an environmental perspective for a building right from its initial stage, which also applies to road development.

NbS is a mechanism for mitigation of the risks that are likely to be inflicted by grey development, especially road, so WWF needs to ensure that the NbS component is aligned in the National Long Term Development Plan (RPJP) planning through activities in the Sustainable Infrastructure Program in Asia (SIPA) project implemented in this study. In essence, the study departs from an effort to answer the question "How can a national strategic planning impact the ecosystem?" "What will change with the existence of this toll road in the future?"

"Road Impact on Wildlife Habitat and Ecosystem Services Study" was carried out through a collaboration between the Faculty of Geography, Gadjah Mada University (UGM) Yogyakarta, and WWF Indonesia supported by WWF US SIPA team, the Directorate of National Priority Infrastructure Project Planning and Development (P3IPN) of Bappenas, and the Organization for Economic Co-operation and Development (OECD). This document is a report synthesis containing the essence of the technical and scientific study report. Statistical data in a more detailed format of this study can be reviewed in the full version of the report.

We hope that this report synthesis can help policymakers and decision makers in understanding the impacts of linear infrastructure on ecosystems and wildlife. Chances are, there may be some imperfections in this report synthesis, and thus we encourage all stakeholders to share inputs and suggestions with us. (*)

Dr. rer. silv. Muhammad Ali Imron, S.Hut., M.Sc.
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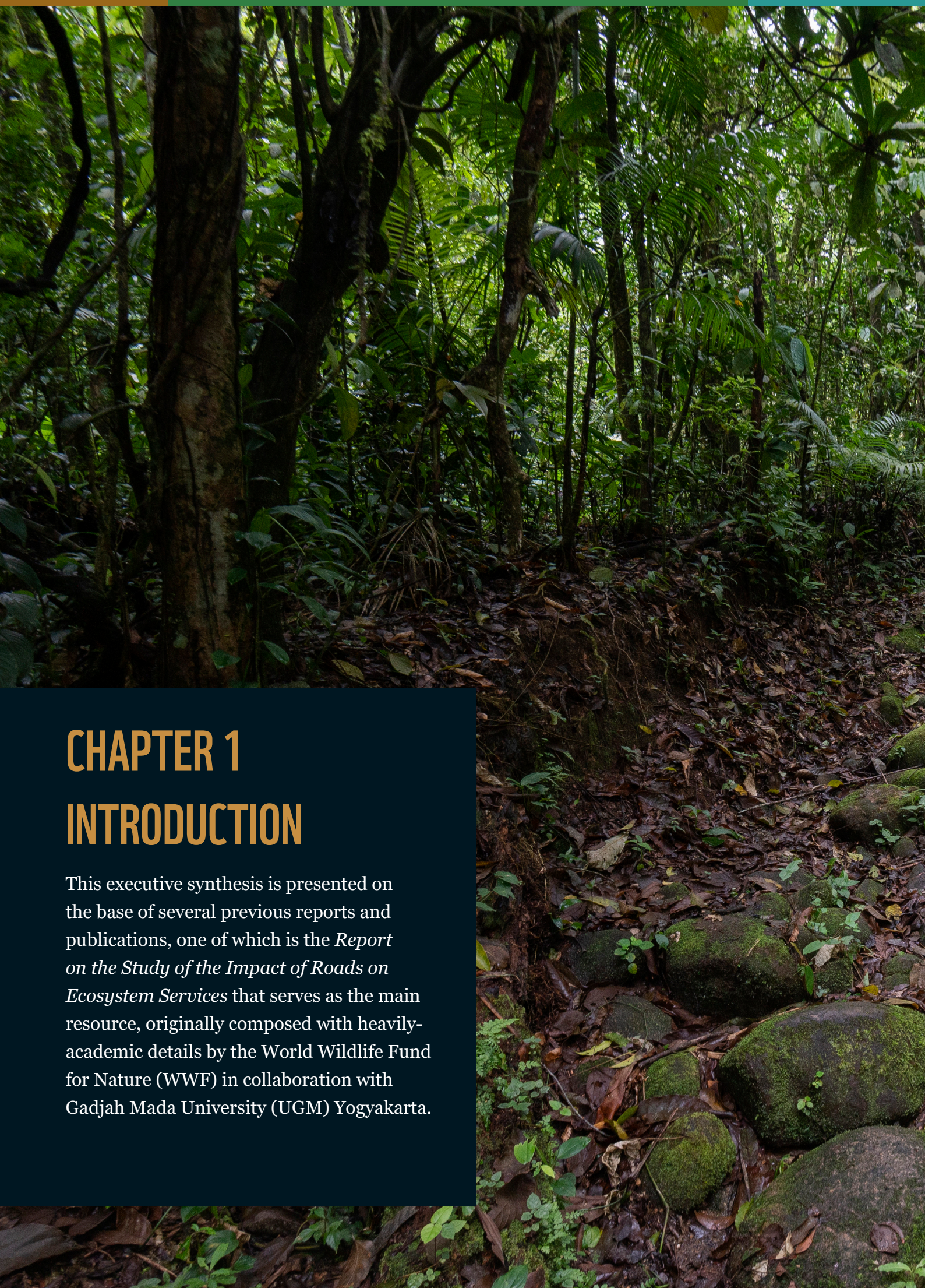

CHAPTER 1
INTRODUCTION

This executive synthesis is presented on the base of several previous reports and publications, one of which is the *Report on the Study of the Impact of Roads on Ecosystem Services* that serves as the main resource, originally composed with heavily-academic details by the World Wildlife Fund for Nature (WWF) in collaboration with Gadjah Mada University (UGM) Yogyakarta.


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The joint study report overall contains the results of a field study

on the impacts that the road network development has made against the elements of natural capital and ecosystem services in the Ecosystem Corridor of Riau-Jambi-West Sumatra (RIMBA).

It is unarguably that the construction of the road network by the Government of the Republic of Indonesia (RI) is intended for regional development and encouraging economic growth.

On the other hand, this activity proves to spark impacts in the form of land cover changes. And in turn, this changing condition of land cover also creates chain excesses to animals' habitat ecosystems as well as to natural capital and ecosystem services. The animals' habitat ecosystem— which was previously intact, expanding as a whole to certain extents— has now become fragmented. The quality and quantity of natural resources and ecosystem services—especially in the form of groundwater catchment and carbon storage— experience severe degradation.

This report synthesis underlines a main message that the development of transportation infrastructure in the form of toll roads and national (non-toll) roads for the sake of economic growth in Sumatra must also provide space for the realization of two important factors to ensure a balanced sustainability. First, the preservation of the natural habitat ecosystem of animals (especially tigers and elephants). Second, the sustainability of natural capital and ecosystem services, more specifically in the form of water catchment capacity and carbon storage in the watersheds— sustained by three major rivers of Batanghari, Kampar, dan Indragiri— of the RIMBA Ecosystem Corridor.

This synthesis is recomposed in a concise format and popular manner, consistently focuses on the subject matter, displaying only relevant data. It is also enriched with supporting illustrations, mostly in simplified infographic version to make it attractive and to help readers of various stakeholders easy to capture the essence of the message without reducing the substance.

This brief report is presented to stakeholders, especially those who hold a decision-making position in several fields— road network infrastructure, regional development, economic growth, and ecotourism expansions. All of these activities have posed excesses to the preservation of habitat ecosystems for tigers and elephants, and also to the preservation of ecosystem services within the Ecosystem Corridor of RIMBA watershed.

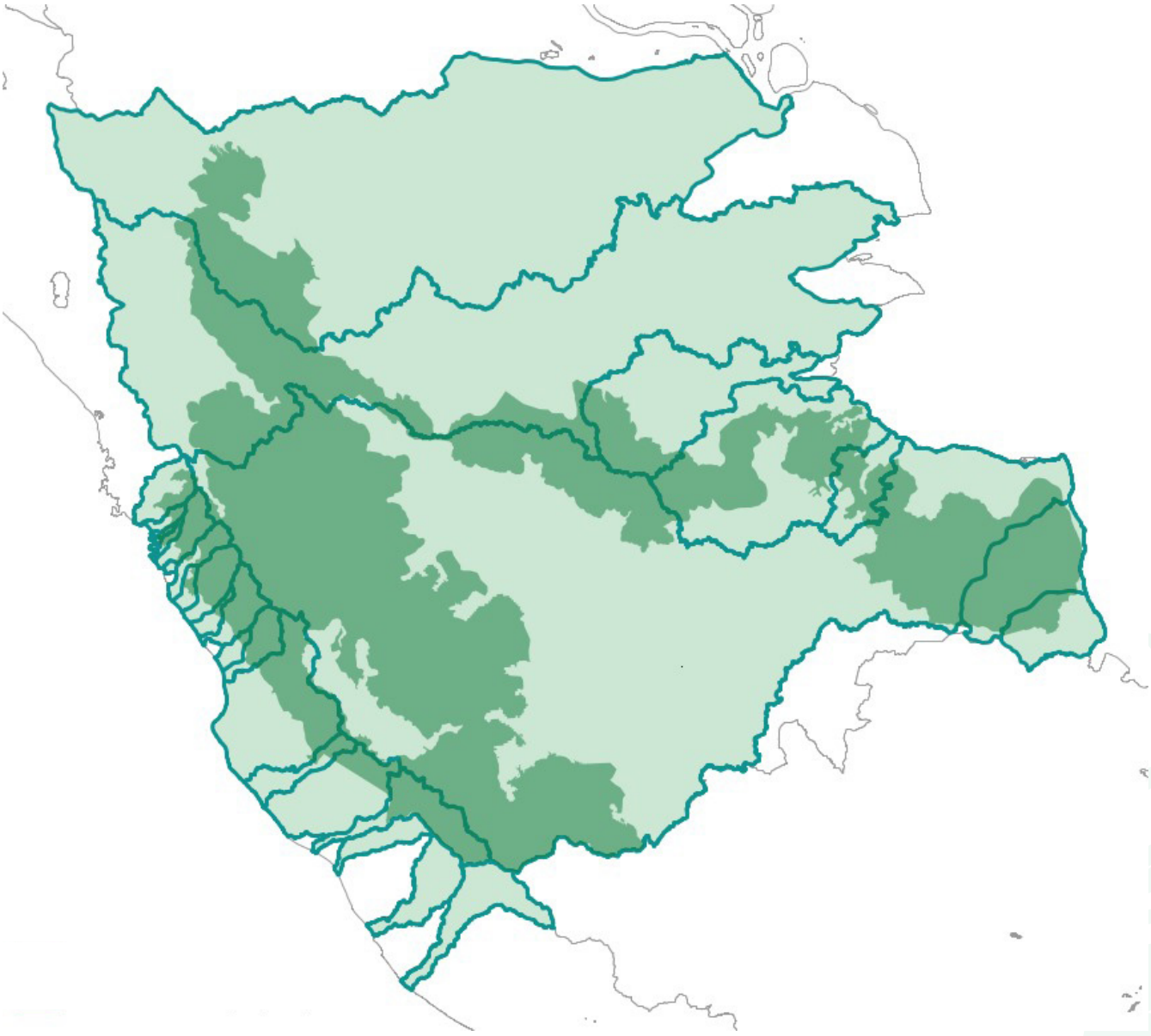
The government's program to build the economy through regional development and tourism in Sumatra is understandably important provided that such goals will not cost harms to ecosystem services or natural capital in the island. Despite the ongoing developments of infrastructure, Sumatra's natural ecosystem must be acknowledged, preserved, and managed under strong regulation and system. Efforts have been made by the Government of Indonesia to save wildlife's habitat ecosystems as well as the natural capital and ecosystem services in Sumatra. A *Presidential Regulation (Perpres) Number 13 of 2012* was launched, explicitly directed to regulate the regional spatial plan (RTRW) for Sumatra, stating that development plans in regions with potential natural resources are able to serve as a protective function of ecosystem corridors— one of which is the RIMBA Ecosystem Corridor— for wildlife, particularly tiger and elephant.

Beside endorsement from the President, the RIMBA Ecosystem Corridor has also received legitimation from the Ministry of Public Works (now the Ministry of Public Works and Public Housing, PUPR) in 2007, in the form of 3.9 million-hectares managing area. This implies that the Indonesian Government actually cares about nature conservation by promoting the initiative to build ecosystem corridors. Apart from the RIMBA Ecosystem Corridor, there are four other ecosystem corridors that the Government has initiated.

For Indonesia, the RIMBA watershed holds very valuable natural resources and ecosystem services; besides also serving as a home for elephants and tigers whose preservation must be maintained amidst the active construction of highways and toll roads that crossing several regions in Sumatra island.

The landscpae of RIMBA watershed is administratively located in three provinces: Riau, Jambi and West Sumatra.

Rimba Ecosystem Area (Watershed)



Ecosystem Corridor RIMBA

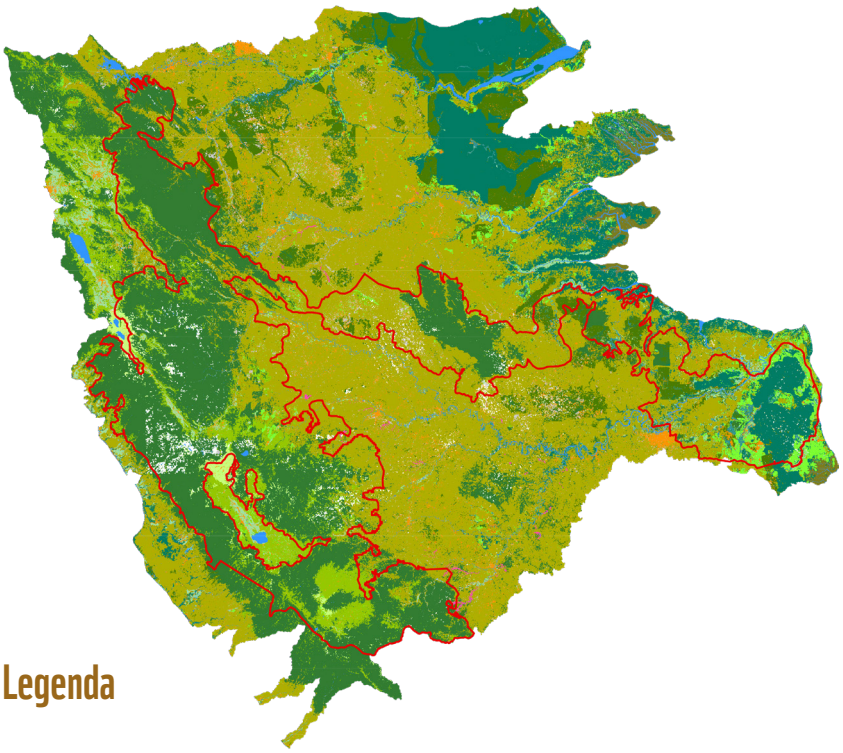
Rimba Ecosystem Area (Watershed)

As to the RIMBA Ecosystem Corridor, the Government intends to set it with a function to maintain interconnection among the wildlife's safe havens which have been increasingly fragmented by the construction of road network infrastructure and regional development schemes.

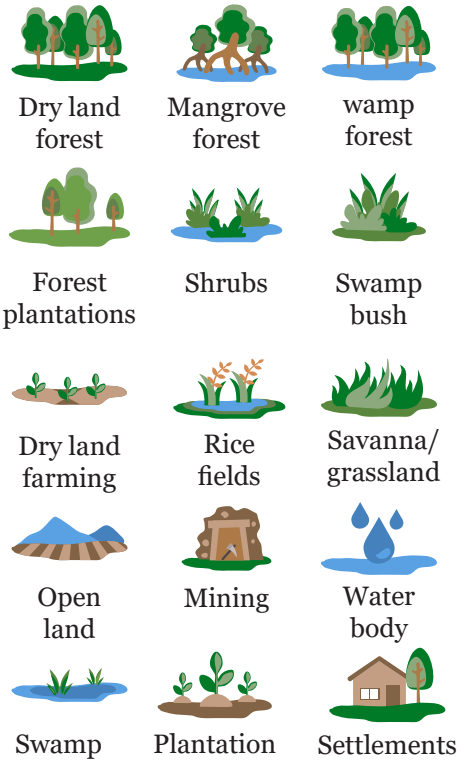
Sumatra is becoming a focal concern in this report considering that at the international level it has been regarded as one of the last buffer of relatively intact natural capital in the form of biodiversity, which is only partly true. As a matter of fact, the reality in the field about Sumatra shows a contrasting picture of a critical condition.

Regional development programs in the name of economic growth— including infrastructure development in the form of road networks and settlements— have forced tigers and elephants to lose their native habitats and food sources. Of any other human activity, the infrastructure development serves as a driver of changes in land use in Sumatra with the most excessive impacts to the wildlife, the natural capital and the ecosystem services.

The campaign to save tigers and elephants in Sumatra is based on the fact that these two key species are iconic animals typical of the island. The Sumatran tiger, for instance, is currently the only remaining animal of the big cat family in Indonesia. Previously, Indonesia once had Javanese tigers and Balinese tigers, but the Balinese tiger was declared extinct since 1930, followed by the extinction of the Javan tiger in 1970. Economic development in the form of road network building, regional development, and new tourism destinations in Sumatra without regard to the quality of the ecosystem as a living space and source of life for tigers and elephants, has apparently caused counter-productive impacts. The narrow living spaces and increasingly scarce food availability for animals in the wild have led to more frequent conflicts between human against the wildlife.



Vegetation and land use in the RIMBA Corridor Area in 2020:



1. The largest number of plantations, precisely in the centre part of the RIMBA Corridor Area (4.87 million hectares)
   - The conversion of land into oil palm plantations is happening very massively, especially in Riau.
   - Oilpalm trees are even planted in swampy areas and steep hills.
   - Rubber trees are even planted on hills 900 meters high.
2. Second largest dry land forest (2.84 million hectares)
   - Stretches along the Bukit Barisan
   - Covers the Kerinci Seblat National Park Area, Bukit Rimbang Bukit Baling Wildlife Reserve, Bukit Batabuh Protected Forest, and Pangean Nature Reserve. Bukit Tiga Puluh National Park.
   - Forest area is decreasing, mostly because it has been converted into oil palm plantations.
3. On the east coast there are swamp forests (1.06 million hectares) and mangrove forests (0.096 million hectares).
   - Swamp forests are found in the areas of Zamrud National Park, Berbak National Park, Kerumutan Wildlife Reserve.

Natural functions of forests (regardless of type: dry land forests, swamp forests, mangrove forests):

- As a habitat for a variety of flora and fauna (including tigers and elephants)
- Storing carbon reserves
  Oxygen provider
- Guardian of land resources
  Natural water reservoir

Other functions of forest areas (economic):

- Tourism (camping, hiking, sports)
- Psychological therapy.

This discussion puts the issues on the Sumatran tiger and elephant's threatened fate in the future at the spotlight given that these two wildlife species are increasingly critical on the verge of extinction. The International Union for Conservation of Nature (IUCN) has made an alarming note in the last few decades by releasing a *Red List of Threatened Species* in which the Sumatran tiger and elephant are concerned. The root of the problem comes from the increase of human activities in pushing the physical infrastructure development— especially the road building— continue to expand to various parts of Sumatra.

Such circumstance has put Sumatra currently in the face of various environmental challenges coming from the increasing number of non-forest-based activities and other activities driven by economic motives. Conditions in the field currently indicate that the protected habitat areas have been fragmented and each fragment is isolated from one another. Thus, it is critical to promote new approaches to regional development that are effective in minimizing the impact of roads and other infrastructures crisscrossing the wildlife habitat.

In order to preserve Sumatra's remaining ecosystems, the Indonesian Government issued regulations on island-level spatial planning, an effort that needs to be appreciated, supported, and endorsed to be implemented. One significant hint of the implementation is the realization of habitat corridors to ensure reconnection among the save heavens serving as home ranges and provide living resources for tigers and elephants. Road construction, regional development, economic improvement, and development of tourist centres must be designed appropriately to reduce the risk of land conversion and their impacts against the remaining biodiversity and inter-connectivity of wildlife habitats on the island.

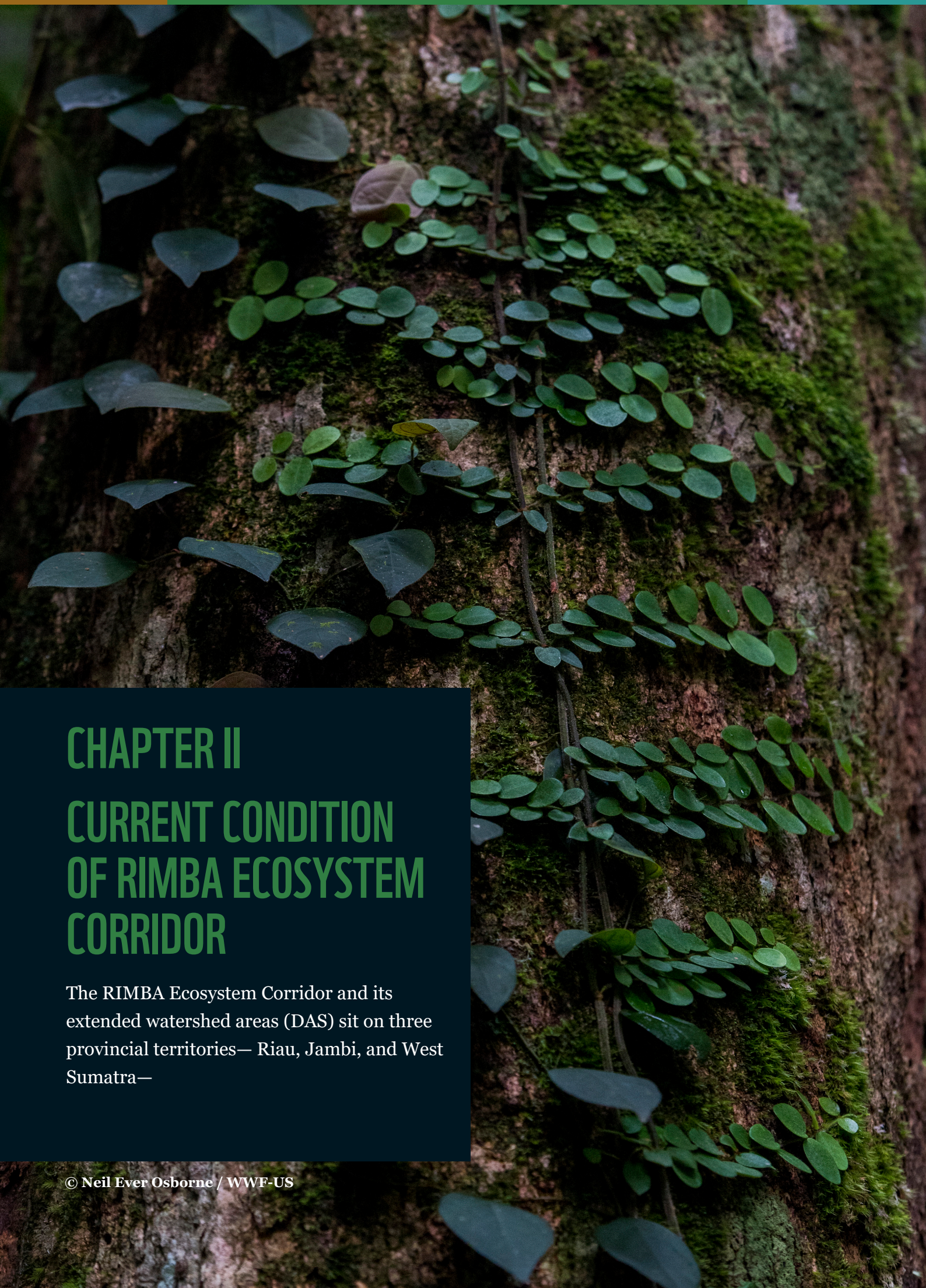
This study is expected to provide input for policy makers on regional development planning, economic development, ecotourism development, and environmental conservation activists.

The Government's efforts to build ecosystem corridors need to be encouraged by providing control over the use of cultivation areas and building settlements around the corridors, ensuring the environmentally-friendly infrastructure. Ecosystem corridor is likely to be opted to become a happy medium that provides benefits for all beneficiaries – namely humans, the environment, and animals (tiger and elephant).

Ecosystem corridor areas with intact quantity and quality are not only beneficial for the survival of tigers and elephants that live inside, but also for humans, especially the local community. Such areas will be able to provide capacity in the form of natural resources which serve as basic needs for humans—clean air, availability of fresh water, flood prevention, plant-based food sources, balanced temperature and climate, and beautiful landscape for tourist destination.

Thus, locations for infrastructure development, economic development, and development of tourist objects should be carefully chosen not only based on economic progress motives, but it also needs to take into account of aspects of ecosystem and environmental sustainability, and socio-culture as well. (*)

"The government's program to build the economy through regional development and tourism in Sumatra is understandably important as long as such goals do not cost harms to the ecosystem services and natural capital in the island."



CHAPTER II

CURRENT CONDITION OF RIMBA ECOSYSTEM CORRIDOR

The RIMBA Ecosystem Corridor and its extended watershed areas (DAS) sit on three provincial territories— Riau, Jambi, and West Sumatra—

and occupy some parts of four districts Kuantan Singingi, Tebo, Sijunjung, and Dharmasraya.

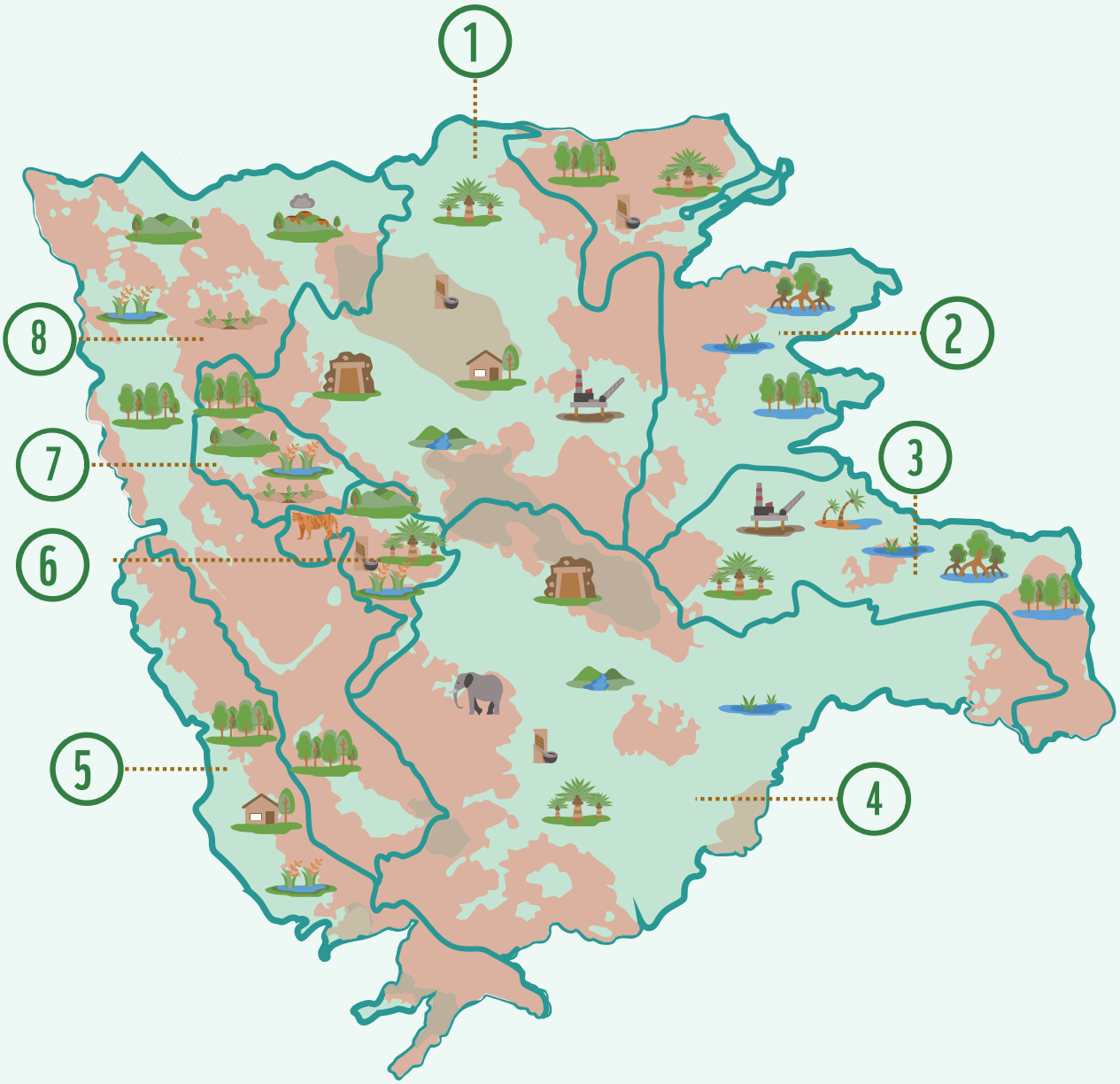
This study was conducted in the watershed area, focusing on tiger and elephant's habitats. It also pays a close attention to the geographical areas long serving as resources of natural capital and ecosystem services—

especially forest land and peat areas whose functions range from being a source of water, preventing erosion, storing and producing carbon, regulating local climate, and providing an ancestral living space and food resources for various types of native Sumatran animals.

There are several aspects that this study addresses on the impact of roads against mobility of wildlife (tiger and elephant) and against natural capital and ecosystem services in the RIMBA Ecosystem Corridor watershed. The study aims to assess the biophysical condition of the landscape. The results of the study are in the form of information concerning the dynamics of quality and quantity of the natural capital, ecosystem services and the wildlife habitat. This information is intended to provide references in the land planning process in Sumatra, serving as useful inputs in the decision-making process for climate change resilience-based development planning.

According to the Regional Infrastructure Development Agency (BPIW) of the Ministry of Public Works and Public Housing (PUPR) an ecosystem corridor functions as a part of a protected area and/ or cultivation area as a migrating route for wildlife, enhancing inter-connectivity among areas. As a core part of the watershed area, the RIMBA Ecosystem Corridor connects several watersheds that serve as living spaces for tiger and elephant, and at the same time it also has a conservation function for natural capital and ecosystem services.

DIVISION OF THE STUDY AREAS OF THE RIMBA ECOSYSTEM CORRIDOR (WATERSHED)



1 AREA 1

Kuantan Singingi, Pekanbaru, Indragiri Hulu, Pelelawan bagian barat.

The region is part of Riau, with a flat to gentl sloping topography, and many company and community-owned oil palm and rubber plantations. Many settlements are on the banks of large rivers. There are also oil and gas mines.

2 AREA 2

Indragiri Hilir dan Pelelawan bagian timur

It is a low-lying area on the east coast of Riau, with many swamp and mangrove ecosystems including the Zamrud National Park, and many oil palm and rubber plantations. The further east you go, the more swamp and mangrove forests there are, especially around river mouths.

3 AREA 3

Tanjung Jabung Timur dan Tanjung Jabung Barat

Enter Jambi, lowland and swampy topography, many smallholder oil palm, areca nut and coconut plantations in the west; swamp and mangrove forests on the coast, oil and gas companies.

4 AREA 4

Bukittinggi, Kampar, Payakumbuh, Solok, Solok Selatan, Tanah Datar, Sungai Penuh

Part of West Sumatra, hilly and mountainous as well as slopes, active volcanoes Mount Marapi and Mount Kerinci, many wet and dry land farms, sparse plantations, adat forests, protected forests, and national parks.

5 AREA 5

Pesisir Selatan, Muko-Muko

Enter West Sumatra, a sloping topography on the west coast of Sumatra Island, with many wetland farms, settlements and forests in Kerinci Seblat National Park.

6 AREA 6

Dharmasraya

Enter West Sumatra, hilly, bordered by Bukit Batabuh to the east; some pockets of tiger habitat, wetland agriculture and plantations (palm oil and rubber) in the valley, forest in the hills.

7 AREA 7

Sijunjung

Part of Riau, hilly to gently sloping, karst topography. In the valley, wetland agriculture is practiced. The highlands are still forested. Between the highlands and lowlands is dryland agriculture.

8 AREA 8

Merangin, Bangko, Bungo, Tebo, Batanghari, Jambi

Enter Jambi, with a sloping topography, many rivers and swamps, bordering Bukit Tigapuluh as an elephant habitat enclave, many community-owned oil palm and rubber plantations, coal and gold mines along the river.

The State of Nature of the RIMBA Ecosystem Corridor, an Overview

The area of this study is located at the heartland of Sumatra where biodiversity once lavishly thrived but now withering away. The area was once intact has now turned fragmented. These changes not only cause severe impacts against the physical condition of the landscape, water availability and climate change; but also trigger impairment against tiger and elephant's living spheres.

The degraded quality and quantity of biodiversity in the central part of Sumatra are mostly owing to human activities and triggered increasingly by widespread development of physical infrastructure on a massive scale, conversion of forest functions (into oil palm and rubber plantations, industrial forest plantations, and unproductive land), illegal logging, and poaching. Apart from causing a change in forest function, such activities have also reduced and fragmented the forest areas.

During 1990 through 2015, Sumatra lost two-thirds of its forest area, especially in the lowlands. And from 1985 to 2008, the island experienced 500 thousand hectares conversion rate of forest land per year. This has caused damage to the physical condition of the landscape and posed critical impacts against the existence of wildlife— especially tiger and elephant— which depend on the habitat inside the forest areas containing natural capital and ecosystem services.

Most of the area where this study was conducted originally used to be natural forest areas, which has now increasingly turned into plantations which continue to expand from year to year. The geographical location of Riau, Jambi, and West Sumatra along the Equator with optimum sun exposure and suitable climate helps the area become fertile ground for oil palm and rubber plantations. In every plantation area there are always buildings for residential and non-residential purposes. Fields of gold mining also can be found alongside rivers with wide expanses of sand along the banks.

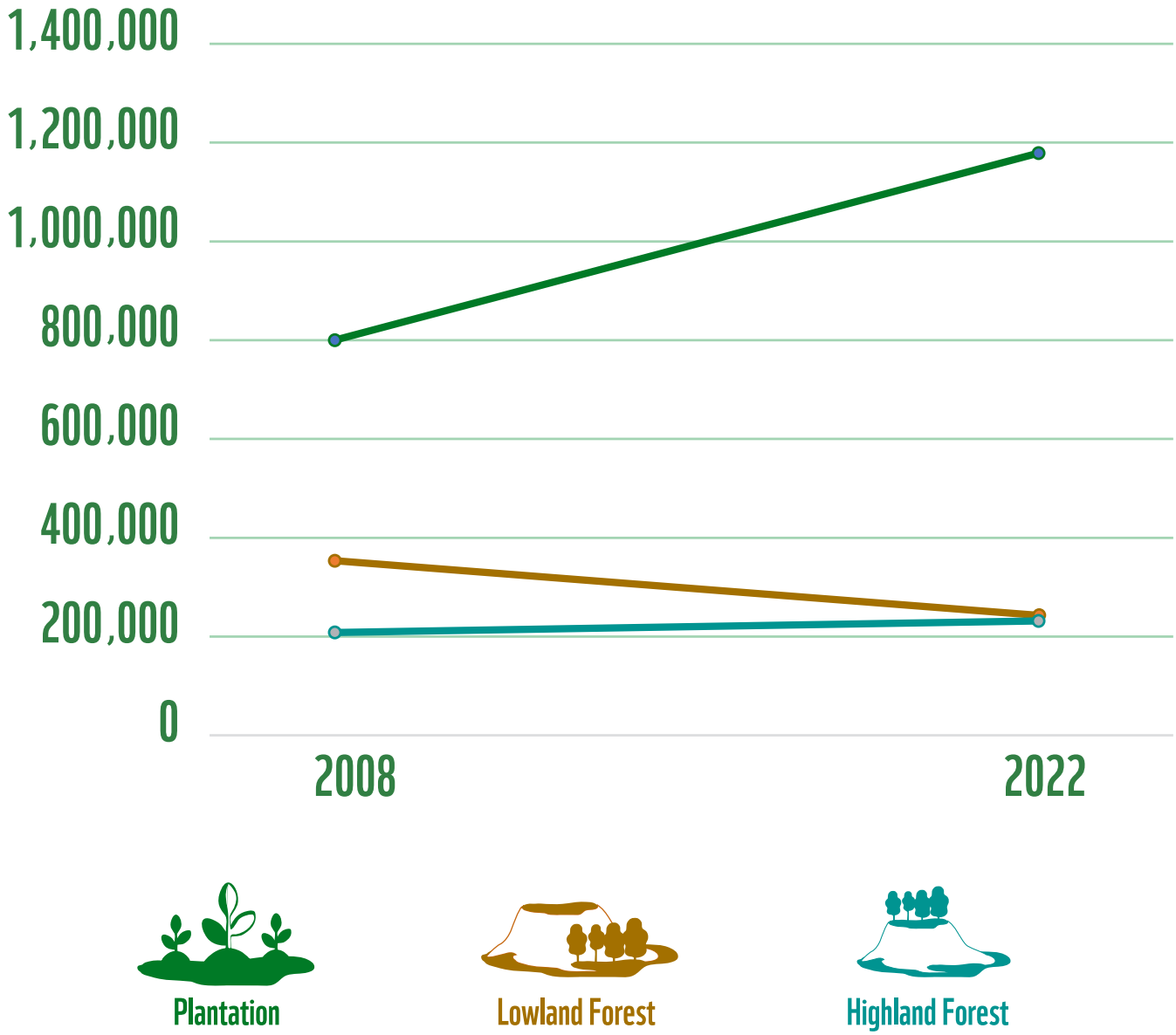
With the increasing amount of conversion of forest lands into plantations, the central part of Sumatra now only spares some natural forest areas, especially the hilly area in the district of Sijunjung, Dharmasraya, and Tebo. All types of forests— including mangrove forests that grow in coastal areas and estuaries— play a very important role as habitat for tiger and elephant, and at the same time contributing natural capital and ecosystem services (carbon reserves, oxygen, land protection, and natural water reservoir).

Potential Sources of Natural Capital and Environmental Services

The RIMBA Ecosystem Corridor watershed holds a high carbon production and carbon storage function, thanks to the natural capital and environmental services, especially in remaining forest and peatland areas. Carbon has the benefit of helping regulate the climate mechanism, especially to reduce global warming. The largest source of carbon on earth comes from above ground biomass (AGB) in lowland forest and highland forest.

A group of wild Sumatran elephants are tracked via a drone in the area of community Plantation Musarapakat village, Pintu Rime Gayo District, Bener Meriah Regency of Aceh Province

COVER AND LAND USE DYNAMICS LAND USE IN THE WATERSHED OF THE RIMBA ECOSYSTEM CORRIDOR IN 2008 AND 2022



LAND COVER	2008	2022
	HECTARES	
Industrial and commercial buildings	0.63	720
Non-residential buildings	57	453
Residental	16,218	41,335
Lake	433	359
Rock overlay	55	485
Lowland forest	353,554	243,095
Highland forest	207,998	232,331
Field	59,721	1,953
Open field	125	4.638
Grassland	1,214	1,766
Plantation	873,513	1,166,758
Mining	0.65	11,464
Swamp	3,180	5,114
Rice fields	24,836	20,074
Shrubbery	211,724	19,581
River	13,247	16,128
Other water reservoirs	289.98	458.12

The continued increase of human activities— road construction, plantations, illegal logging, and settlements— in and around the Ecosystem Corridor RIMBA has an impact on changes in the quantity and quality of forest vegetation and peatlands. This results in the decrease of carbon production and carbon storage capacity (carbon loss). The report on the study predicts that total carbon storage in the RIMBA Ecosystem Corridor in 2030 will drop by 8.2 million tons to become around 150 million tons.

A global scheme is usually used to help capitalize the capacity of carbon production and storage in an ecosystem. As an illustration, on the basis of average land value, ecosystem in Kuantan Singingi is eligible to acquire some IDR 159.2 billion— the highest figure compared to that in Sijunjung, Dharmasraya and Tebo— for its carbon production and carbon storage per hectare. Apart from carbon, hydrology is also an important element when it comes to natural capital and ecosystem services. In the RIMBA Ecosystem Corridor watershed, the hydrology system is naturally sustained by the three major rivers— Batanghari, Kampar, and Indragiri. Hydrological analysis is not only seen from quantity, but also quality.

Water quality generally differs from upstream, middle, and downstream terrains. The conditions in upstream river are typically better than in the middle and downstream, thanks to the land cover along the riverbank in the mountains or hills where the vegetation is still dense, diverse, and the interference of human activity is low. Southern part of Solok and most terrains in West Sumatra still have a lot of vegetation. Sitting on a height, the upstream river basins have many very steep cliffs and riverbanks which is uneasy for human to access.

The quality and quantity of vegetation alongside rivers also affect water capacity and quality in the watershed area. Upstream watershed still has a lot of vegetation cover, rivers still manage to produce large amount of water discharge to support living creatures within and around the watershed areas.

The river surface also remains intact, capable of accommodating large volume of water. The existence of the RIMBA Ecosystem Corridor on the Equator belt means that the watershed there receives large volumes of annual rainfall, which supports sufficiency of water supply.

Meanwhile, in the watershed areas in the middle and lower streams— where footprints of human interferences apparently can be seen from the presence of plantations, settlements, road construction, forest encroachment, and recently natural tourism— water in some rivers begins to look brownish, indicating they are suffering from pollutions. Apart from human activities, water pollution in the middle and downstream of the watershed areas is also triggered by erosion and sedimentation, as it can be seen in several rivers in Riau and Jambi.

The study on the natural capital and ecosystem services in the RIMBA Ecosystem Corridor watershed was not only conducted to evaluate its carbon and hydrological conditions, but also the geological state of the soil. There is a lot of peat lands in the eastern regions, downstream and in the form of swamps; but unfortunately most of the areas have been converted into oil palm plantations and production forests (*acacia*).

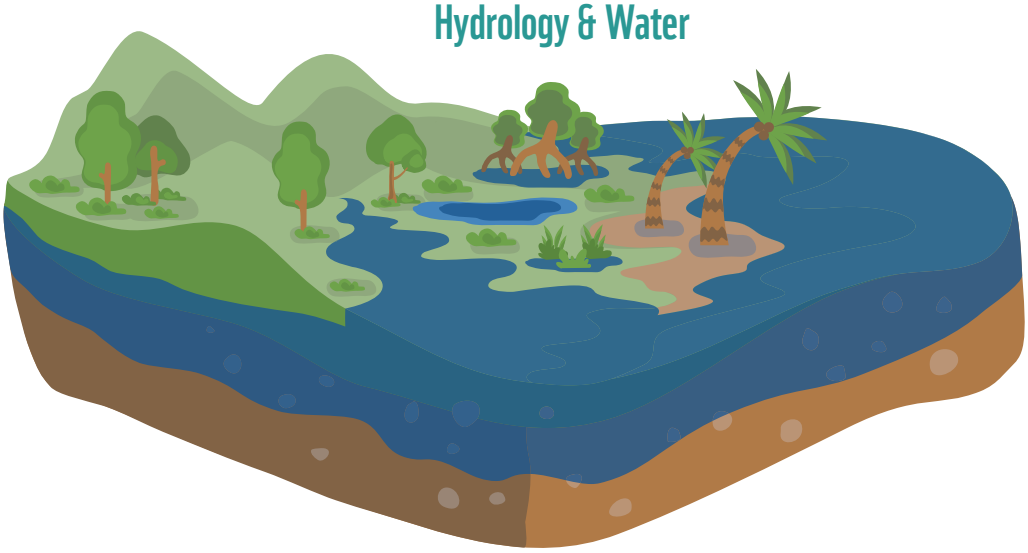
The Importance of Conserving Soil and Water System

Soil conservation, a treatment of each piece of land to be used according to the soil's capabilities, makes it possible to reduce the rate of erosion. Soil conservation has something close to with water conservation, implying that each and every treatment on a piece of land will affect the water system. Soil conservation is conducted as a means to reverse the current land use unsuitable with its natural purpose.

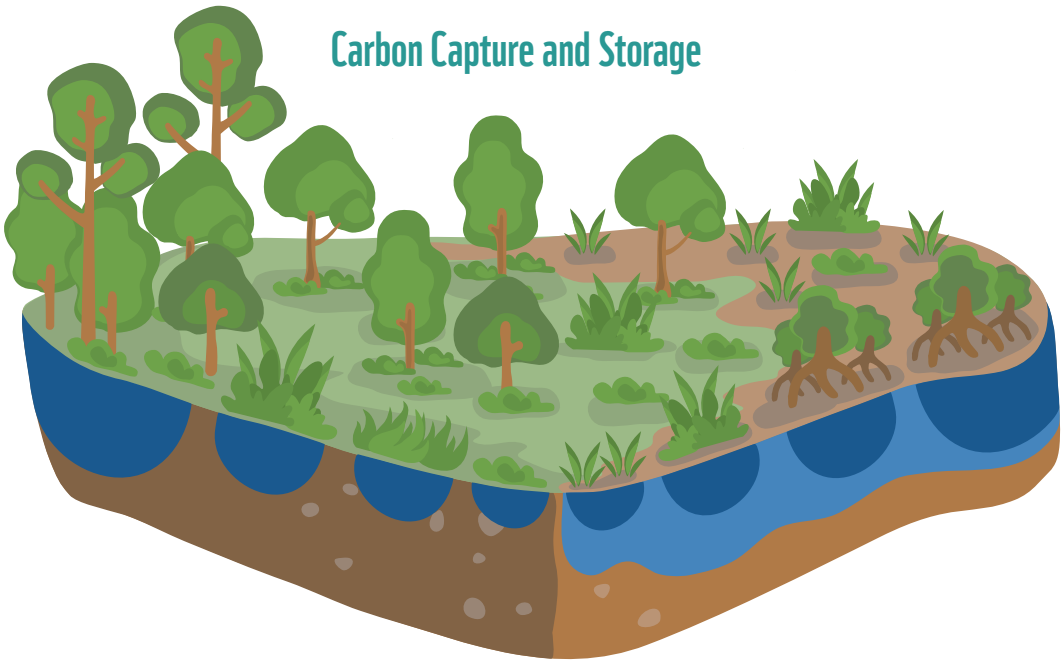
DIVISION
ECOSYSTEM SERVICES ANALYSIS

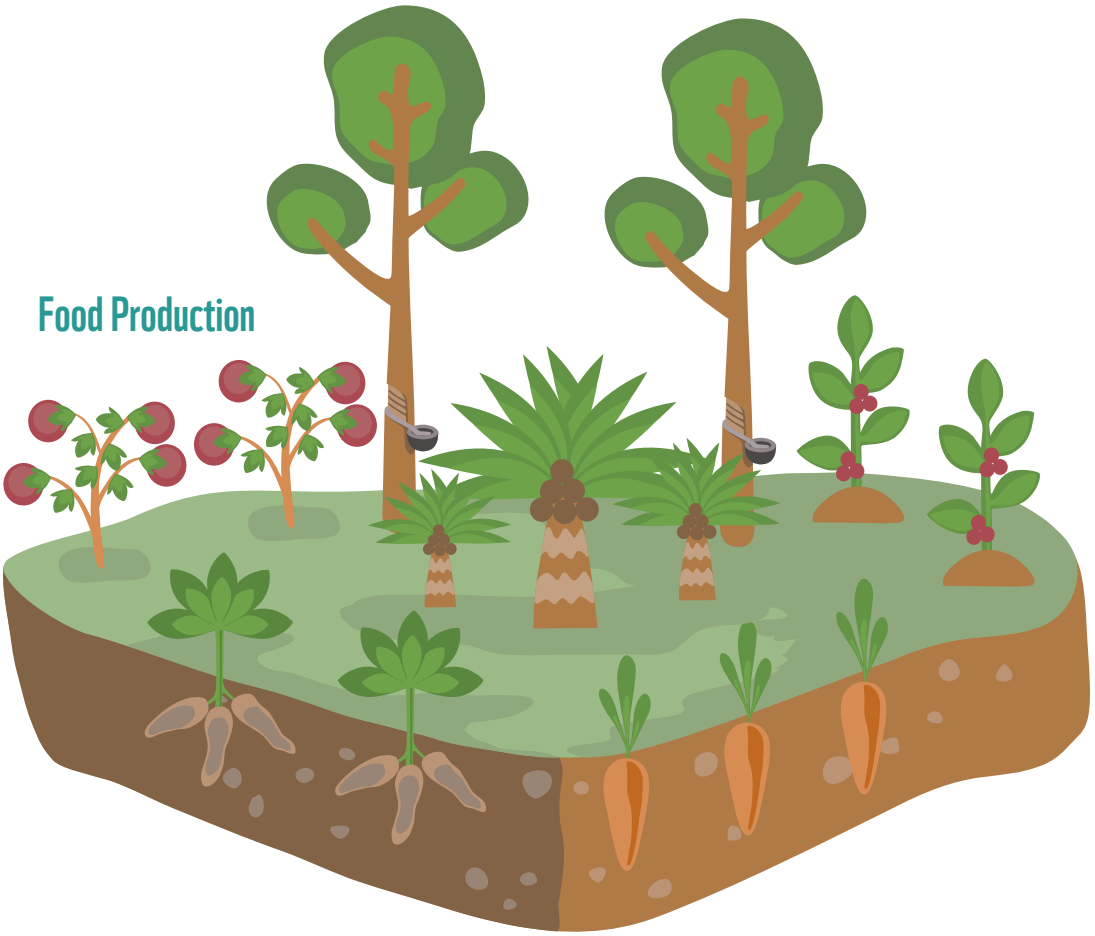
Some Key Elements of Natural Capital and Ecosystem Services within the RIMBA Habitat Ecosystem Watershed Area

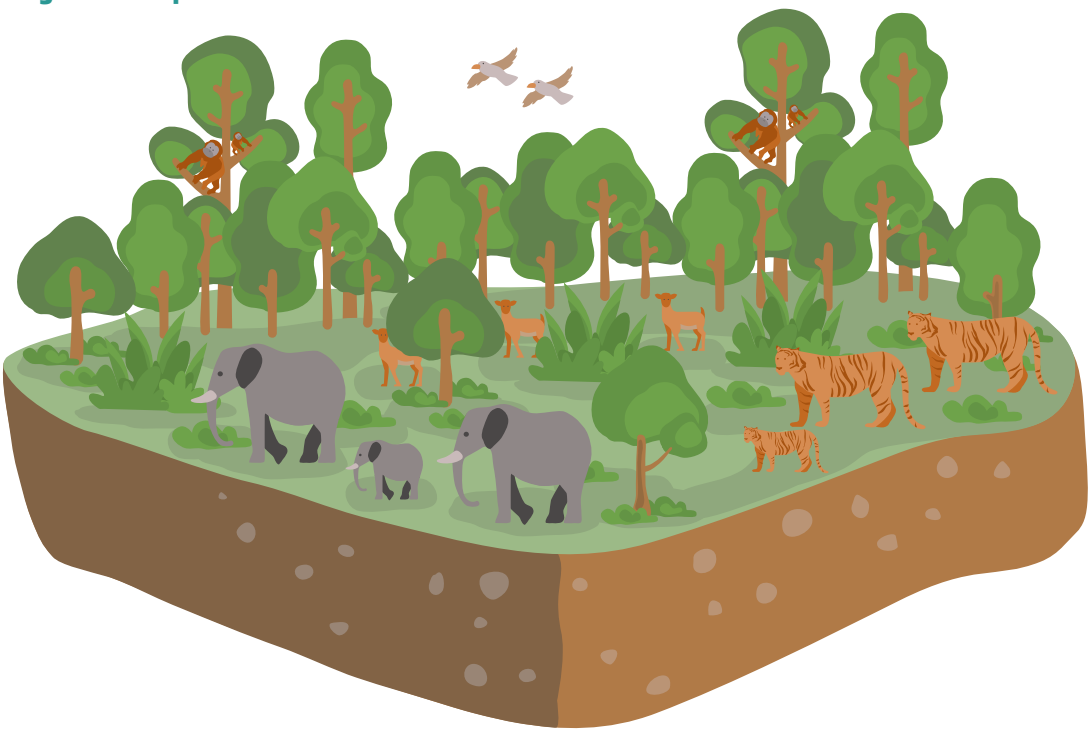
Hydrology & Water



Carbon Capture and Storage




Food Production


Tigers & Elephants

Watershed conservation needs to be made to restore deteriorating water quality so as to comply with quality standards, in accordance with the *Government Regulation (PP) No. 37 of 2012 on Watershed Management*, stating that watershed management activities are directed in order to restore the watershed's capacity in accommodating water system. In terms of volume, the mountainous areas in Sijunjung have lager volume of annual water storage than other areas do. In Kuantan Singingi and Dharmasraya the volume of annual water storage is medium, while Tebo is the lowest.

Based on the average annual water storage in 2022 in the RIMBA Ecosystem Corridor, there is a prediction that by 2030 the volume of annual water storage is likely to decrease. And in areas where water reserves are decreasing, there must be conservancy efforts to slow down water evaporation so as that the amount of water reserves will improve. Enriching vegetation types and improving vegetation density with trees replanting can help improve soil quality and water absorption capacity. This conservation step has the opportunity to fulfil one of the goals of watershed management, namely the increasing or developing water resources.

Elephant Habitat Ecosystem Conditions

Inside the RIMBA Ecosystem Corridor watershed there are several national parks, three of which are Tesso Nilo, Bukit Tigapuluh, and Kerinci Seblat officially designated to function as major wildlife habitat enclaves. Each enclave has different values of natural capital and ecosystem services. Tesso Nilo National Park and Bukit Tigapuluh National Park have moderate natural capital and ecosystem service values which are threatened to lose their crucial functions if there are no immediate mitigation measures to improve the quality of elephant's habitat.

The elephants' natural habitat has been fragmented into sizable estates, decreasing in size, and losing its sustainability due to human's activities that continuously converse forest lands into some other uses— plantations, settlements, and fragmented by

the construction of road networks. The lost forest areas in Tesso Nilo National Park and Bukit Tigapuluh National Park have caused water reserves to drop and encouraged land erosion. And when water availability decreases, elephants lose natural resources to support their daily needs for survival. Elephant has ability to choose their habitat carefully based on the availability of sources of foods and drink, as well as dense shrubs and trees for shelter.

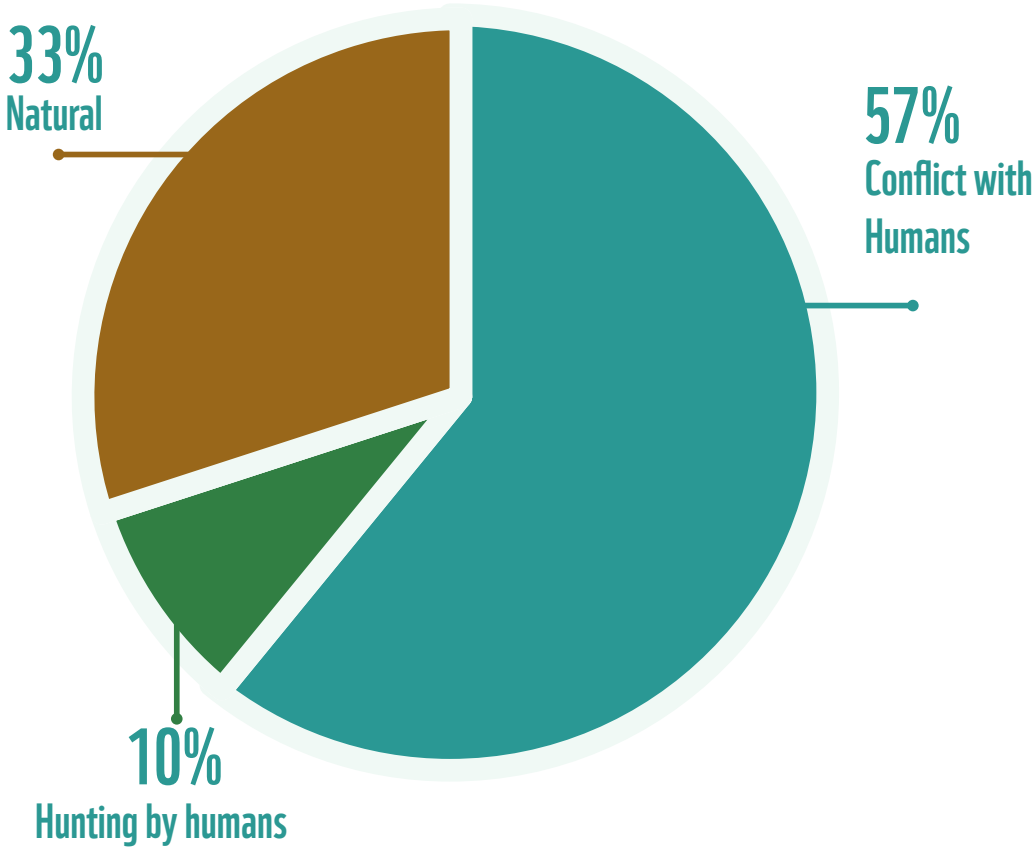
Elephants play an important role in the process of nature's stability. Elephants contribute to the high value of carbon stores in the forest, thanks to their habitual activity to explore their territories which indirectly help spread plant seeds. Elephants only eat young sprouts and plants within their trunk's reach, leaving alone the old trees to keep growing. Elephants play a key role in the wild, their existence indicates the quality of a certain ecosystem.

Condition of Tigers' Habitat Ecosystem

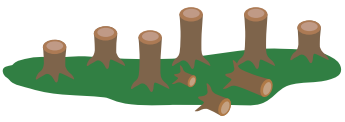
Sumatra serves the only remaining island in Indonesia where tigers survive. The island holds several enclaves of tigers' habitat, extending across several territories from Lampung in south to Aceh in north. Inside the area of the study (in central part of Sumatra), there are five main enclaves of tigers' habitats—Bukit Bukit Tigapuluh National Park, Tesso Nilo National Park, Kerumutan Wildlife Reserve, Berbak National Park. Bukit Barisan zone alone has several nature conservancies (Bukit Rimbang Baling Wildlife Reserve, Pangean Nature Preservation, and Kerinci Seblat National Park).

Tigers have much wider habitat ecosystems than elephants, owing to the big cats' physiological characteristics that help them easily adapt to living in terrains of various elevations, making it easier for them to find prey in a wider prowling range. Each individual tiger has its own home range with varied roaming range, depending on their sex and the prey population. The territories of adult males usually overlap with the territories of several females. Due to the large area of their home range, tigers often use concession areas around their habitat pockets to search for food or move from one habitat pocket to another.

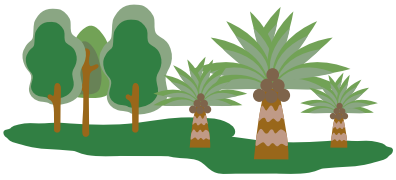
57% OF CAUSES OF ELEPHANT DEATH IS CONFLICT WITH HUMANS



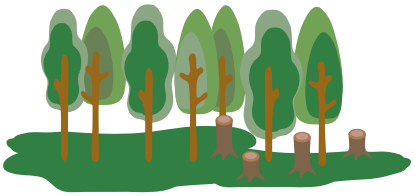
Human activities in the watershed of the RIMBA ecosystem corridor



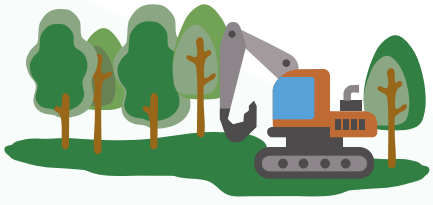
Illegal logging



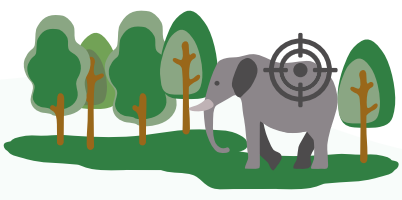
Converting forest areas into oil palm plantations



Converting forest area to plantation forest Industrial

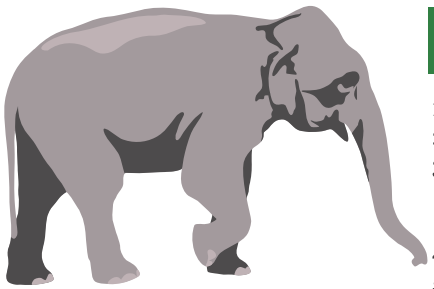


forest encroachment



Poaching

Settlement

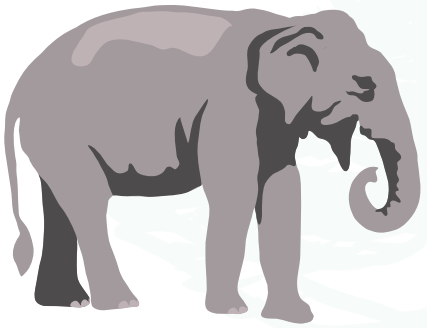


Elephant Facts I

1. In Sumatra, elephants are spread across 22 pockets in seven provinces.
2. Almost 80 % of elephant enclaves are outside conservation areas.
3. Of the 80 % of elephant enclaves outside conservation areas, 56 % are in commercial concession areas (plantations and industrial timber estates), without the protection of conservation laws.
4. The existence of elephants is under high threat.
5. The commitment and cooperation of various parties is needed to protect the remaining elephant habitat.

Elephant Facts II

Elephant habitats within the RIMBA Ecosystem Corridor fall within the administrative areas of three provinces



1. Riau
2. Jambi
3. West Sumatra

The highest risk elephant habitat ecosystem in the RIMBA Ecosystem Corridor is in the area:

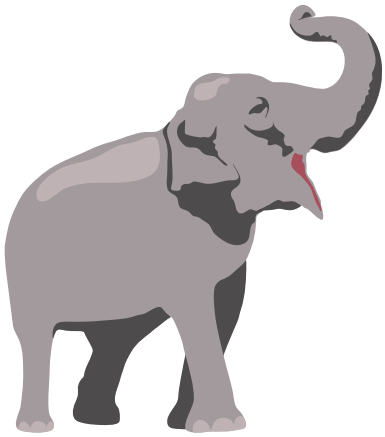
a.TN Tesso Nilo:

1. There is a former concession area with a network of roads accessing the area
2. Flat topography, making it easy for people to clear land
3. Most of the area has been converted from forest to plantation.
4. plantation

b. TN Bukit Tigapuluh:

1. Has a lowland tropical rainforest ecosystem
2. Rich in biodiversity; almost all species of flora and fauna on Sumatra Island.
3. Ranked as a top 20 global priority area for tiger conservation by species experts in 2006.

Elephant Facts III



Impact of human activities on elephant habitat :

1. Loss of habitat ecosystem area
2. Habitat area fragmented
3. Elephants' ideal living space narrows (elephants need large living space)
4. Availability of food vegetation for elephants decreases (elephants need a lot of food)
5. Damage to the quality of the habitat ecosystem
6. The availability of water in nature as a source of life for elephants is reduced
7. Elephants that lack food and feel less free in an enclave, will cross into the surrounding area.
8. Frequency of human-elephant conflict has quadrupled over the past 10 years
9. Elephant survival is compromised
10. Elephant reproduction also decreases (the age of active reproduction in elephants is influenced by environmental conditions, availability of food resources and ecological factors)
11. by environmental conditions, availability of food resources and ecological factors).
12. The narrowing habitat will also lead to interbreeding that damages the physical condition of young elephants.

A male tiger's territory usually lies side by side with that of their female counterparts. There are times, due to their capability of roaming wider range, when tigers breach the boundaries from one enclave to another on their way prowling inside concession areas close to their natural habitats.

The Bukit Rimbang Baling functions as one of wildlife reserve forests with a high level of ecosystem diversity, various types of vegetation, and precious natural capitals and ecosystem services. It serves as an important habitat for endangered and protected wildlife, including tigers. It also has received a global recognition to become a long-term priority area of the Tiger Conservation Landscape (TCL).

There is another enclave of tigers' habitat in Bukit Tigapuluh National Park, which is officially dedicated to becoming a conservation area. Administratively, the national park occupies a part of five districts in provinces of Riau and Jambi, namely Indragiri Hulu and Indragiri Hilir (Riau), Bungo, Tebo, and Tanjung Jabang (Jambi). This mostly comprises of forested area with abundant food sources to support tigers' life. The ecosystem services in this national park are in quite good condition with an important role as a rain water catchment basin. However, the quality and quantity of this national park continues to decline as a result of human activities which cause changes in land use from forests into monoculture plantations.

The presence of enclaves of tigers' habitat can also be identified in Pangean Nature Reserve (Sijunjung, West Sumatra). The condition of Pangean is characterized by the increasing number of changes where forest lands have been converted into plantations. As a result, vegetation recedes, water catchments decrease, erosion is high, and tigers' home ranges are crisscrossed into smaller acres. Similar conditions can also be identified in some other enclaves of tigers' habitat in Kerinci Seblat National Park and Tesso Nilo National Park.

The forest in Tesso Nilo National Park is apparently becoming the last remaining lowland tropical rain forest in Sumatra

today despite the fact that the forest in this area has won a wide recognition for being a representative of highland and lowland transition ecosystems that have high biodiversity.

The Kerumutan Wildlife Conservancy, located in Pelalawan and Indragiri Hulu (Riau), also provides a conservation function for tigers' natural habitat. This is the second largest conservation area in Riau after the Bukit Rimbang Baling. This conservation area comprises a great deal of swamp and mangrove forests, and is one of the five peat swamp ecosystem conservation areas in Riau. The quality of Kerumutan's ecosystem services is in quite good condition with capacity of supporting the life of the animals in it. This area plays a strategic role as a carbon storage, thanks to its being a wet and dry peatland rich of carbon.

Tigers' presence in their habitat enclaves are also found in Berbak National Park (Jambi). In the form of swamp and mangrove forests, this national park is a part of the Berbak Peat Forest Landscape. This national park is the largest wetland and swamp conservation area in Southeast Asia. Like Bukit Rimbang Baling Wildlife Conservancy, the Berbak National Park functions as an important habitat for tigers and has also become a long-term priority area in the TCL.

The quality of ecosystem services in the Berbak National Park area is in good condition as it manages to provide supports to the lives of the animals in it, especially tigers. Being a peat swamp, Berbak National Park requires tough challenge for people to access. With the absence of people's interference, the vast swamp and peat forest of Berbak remains as an important area for carbon storage. This national park has also become a part of the Reducing Emissions from Deforestation and Degradation (REDD) Plus scheme in Indonesia. Regulation of carbon storage in Berbak is one of the targets for reducing carbon emissions, as stated in *Presidential Regulation Number 61 of 2011 on the National Action Plan for Reducing Greenhouse Gas (GHG) Emissions*. (*)

CHAPTER III

INFRASTRUCTURE DEVELOPMENT INSIDE THE ELEPHANT AND TIGER HABITAT ECOSYSTEM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THE RIMBA ECOSYSTEM CORRIDOR HABITAT

01

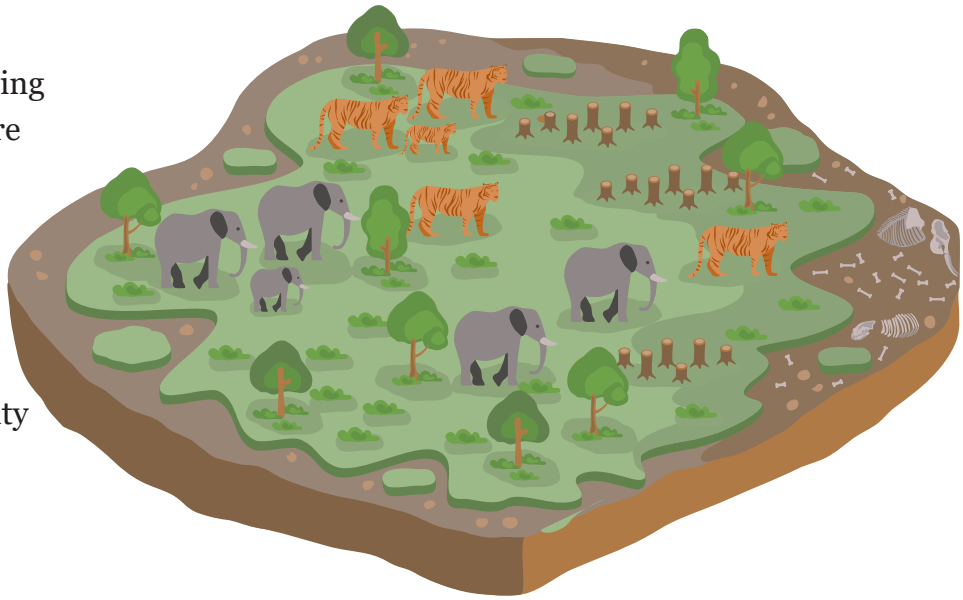
Some human activities are intended to develop the region and boost the economy: Infrastructure development of highway and toll road networks

1. Land clearing for plantation
2. Land clearing for industrial forest plantation
3. Land clearing for agriculture
4. Mining
5. Construction of physical settlement facilities

The impact of disrupting the existence of tigers and elephants in the RIMBA Habitat Ecosystem Corridor area:

04

1. Tiger and elephant populations are dwindling
2. Tigers and elephants are becoming endangered animals
3. Tigers and elephants eventually become extinct
4. Indonesia and the international community are losing the iconic Sumatran tiger and elephant.

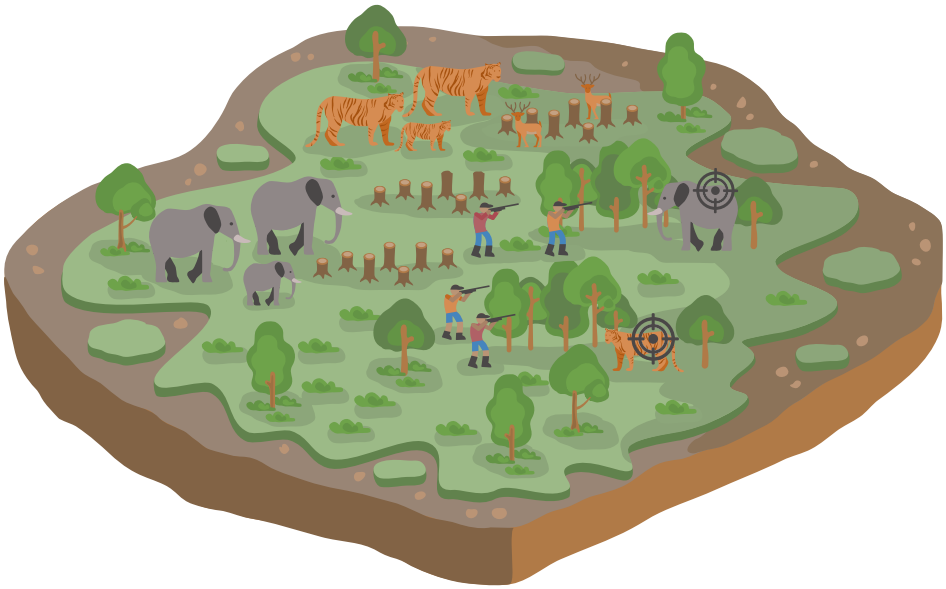


02

The impact of human activities that intervene in natural capital and ecosystem services found within the RIMBA Habitat Ecosystem Corridor area (natural forest, mangrove, savanna, river, peat):

1. Forest land fragmentation
2. Forest encroachment
3. Illegal logging
4. Poaching
5. Forest land narrowing
6. Narrowing of vegetation
7. Reduced rainwater infiltration
8. Flooding
9. Erosion
10. Silting of rivers and estuaries
11. Atmospheric warming
12. Forest and land fires

03



The impact of damage to natural capital and ecosytem services on the existence of tigers and elephants living in the Habitat Ecosystem Corridor area:

1. Living and roaming space narrows
2. Food sources are reduced
3. Reproductive activities are disrupted
4. Easy target for hunting
5. Conflict with humans increases

It was a morning in mid-February 2022 when an adult elephant crossed the Pekanbaru-Dumai toll road.

The incident took place at the administration of Pinggir Village, Pinggir District, Bengkalis Regency (Riau). An incident of an elephant crossing the toll road is just the tip of an iceberg. Behind this incident, there lie some more substantial facts which have forced the elephant to breach the perimeters and make its way into the toll road.

To be sure, the incident is one of the impacts that the newly-built toll road triggered against the quality and quantity of wildlife habitat ecosystems (elephants and tigers), and also against natural capital and ecosystem services.

The 131 kilometer-long Pekanbaru-Dumai toll road section was built on an area that was originally a habitat for elephants— as well as other Sumatran endemic wild animals.

The Riau Province Natural Resources Conservation Centre (BBKSDA) explained that the elephant crossing the toll road was one among 40 others inhabiting the Giam Siak Wildlife Reserve. It was believed that, when crossing the toll road, the elephant was on its way from Giam Siak to a neighbouring enclave at Balai Raja Wildlife Reserve. The elephant waded through the toll road as an animal crossing facility— built in the form of a tunnel under the toll road (underpass)— was at that moment being flooded during the rainy season.

Apart from the underpass at Km 72, the Government has also built four other animal crossing facilities in the form of underpasses between Km 61 and Km 74. Those five animal crossing facilities were built to ensure the interconnectivity of wildlife habitats from the Giam Siak Wildlife Reserve to the Balai Raja Wildlife Reserve, and *vice versa*.

The incident where an adult male elephant crossed the toll road also explains a subtler implication; that the existing animal crossing facilities that have been already built prove to fail to function properly. This reveals that in a situation where wildlife has lost its living resources, the conflict between animals and humans is almost inevitable, and even the frequency of conflicts is intensified in line with the increase in human economic activities (hunting, conversion of forests for plantations and agriculture, as well as the construction of several types of physical infrastructure, such as road networks, settlements, and recently, tourism has become more popular). Human activities inside animal habitats results in disturbance, destruction, fragmentation, and a sense of imprisonment.

Road Networks inside the RIMBA Watershed

Sumatra roughly has 13.7 thousand kilo meter-long road networks of various classes— arterial roads, collector roads, local roads, and other roads— some of which crisscross the Ecosystem Corridor of RIMBA watershed. Recently, several lengths of toll roads with highly-frequent mobility were built recently. The construction of toll roads is aimed at increasing economic growth and equitable regional development. The Government designates Sumatra to become one of the prioritized areas to boost trade to international scale. Sumatra's geography lends a gateway to regional cooperation and the ASEAN economic community to expand trade investment and diversified regional and global markets.

According to the Ministry of Public Works and Public Housing (PUPR), construction of the Sumatra toll road is currently covering 2.9 thousand-kilo meters long connecting Lampung at the southern part of the island, West Sumatra at the west coast, to Aceh at the northern part, and several other provinces in between. There are four sections of the toll road built across the Ecosystem Corridor of RIMBA watershed, namely Pekanbaru – Dumai section (131 kilo- meters), Jambi – Rengat section (198 kilometers), Padang – Pekanbaru section (254.8 kilo- meters), and Rengat – Pekanbaru section (205 kilometers). These four toll road sections have created further fragmentations in the RIMBA Ecosystem Corridor watershed, including the enclaves where tigers and elephants live.

Some types of roads— toll, arterial, collector, and local— that crisscross the RIMBA Ecosystem Corridor watershed are categorized as high-impact roads. This means that these types of roads have the potential to create high risks to the lives of tigers and elephants, as well as to the integrity and quality of natural capital and ecosystem services inside the watershed.

Meanwhile, roads categorized as “other roads” are regarded to be low-impact ones. In Riau and Jambi, road building is driven by plantation and mining activities, through which people travel to and from plantations and settlements. Between 2016 and 2022, the Government built several other roads through West Sumatra so as to connect the central part (Taluk Kuantan) to accelerate economic growth.

Road building has actually been conducted by taking into account of the necessity to make room for mobility of tigers and elephants living inside the wildlife enclaves of the RIMBA watershed. The five animal crossing facilities in the form of tunnels to create connectivity of each wildlife enclave can be regarded as a good example. On the road across the Bukit Batabuh, several animal crossing facilities were built by modifying the bridge under which there is a river, where tigers and elephants can cross and find water to support their lives. There are also ordinary pathways for people to pass, which at the same time also provide alternatives for wildlife mobility.

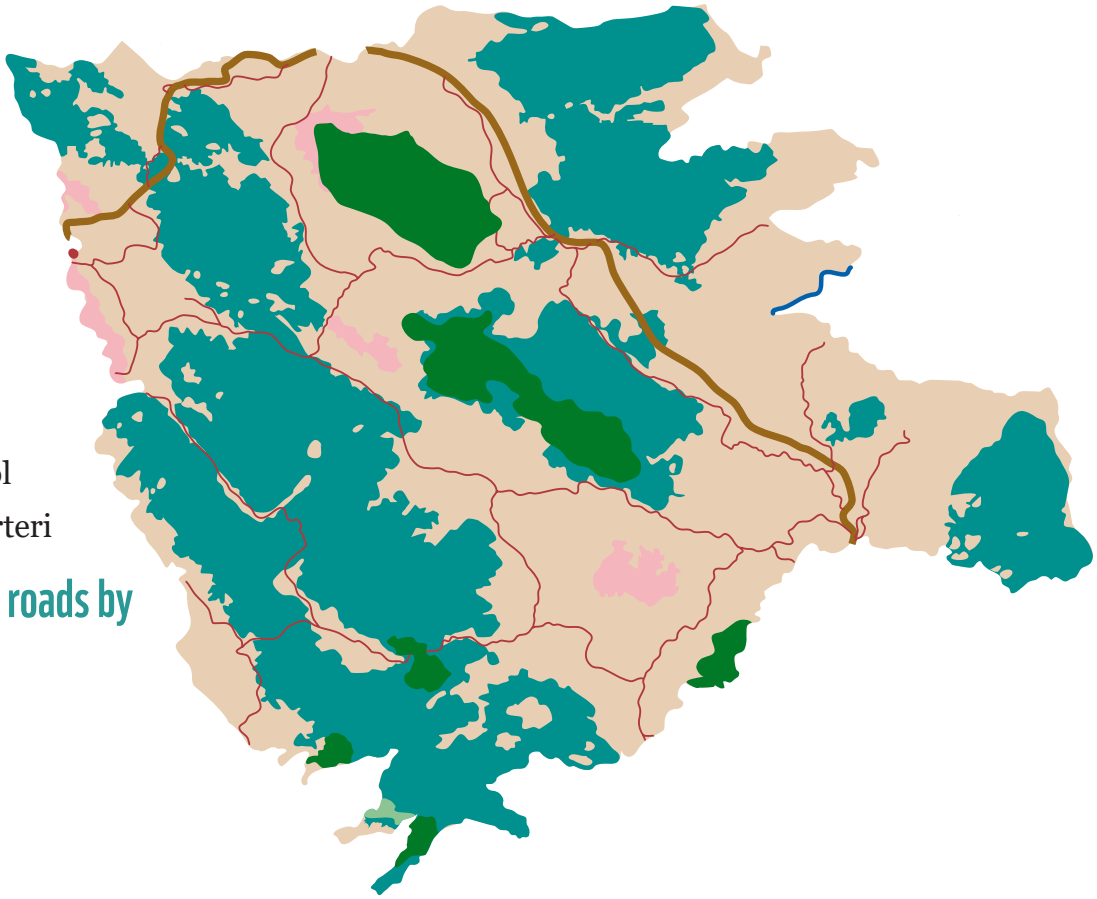
Elephants’ habitat inside the RIMBA watershed can be found in Kuantan Singingi and Tebo which condition is currently at high risk. An assessment on habitat ecosystem risk indicates that road networks— including that of “other roads” type which are described as road with the simplest construction— is a human activity that has created the highest risk to elephants and tigers’ habitats in the RIMBA watershed. The “other roads” type originally had a low frequency of motorized vehicle mobility which people used to transport plantation produce, and could only be passed by pedestrians or motorbikes. But over time, this type of road still makes it easier for humans to breach into the forest areas of the RIMBA watershed for illegal hunting. This type of road practically serves as a pioneer road that humans use to access into elephants’ and tigers’ habitat, which threatens the sustainability of the area.

Road Impacts against Wildlife Habitat, Natural Capital, and Ecosystem Services

The incident where an elephant entered the toll road in Bengkalis (Riau) empirically shows that the toll road network creates disruption of habitat connectivity and wildlife mobility, particularly elephants which in the past time enjoyed their freedom to roam the forest for food, protection, and breeding. Toll roads have established physical barriers for elephant movement, putting the animal as being confined within only a piece of land and unable to move to other areas. Limited habitat causes elephants, and even other wild animals, more vulnerable.

Road traffic and human mobility cause vulnerability against wildlife habitats; creating fragmentation over tigers' and elephants' living spaces and disrupting connectivity of one wildlife's habitat with another. Of all road networks in the four districts where the RIMBA Ecosystem Corridor is located, the paved roads— due to their traffic density, frequency, noise, and high speed of motorized vehicles— have the most potential to pose a greater threat to wildlife's mobility. Besides, wildlife creatures would rather pass through the simpler pathways made of clay where fences or other boundaries are not required, shying away from the high-traffic roads.

In such disturbing circumstances, forest becomes a type of land that is most vulnerable to suffer from use change by human activities in the form of illegal logging, clearing land for plantations or industrial forest plantations, constructing buildings for residential or non-residential areas, even expanding administrative areas. In turn, the land use change of forest triggers a decreased habitat quality, dying water reserves, lost carbon reserves, increased habitat risks, and rising amount of soil sediment and nutrient transport.



Jalan tol

Jalan arteri

Classification of roads by function

1. Expressway
2. Arterial road
3. Collector road
4. Local road
5. Other roads
6. Footpath

Classification of roads based on impacts on natural capital and ecosystem services:

High impact road, has a high impact:

1. Toll road (motorway): an expressway for four-wheeled vehicles or more and paid.
2. Trunk/primary arterial road: connects national activities with regional activity centers, most important as a means of community mobility.
3. Collector roads (secondary) connect cities between regional activity centers and local activity centers.
4. Local roads (tertiary): for local transportation vehicles.

Low impact road, has low impact:

1. Other roads: Special connecting function, with low mobility frequency.

The remaining natural forests rich in natural capital and ecosystem services in Sumatra are mostly located in the highlands, one of which is in Bukit Barisan National Park that happens to be a habitat of tigers. However, the conversion of natural forest land into other functions has reduced the quantity and quality of natural capital and ecosystem services in the region. The declining quantity and quality of natural forests can be seen in the four districts where some parts of the Ecosystem Corridor of RIMBA are located.

Almost 50% of Tebo administrative area where enclaves of tigers and elephants' habitats lie is in an environmentally-vulnerable condition. The existence of residential buildings turn to have the worst impacts against the quantity and quality of the habitat ecosystem. A large portion of forest have been converted into other land functions, which have been initiating conflicts between animals and humans.

Threatening risks against natural capital and ecosystem services also come from the fact that road networks have crisscrossed the forest areas once intact as a whole into smaller fragments. Any type of road also lend as an access for illegal hunting.

The conservation area in Tebo, apart from its crucial role as a home for tigers and elephants, also functions as a source of natural capital and ecosystem services—especially its capability of ensuring water supply. The conservation area in Tebo is a forest covering an area of 286.8 million hectares divided into several functions, including Bukit Limau Protected Forest, Bukit Tigapuluh National Park, Bukit Duabelas National Park, Bukit Sari Grand Forest Park (*Tahura*), Hulu Sekalo Limited Production Forest, Forest Sungai Sirih Limited Production Forest, Sungai Sragen Hulu Lake Bangko Limited Production Forest, Pasir Mayang Production Forest, Tabir Kejasung Production Forest, Batang Tabir Production Forest, and community forests.

The declining quantity and quality of habitat ecosystems inside the RIMBA watershed in Tebo was responded by the Regional Administration (*Pemkab*) with a decision to take steps to improve and preserve the ecosystem. The Pemkab of Tebo drafted the planning in the *Tebo Regional Medium Term Development Plan* (RPJMD). The RPJMD basically emphasizes the need for efforts to improve spatial balance in order to maintain the human needs and the ecosystem sustainability.

The declining quantity and quality of wildlife habitat and ecosystem services in forest areas is also taking place in Dharmasraya. A number of key stakeholders agree that this district needs to be prioritized in the cause to preserve its habitat conditions. Concerns on the condition of forests and ecosystem services in Dharmasraya can be seen, among others, from the *Decree of the Minister of Environment and Forestry (SK MENLHK) Number: 6599/ MENLHK-PKTL/ KUH/ PLA.2/ 10/2021 on Development Map of Forest Area Confirmation West Sumatra Province until 2020*.

The district has forest areas of around 81 thousand hectares, but 86% of them have been converted into production forest. The remaining 14% of the area still has to be divided into protected forests, national parks, and nature reserves. Public attention and concerns about the condition of the surrounding ecosystem also emerged in public consultations at the end of 2021 through which the public has basically been able to identify several environmental problems— degenerating water quality, low waste management capacity, and land (forest) conversion— in their area.

They agreed that such problems should be prioritized to find some viable solution to fix. The close social, cultural, emotional, and ecological bonds between Dharmasraya community and the environment in which they live have apparently been developing for a long time. This can be seen from the existence of traditional regulations that justify the Dharmasraya community to have management rights over two village forest areas, namely the Lubuak Karak (in Nagari Lubuak Karak) and Lubuak Simantuang (Nagari Gunung Selasih). Another traditional regulatory product that indicates the socio-cultural, emotional, and ecological closeness between the Dharmasraya community and the forest is the recognition of management rights over two customary forest areas, namely Rimbo Ubau and Rimbo Tolang.

DYNAMICS OF LAND COVER AND LAND USE IN THE WATERSHED RIMBA ECOSYSTEM CORRIDOR IN 2022-2030

Dharmasraya

Kuantan Singingi

Sijunjung

Tebo

LAND COVER AND USE	HECTARES			
	DHARMASRAYA	KUANTAN SINGIGI	SIJUNJUNG	TEBO
Industrial and commercial buildings	104	290	38	287
Non-residential buildings	19	56	50	328
Residental	9,883	13,279	4,908	13,262
Lake	18	329		12
Rock overlay	8	70	14	393
Lowland forest	41,224	83,922	55,628	62,269
Highland forest	25,234	35,570	152,617	18,862
Field	980	509	439	25
Open field	219	2,002	1,007	1,408
Grassland	358	342	274	790
Plantation	213,032	360,686	78,711	514,127
Mining	1,841	7,840	341	1,440
Swamp	2	806	297	4,008
Rice fields	3,624	3,639	11,425	1,386
Shrubbery	3,483	14,258	751	1,085
River	1,648	5,707	1,252	7,507
Other water reservoirs	18	313	62	64

Sijunjung is another district with some parts of its administrative territory falls into the RIMBA watershed. Over 50% of the district's administrative area is forest land with several functions and in several locations, including Pangian I and Pangian II Nature Reserve Forests, Protected Forests, Limited Production Forests and Permanent Production Forests. The communities hold customary rules governing the use of non-timber forest products. However, several forest areas in Sijunjung are currently under serious threat. Forest areas are declining, so is its capacity in providing resources of natural capital and ecosystem services within. With forest areas constituting 50% of the entire administrative area, Sijunjung has significant natural capital and ecosystem services, which require stakeholders' collaboration for salvation. Kuantan Singingi has a number of areas that have long served as habitat enclaves for tigers and elephants, and almost all of them are currently at high risk. Incessant activities to develop the economy have apparently changed the function of the wildlife's habitat ecosystem where dwelling sites, agricultural estates, plantation, mining fields, industrial hubs, and tourism facilities have defaced the forest lands.

In general, all tigers' enclave inside the RIMBA watershed (four districts) are at high risk. The uncontrolled conversion of forest land to other uses has been putting increasing pressure on animal habitats. Collaboration among core stakeholders in the efforts to improve the quantity and quality of tigers and elephants' habitat as well as natural capital and ecosystem services needs to be strengthened in order to encourage the ongoing conservation campaigns.

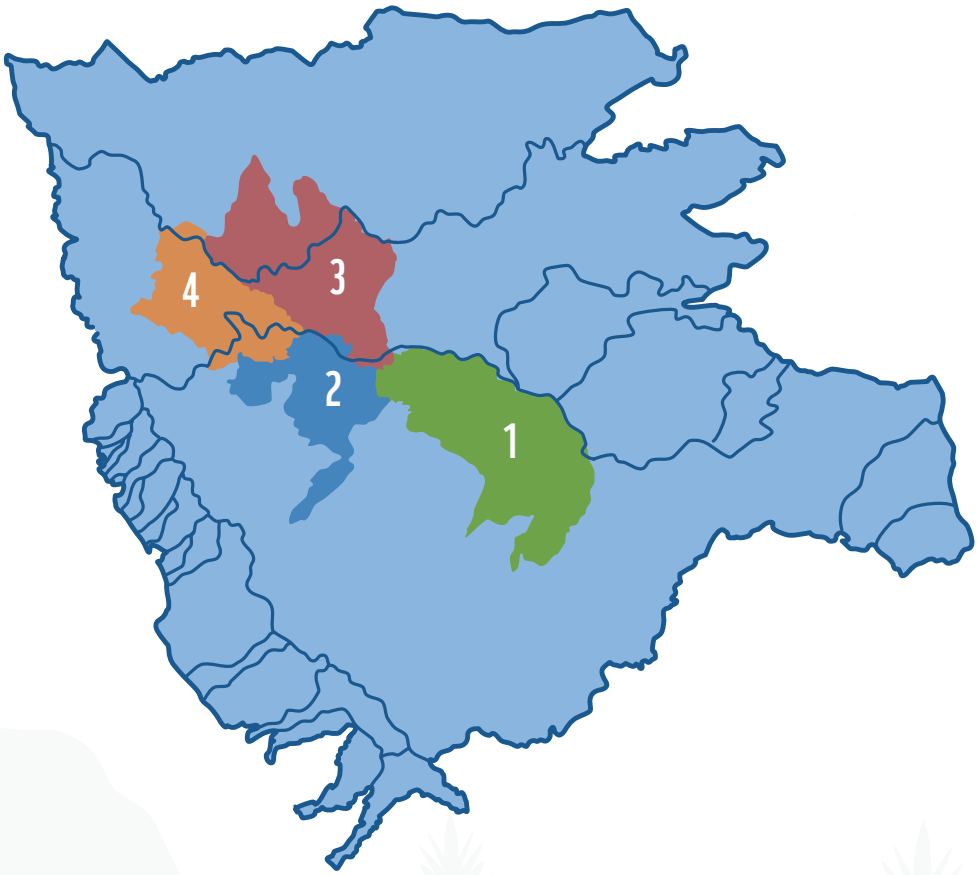
Of all human activities, road construction has the most negative impact against wildlife habitats. Road construction undoubtfully disrupts animals' activity and mobility, slicing the whole ecosystem areas, and creating boundaries among habitat enclaves. Thus, regional development must be conducted by taking to account of practices for preservation of the wildlife—tigers and elephants, natural capital, and ecosystem services—and help them from the threats of extinction.

Therefore, it is necessary for stakeholders to make conscientious studies on the road impacts against the ecosystem habitats of tigers and elephants which have been drafted in the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN). Moreover, there must be bold initiatives to ensure that the positive impact of development is not only in the form of benefits for the economy, but also for environmental sustainability.

In Indonesia, the preservation of Sumatran tigers is supported by strong legal basis, including the *Presidential Decree 13/2012,* and *Minister of Forestry Decree P. 42/2007 on Strategy and Action Plan for Conservation of the Sumatran Tiger* (*Panthera tigris sumatrae*) *2007 – 2017.* It is implied that the central section of Sumatra is designated as a connecting corridor of several conservation areas, namely Bukit Tigapuluh National Park (in the east), Rimbang Baling Wildlife Reserve, Kerinci Seblat National Park, Batanghari II Protected Forest, and Bukit Duabelas National Park. The strips connecting these conservation areas are known as the Ecosystem Corridor of RIMBA. (*)

"Threatening risks against natural capital and ecosystem services also come from the fact that road networks have crisscrossed the forest areas once intact as a whole into smaller fragments. Any type of road also lend as an access for illegal hunting."

PRIORITY ORDER OF FOUR DISTRICTS RIMBA ECOSYSTEM WATERSHED LOCATIONS THAT NEED CONSERVATION EFFORTS DUE TO THE CONDITION OF ITS HABITAT ECOSYSTEM WHICH IS PREDICTED TO BE POTENTIALLY MORE CRITICAL BY 2030:

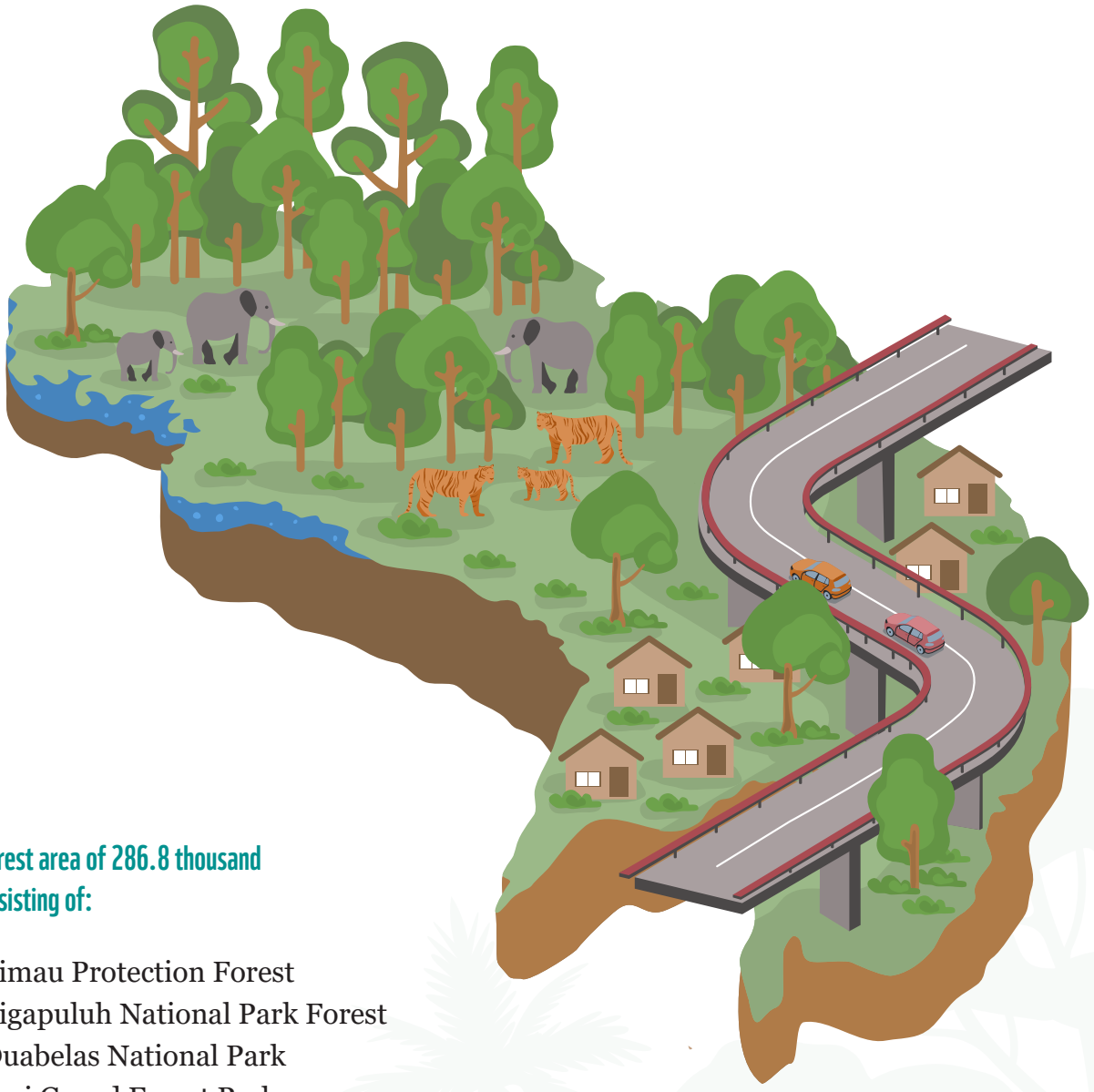


Priority Order

Priority 1	Priority 2	Priority 3	Priority 4
TEBO	DHARMASRAYA	KUANTAN SINGINGI	SIJUNJUNG

TEBO has the highest risk of damage by 2030

TEBO has the highest risk of damage by 2030



Tebo has a forest area of 286.8 thousand hectares, consisting of:

- Bukit Limau Protection Forest
- Bukit Tigapuluh National Park Forest
- Bukit Duabelas National Park
- Bukit Sari Grand Forest Park
- Hulu Sekalo Limited Production Forest
- Sungai Sirih Limited Production Forest
- Sragen River Limited Production Forest
- Upper Bangko Lake
- Pasir Mayang Production Forest
- Tabir Kejasung Production Forest Production Forest Batang Tabir
- Rakyat Forest.

Almost 50 percent of Tebo's administrative area is a habitat ecosystem for tigers and elephants in high-risk conditions.

Conservation areas in Tebo also serve to maintain water security.

The human activities that pose the most risk are:

- Settlement buildings
- Roads, which have the effect of fragmenting previously intact forest land, opening up pathways for hunting, conversion of forest land to plantations and settlements.

Tebo has its share of protected and conservation areas:

- Most of the area is Bukit Tigapuluh National Park.

DHARMASRAYA

Prioritize the preservation of habitat conditions.

Based on the Minister of Environment and Forestry Decree Number: 6599/MENLHK-PKTL/KUH/ PLA.2/10/2021 concerning the Map of Forest Area Confirmation Progress of West Sumatra Province until 2020, Dharmasraya has a forest area of 80.8 thousand hectares, consisting of:

1. 68 thousand hectares: Production forest
2. 12.8 thousand hectares: Protected forests, national parks, and nature

In Dharmasraya, there are parts of protected and conservation areas:

Most of the area is Kerinci Seblat National Park.

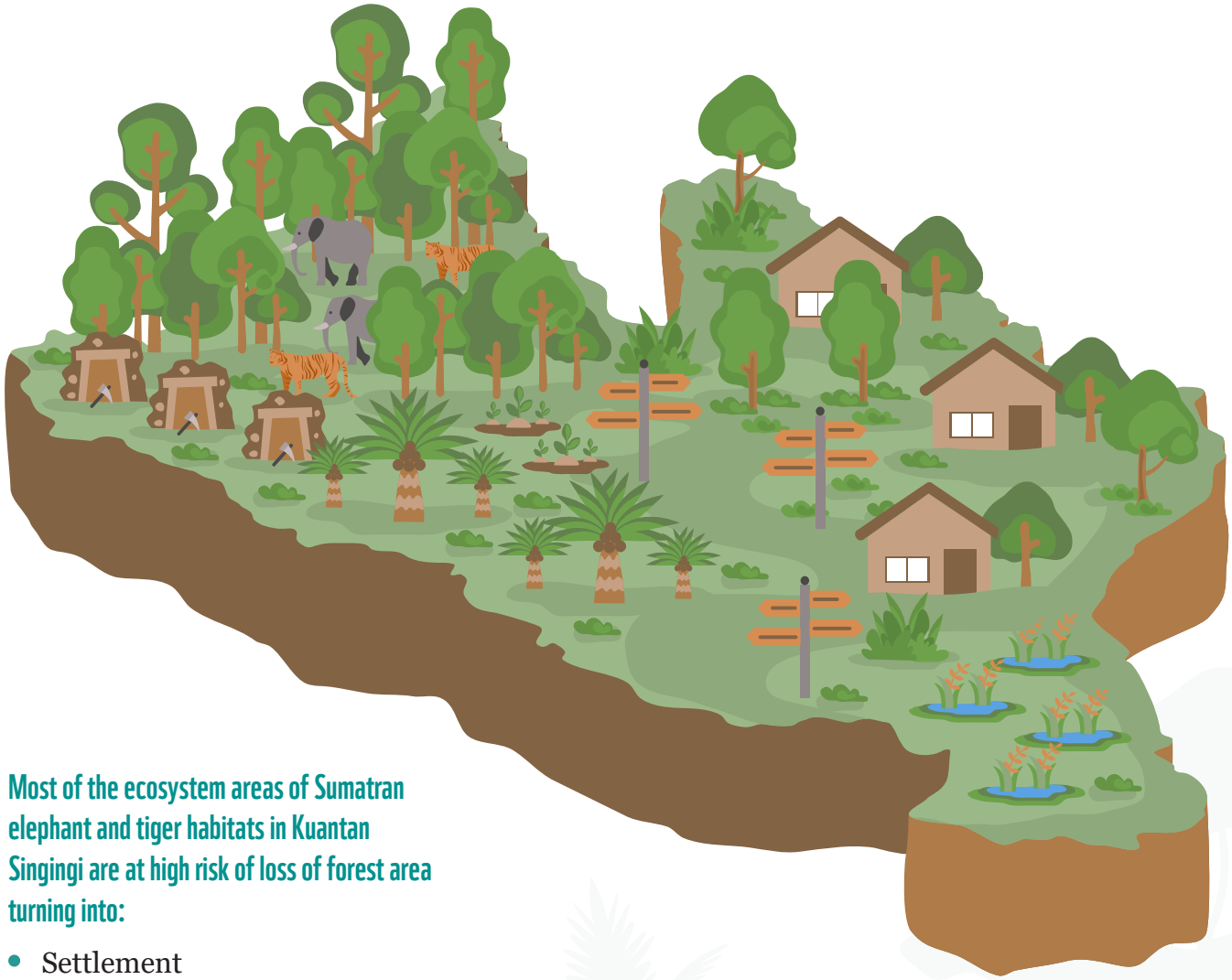
Priority environmental issues in Dharmasraya:

1. Declining water quality
2. Low waste management capacity
3. Land conversion (from forest to plantation and building)

Dharmasraya:

1. Management rights for Lubuak Karak Village Forest in Lubuak Karak Nagari and Lubuak Simantuang Village Forest in Gunung Selasih Nagari.
2. Adat forest, namely Rimbo Ubau and Rimbo Tolang.

KUANTAN SINGINGI



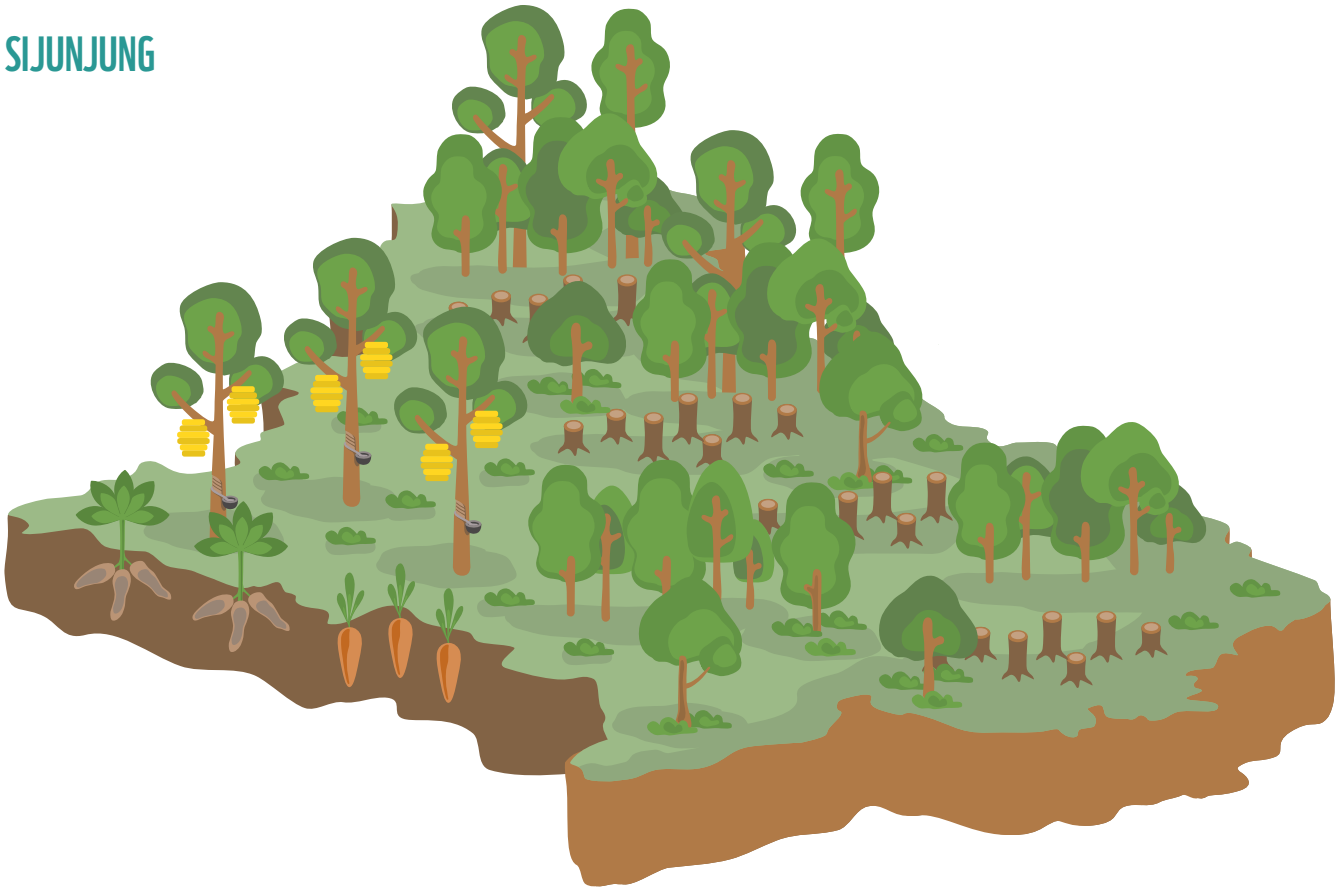
Most of the ecosystem areas of Sumatran elephant and tiger habitats in Kuantan Singingi are at high risk of loss of forest area turning into:

- Settlement
- Agriculture
- Plantation
- Mining
- Industry
- Tourism.

In Kuantan Singingi there are several sections of protected and conservation areas:

- Part of Tesso Nilo National Park
- Part of Bukit Rimbang Bukit Baling (Wildlife Reserve)
- Bukit Batabuh Protection Forest

SIJUNJUNG



More than 50 percent of Sijunjung is forested, consisting of:

- Pangian I and Pangian II Nature Reserve Forest.
- Protection Forest
- Limited Production Forest
- Permanent Production Forest.

In the collection of forest products, the Sijunjung community has customary rules; it is allowed to take non-timber forest products (rattan, honey, sap, leaves, agarwood, bark, medicinal plants and tubers).

Some forest areas such as Rimbo Larangan Paru are in critical condition due to deforestation.

Sijunjung has the potential for forests rich in natural resources

The Ministry of Environment and Forestry provides opportunities for forest management cooperation in various forms.

In Sijunjung there are several sections of protected and conservation areas:

1. Part of Bukit Rimbang Bukit Baling (Wildlife Reserve)
2. Part of Batang Pangean Nature Preserve

CHAPTER IV

THE IMPORTANCE OF ANIMAL CORRIDOR FOR TIGER AND ELEPHANT'S HABITATS

Three provinces— Riau, Jambi, and West Sumatra— whose administrative areas partly fall into the RIMBA watershed have highly people-driven activity and frequent mobility of land transportation.

In turn, the high frequency of traffic between cities via the road network that crosses the watershed also causes a declining quantity and quality of forest areas in which tigers and elephants' habitats and sources of natural capital and ecosystem services lie.

Human activities have caused the RIMBA watershed fragmented into smaller zones isolated from one another, forcing tigers and elephants currently to lose resources to support their life.

Those two Sumatran endemic species have been drafted as critically endangered status according to the IUCN (International Union for Conservation Nature). And in Indonesia, conflict with humans becomes the main cause of the continuously-declining tigers and elephants' populations in the island. This conflict takes place in several cases, such as elephants entering residential areas, elephants destroying farmer's fields, tigers and elephants attacking humans, illegal hunting, and the death of elephants and tigers due to snares or poison.

The Government responded to this condition by drafting tigers and elephants and their habitats as part of natural resources to be protected and given conservation priority in accordance with *Minister of Forestry Regulation No. P. 57/ Menhut-II/ 2008 on Directions for National Species Conservation Strategy*. The Government's stance was taken considering that tiger and elephant population— including those living inside the RIMBA watershed— continues to decline from year to year. Overall, the tigers and elephants' habitat ecosystem in the RIMBA watershed is currently at high risk as a result of the intensifying human activities inside and around the area.

Tesso Nilo National Park and Bukit Tigapuluh National Park are two of several areas inside the RIMBA watershed with high habitat risk. Based on the Tesso Nilo National Park's official website, there are several major problems— encroachment, illegal logging, and expansion of dwelling sites into the park— affecting the recent condition inside the national park.

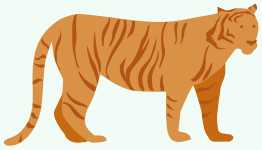
The Tesso Nilo National Park expands across two regencies, Pelalawan and Indragiri Hulu, both of which lie in Riau Province administrative region. Various human activities in the Tesso Nilo National Park area which inflicted ecological impacts had occurred since this area was still an estate of logging concession (HPH) for commercial functions.

Tesso Nilo area changed from being an HPH to becoming a national park in a process with gradually-increasing extents, as well. The park was initially designated by the Minister of Forestry in 2004 with an area of 38.6 thousand hectares. In 2009 a Minister of Forestry decree was issued to increase the area to 83 thousand hectares. Now the extent of the Tesso Nilo National Park ecosystem has reached 568.7 thousand hectares. Its designation as a national park was reconfirmed with the *Decree (SK) of the Minister of Forestry Number SK.788/ Menhut-II/ 2012 in 2012*.

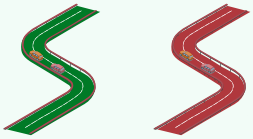
The problem is that some forest plantation (HTI) areas still remain around the national park, which in some ways pose risks to the park. There is also a large road left by the HPH company, as well as a network of other various types of roads through which people can find access for illegal logging within the park's zone. Tesso Nilo's topography lies in a flat bed of lowland, lending an easy access for public to sneak in and out for land clearing and committing other unlawful activities inside the area. In other words, when it was officiated to become a national park, the ecosystem in Tesso Nilo had already been in an environmentally-severe condition that people take for granted. A recent satellite imagery gives some hints that currently the remaining natural forest only constitutes 17% of the Tesson Nilo National Park's entire area.

Being a national park and safeguarded with strict regulations as it is, Tesso Nilo is still not free from human interferences that create threatening risks to the quantity and quality of tigers and elephants' habitat as well as the natural capital and ecosystem services inside the park's zone. With the ongoing human activities— such as plantation and conversion of forest lands— inside the park zone to this day, conflict between human and the wildlife still looms ahead.

DYNAMICS OF LAND COVER IN TIGER HABITAT POCKETS 2016, 2022, AND 2030 PREDICTIONS



Tiger Habitat Pockets



Toll Road Arterial Road

Most pockets of tiger natural habitat in the RIMBA Ecosystem Corridor watershed area are in critical condition.

Natural tiger habitats that are in a critical and priority state need special attention:

1. Tesso Nilo National Park
2. Bukit Tigapuluh National Park
3. Pangen Nature Reserve
4. Kerumutan Wildlife Reserve
5. Zamrud National Park
6. Bukit Rimbang - Bukit Baling Wildlife Reserve
7. Berbak National Park

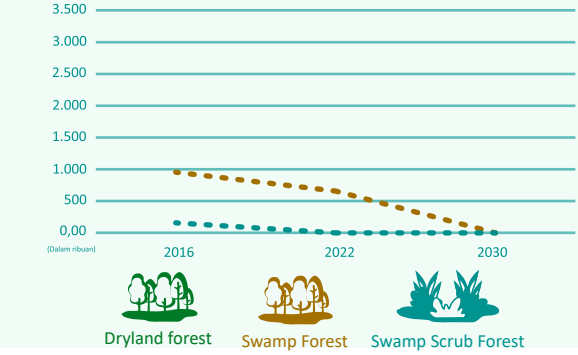
RIMBA Ecosystem Corridor watershed area:

1. Significant decline in dryland forest area
2. Increased area of plantations and industrial forest plantations
3. Narrower forest area
4. The remaining area is getting narrower, its capacity is below the ideal capacity for tiger populations
5. Increased frequency of competition among tigers
6. Tigers that lose the competition leave the area in search of new territory
7. The frequency of interaction and conflict between tigers and humans increases.

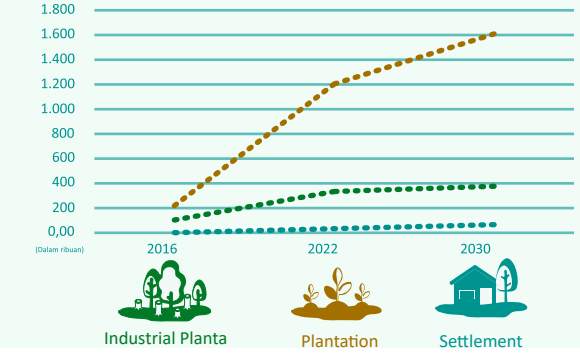
Tiger's natural character:

1. The natural habitat of the tiger is the forest
2. Tigers are carnivores and predators
3. Needs a large home range, larger than an elephant's, to fulfill food needs, or control territory related to breeding and rearing activities
4. Tigers can survive in high altitude and swampy areas, as long as there are tiger food animals.

Graph of Decrease in area of cover type



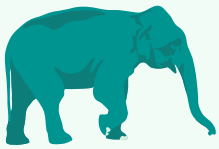
Graph of Increase in area of cover type



LAND COVER TYPES OF HABITAT POCKETS TIGERS IN THE WATERSHED OF THE RIMBA ECOSYSTEMS	LAND COVER TYPE CHANGES IN TIGER HABITAT POCKETS IN THE WATERSHED OF THE RIMBA ECOSYSTEM CORRIDOR FROM 2006 TO 2030 (IN HECTARES)		
	2006	2022	2030
 Dryland forest	3,095,272.77	2,535,254.74	2,163,228.12
 Mangrove forest	15,277.63	16,451.57	16,743.29
 Swamp forest	955,425.43	657,783.60	636,710.05
 Industrial plantation forest	103,305.50	334,186.77	376,593.45
 Plantation	219,926.90	1,205,362.86	1,609,234.23
 Shrubs	198,449.22	354,058.90	206,858.26
 Swamp shrub	157,339.58	1,486.13	701.67
 Grassland	32.41	132,974.31	131,345.87
 Dryland farming	522,039.77	56,016.82	16,653.95
 Rice fields	18,520.42	36,626.38	32,696.02
 Settlement	771.53	59,848.14	67,316.18
 Open land	94,530.76	56,389.79	16,316.18
 Mining	750.34	1,148.54	1,159.40
 Water body	19,024.65	21,885.22	16,162.11
 Swamp	0	32,773.33	24,564.60
 Clouds	2,665.55	2,665.55	85,468.62*

*Spatial prediction, further analysis is needed regarding cloud cover prediction.

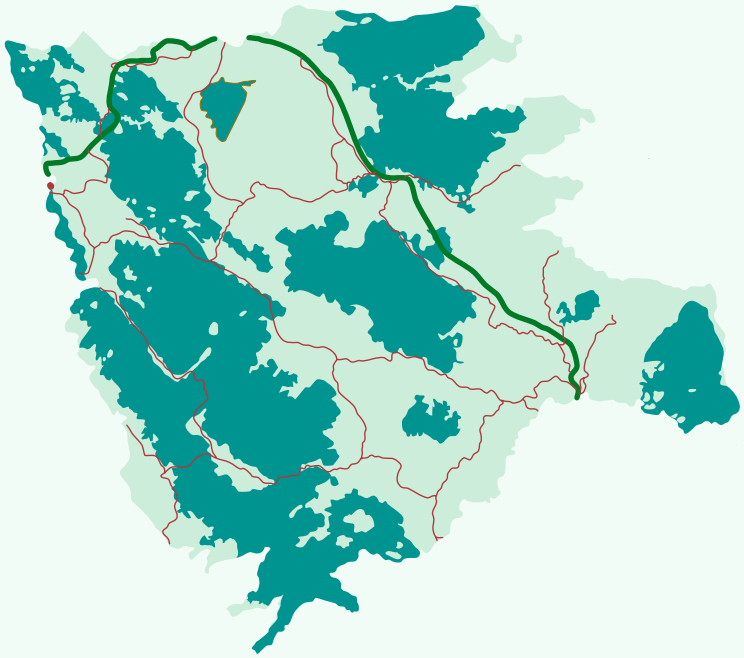
DYNAMICS OF LAND COVER IN ELEPHANT HABITAT POCKETS 2016, 2022, AND 2030 PREDICTIONS



Elephant Habitat Pockets

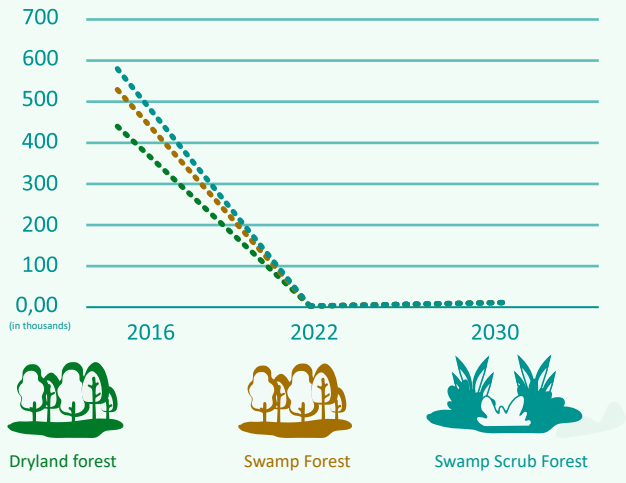
Toll Road

Arterial Road

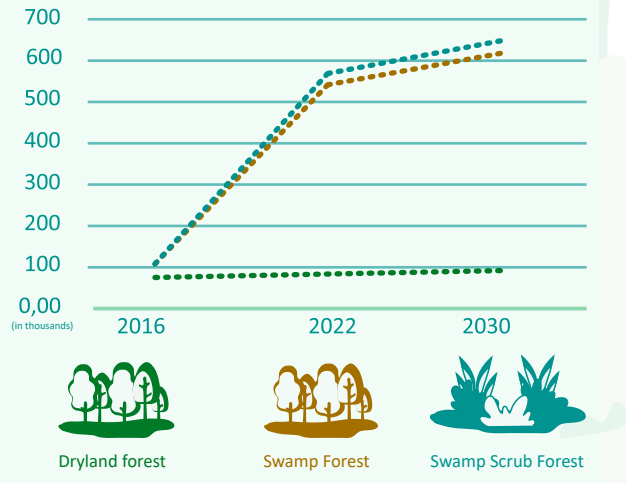


1. The greatest threat to the quality and quantity of ecosystem habitats comes from human activities in the RIMBA Ecosystem Corridor watershed area.
2. Of the several human activities, plantations, settlements, and industrial timber plantations are the cover types in the RIMBA Ecosystem Corridor watershed that create the greatest threat in terms of quality and quantity.
3. Plantations, settlements, and industrial timber plantations are the cover types in the RIMBA Ecosystem Corridor watershed that have the most phenomenal increase in area from year to year.
4. The increase in the area of plantations, settlements, and industrial forest plantations is triggered by the continued increase in road infrastructure networks that cross the RIMBA Ecosystem Corridor watershed area.
5. The increase in the area of plantations, settlements, and forest plantations, as well as the increase in road infrastructure networks that cross the RIMBA Ecosystem Corridor watershed area, has resulted in the loss of forest area in elephant habitat pockets.

Graph of Decrease in area of cover type



Graph of Increase in area of cover type



LAND COVER TYPES OF HABITAT POCKETS ELEPHANTS IN DAS CORRIDOR JUNGLE ECOSYSTEMS	LAND COVER TYPE CHANGES IN ELEPHANTS HABITAT POCKETS IN WATERSHED RIMBA ECOSYSTEM CORRIDOR FROM 2006 TO 2030 (IN HECTARES)		
	2006	2022	2030
Dryland forest	440,111.85	89,403.65	50,578.60
Mangrove forest	0	0	0
Swamp forest	3,067.43	0	0
Industrial plantation forest	75,177.49	84,039.23	92,071.53
Plantation	32,914.74	457,473.58	525,384.46
Shrubs	53,707.80	16,505	12,419.40
Swamp shrubs	11,279.12	0	0
Grassland	4.31	10,271.37	8,755.43
Dryland farming	77,286.55	0	48.3
Rice fields	4.58	2,003.47	898.39
Settlement	145.0	27,499.41	30,418.70
Open land	43,025.93	37,940.75	5,173.08
Mining	0	720.35	730.76
Water body	131.36	1,538.03	707.06
Swamp	0	607.76	168.08
Clouds	339.48	8,797.27	9,393.72

*Spatial prediction, further analysis is needed regarding cloud cover prediction.

A similar circumstance, where several forms of human activities have created impacts and threats to the integrity of tigers and elephants' habitats as well as natural capital and ecosystem services, also happens to Bukit Tigapuluh National Park. The park's area stretches across several provincial and district administrative areas, namely in Indragiri Hulu Regency and Indragiri Hilir Regency (Riau) as well as in Tebo Regency and West Tanjung Jabung Regency (Jambi). Having an area of 143.1 thousand hectares, Bukit Tigapuluh zone was designated as a national park area through the *Decree of the Minister of Forestry Number 539/ KPTS-II/ 1995*. Safe havens of flora and fauna habitat— including tigers and elephants within the Bukit Tigapuluh National Park have been under highly-risky condition.

The most apparent threat against the wildlife habitats comes from illegal logging and oil palm plantations which result in high rate of soil erosion inside the national parks' areas. The Bukit Tigapuluh National Park area constitute a lowland tropical rainforest ecosystem with such a rich in biodiversity it has been dubbed as a miniature of Sumatra Island in terms of flora and fauna. Almost all species of flora and fauna of Sumatra can be found in the park, which also happens to serve as the home of tigers, elephants and orangutans— the three being keystone species of Sumatra, but all of which have been in alarming dangers and facing the threat of extinction. In 2007, global species experts drafted the Bukit Tigapuluh National Park in the list of 20 global priority areas for tiger conservation.

Tiger Rescuing

Sumatra, the only island in Indonesia where tiger remains, holds several areas that need to be prioritized for tiger's habitats so as to make appropriate steps in the future to protect tiger's natural habitats. It is important to determine conservation priorities by identifying some wildlife conservation areas in critical condition and lack supporting capacity for tigers to survive.

The absence of prey animals within tigers' habitat will put the big cats in despair, going out of their way to places nearby where preys can be found regardless of human's presence— a condition that brings tigers into conflict with humans.

Tigers' opportunity to survive and reproduce are influenced by the availability of prey animals inside their habitats. Tigers, being the apex predators in the Sumatran forest ecosystem, plays an important role in keeping the balance of herbivores' population and plant density. Physiologically, tigers have the ability to easily adapt to various environmental conditions—in the highlands, forests, grasslands, or swamps— as long as there is sufficient preys and adequate water supply.

But the latest global trend shows that the continued increase in human population, the increasing frequency of human mobility, and the expansion of plantations on forest lands, have placed tigers as a species whose existence is in critical condition. Several efforts have been made by the international community for tiger salvation from extinction. In Indonesia, the Government has made efforts to save tigers and their habitats through the National Indonesian Tiger Recovery Program which is also part of a global program, covering six prioritized tiger landscapes, namely Ulumasen National Park (Aceh), Kampar-Kerumutan (Pelalawan, Riau), Bukit Tigapuluh National Park (Riau), Kerinci Seblat (Riau), Bukit Balai Rejang Selatan (Bengkulu), and Bukit Barisan Selatan National Park (Lampung).

Within the RIMBA Ecosystem Corridor there are 22 enclaves of tigers; namely, among others, Kerinci Seblat, Kuala Kampar-Kerumutan, Bukit Barisan Selatan, Tesso Nilo, Berbak, and Bukit Tigapuluh. Tigers can find spacious areas in the form of lowland rain forests to highland terrains in which they roam. They inhabit various types of habitats— peat swamp forests, mangroves, coastal forests, primary forests, secondary forests, logged forests, oil palm and HTI plantations, and savannas.

Regardless of being located inside conservation areas with protecting regulations, the wildlife enclaves— for example, the Tesso Nilo National Park, Bukit Tigapuluh National Park, and Berbak National Park— are not practically free from threats and full of risks. The biggest threat to tiger habitats comes from human activities in the form of plantation which results in damage to land quality and destruction of habitat. Currently, within the RIMBA Ecosystem Corridor which covers an area of 3.9 million hectares where enclaves of tigers' habitats lie—

there is still a portion of plantations (48.9 thousand km2). The plantation inside the RIMBA Ecosystem Corridor is even expanding from year to year. Forest land in which tiger lives has been converted into plantations with various human activities, which triggers conflict between tigers and humans.

Once there is human interference, conflict between tiger with humans can even happen in plantations outside the enclaves but still under the animal's reach, let alone inside their own home range. A plantation is definitely where human presence occurs. The more often human activity, the higher the possibility of interactions with tiger— a species that is able to explore vast areas in various terrains and various types of land cover.

Tigers need food stocks in the form of prey animals in sufficient quantities and adequate roaming range. However, when an enclave of tiger habitat is converted into plantations and there are roads in them, the tiger's home range will become increasingly narrow. The narrower the tiger's habitat, the more limited its living and roaming space becomes. Tigers also lose their food stocks and other necessities with which they can survive. When a tigers' habitat ecosystem is destroyed and it is difficult to look for preys, tigers will leave their habitat and roam other places, including plantations nearby the forest, which leads to conflict with humans. On the one hand, tigers instinctively need enough food supplies and adequate roaming space. On the other hand, humans feel threatened to death by the tigers' presence.

The lost living space of tigers in their habitat ecosystems as a result of human activities in the form of plantations and roads not only causes impacts on the low population of prey animals, but also on tigers' behaviour or social hierarchy. The narrowing living space will spark fierce competition among tigers to fight over territory, food, or female. Tigers who lose in the competition have to move away to other areas, some of whom dare to brace the surrounding plantations and even settlements.

The Sumatran tiger is one of the world's endangered tiger subspecies. In order to save tiger, the Indonesian government has launched conservation legislations recognizing that tiger is protected animal species. The government regulates conservation campaigns in several legislative products, for example *Law (UU) no. 5 of 1990 concerning Conservation of Biological Natural Resources and Their Ecosystems, Law no. 41 of 1999 concerning Forestry, Law No. 13 of 2014 concerning Prevention and Management of Forest Destruction*. Moreover, the campaigns also prioritized tiger conservation under the *2018-2028 Sumatran Tiger Conservation Strategy and Action Plan*.

According the *Law Number 5 of 1990 in Conservation of Biological Natural Resources and Their Ecosystems,* Article 5 letter b, the conservation of biodiversity and the ecosystems is carried out through activities to preserve the diversity of plant and animal species and their ecosystems in the area (*in-situ* conservation) or outside the area (*ex-situ* conservation). The legislation have long been proposed to be revised and unfortunately it takes such a lengthy process and remains incomplete up to the present. Tiger conservation by the Government is carried out by means of *in-situ* and *ex-situ* conservation. The government only allows maintenance and breeding by *ex-situ* conservation institutions, such as zoos and safari parks.

Further conservation measures through habitat monitoring, protection and distribution of tigers have been made without regards of the boundaries of the national park area. This includes occupancy analysis and surveys, capture-recapture, potential tiger habitat surveys, and establishing a tiger monitoring team at site level. Regarding human activities in the form of hunting and trading, the Government has classified them as illegal activities by setting up law enforcement mechanisms, including confiscating and rehabilitating the trafficked animals.

At the community level, the Government has prepared an outreach mechanism to build public awareness about the importance of conserving tigers and their habitat. The public is also encouraged to be aware of the law that the existence of tigers and their habitats is officially and legally safeguarded by law.

Elephant Rescuing

Sumatra, and also Kalimantan, is the home of elephants in Indonesia. In Sumatra, elephants inhabit 22 enclaves in seven provinces. However, almost 80% of those 22 enclaves of elephant habitat are located outside conservation areas such as national parks, wildlife reserves, or nature reserves. Of the 80% of elephant habitat enclaves outside the conservation areas, almost 56% are in concession lands. This means that elephants throughout Sumatra are under high threat because their habitat is located in territories with minimum conservation values and outside the jurisdiction of animal protection. The presence of elephants outside conservation areas, especially those in concession lands, is one of the causes of conflict between elephants and humans.

The frequency of conflicts between humans and elephants has quadrupled over the last 10 years. Conflict with humans is the main cause of elephant deaths (57%), 10% elephant death is by human hunting, and 33% is natural death. This condition explains why the elephant population have been declining through the

years. The data at the Indonesian Elephant Conservation Forum in 2014 illustrated that of the 56 points suspected to be elephant habitats throughout Sumatra, 13 of them turned out to be empty.

Conflicts between elephants and humans have an impact on increasing threats to elephant conservation, and causing many losses to humans, too. Oil palm and rubber plantations located directly adjacent to the forests— elephant habitat ecosystems— can easily cause the animal and human collide. Elephant is one of the mammals gifted with high intelligence in the form of a very sharp memory.

Elephants have a habit of exploring their ancestral living spaces by following exactly the same paths that their predecessors had travelled decades before. No matter how their ancestral living spaces have been crazed and replaced with settlements and plantations, elephants will still explore the area, which causes the more intensified conflicts between elephants and humans. When roaming the oil palm or rubber plantations for foods, herds of elephants will be likely to cause economic damages to human. Elephants usually mobilize in groups of around 15-20 individuals.

The narrow and fragmented habitats, combined with the decreasing ecosystem quality, has created serious threats to elephants and their habitat ecosystems. Elephant population continues to drop as their habitat is destroyed, failing to further support the elephants' daily needs. In 2020, the Ministry of Environment and Forestry updated the elephant enclave maps, with the results showing that compared to the previous mapping (2007), elephants have lost their habitats by 1.4 million hectares. Human activities in the form of land clearing for industrial forest plantations (HTI) have been identified as causing the greatest loss of elephant habitats.

Elephants' lost habitats means the loss of food resources and livelihood for the animal. Elephants need considerably-vast living space to find food and fulfil their daily needs. With shrunken habitat's quantity and quality, food supplies become increasingly scarce, a condition that drives elephants to move out of their habitats for food in the neighbouring plantations and agricultural estates.

Damage to elephant habitat enclaves in the form of narrowing of living spaces, reduced vegetation, loss of water resources not only has an impact on elephants' need for foods and drink, but also on the quality of elephants' reproductive abilities. The narrowing of habitat, for instance, triggers interbreeding, a reproductive process that is completely contrary to the concept of ex-situ elephant management. As a species with considerably-high sensitivity, elephant's reproductive rite is greatly influenced by environmental conditions, availability of food resources, and ecological quality.

The elephant's habitat enclaves within the Ecosystem Corridor of RIMBA are located in a number of conservation areas, including Tesso Nilo National Park, Bukit Tigapuluh National Park, parts of Bukit Dua Belas National Park, and parts of Bukit Barisan National Park. The conservation areas within the RIMBA occupies the administrative areas of four districts— Kuantan Singingi, Dharmasraya, Tebo, and Sijunjung. Elephants, with their sharp knack, are very careful in determining a habitat perfectly suitable with their living needs. They will always take into account the availability of several aspects of the carrying capacity of natural resources in a place— such as the availability of food, canopy cover as a shelter, and the availability of resources for water supply.

Conditions in the field indicates that some 4.6 million hectares of once forested areas serving as elephant's habitat enclaves inside the RIMBA watershed have been converted into plantations. Plantations areas have even recently been increasing by 4.2 million hectares, almost 100%. Meanwhile, dry land forest in elephant's habitats has decreased by 2.5 million hectares. Some conservation areas— the Tesso Nilo National Park and the Bukit

Tigapuluh National Park— where elephant's habitat enclaves lie have become top priority for conservation considering that those parks' condition is currently at risks of destruction.

Second priority goes to elephant's habitat enclaves inside the Kerumutan Wildlife Reserve, the Bukit Rimbang Bukit Baling Wildlife Reserve, and Pangean Nature Preserve. The third priority goes to the Zamrud National Park, the Kerinci Seblat National Park, and the Berbak National Prak.

Campaigns for elephant salvation have actually been made since almost 100 years ago, before Indonesia gained its independence. Since 1931, the Dutch Colonial Government has paid attention to elephant conservation.

Elephants were officially declared protected animals through *Wild Animal Protection Ordinance Numbers 134 and 226*. This conservation effort was then further strengthened by the Indonesian Government with *Law of the Republic of Indonesia No. 5 of 1999* and *Republic of Indonesia Government Regulation no. 7 of 1999 concerning Preservation of Plant and Animal Species*. However, the conservation efforts were in no aval due to obstacles— such as conflicts of interest over land in elephant habitat, inadequate law enforcement, lack of human resource capacity, lack of quarantine and rehabilitation places. Economic factors and public awareness also trigger elephant poaching, which hinder elephant conservation efforts.

Referring to the Indonesian Ministry of Forestry (2007)— there are several efforts that have been made by the Government in collaboration with a number of stakeholders in the efforts to secure elephant conservation in Indonesia. This includes mitigation of human-elephant conflict by establishing a mobile mitigation team at site level to assist residents in dealing with conflicts with elephants to raise awareness among local communities that elephants are not enemies and that poaching is a serious crime, and to build understanding in society so as to live in harmony with elephants.

In addition, they also register tame elephants whose bodies are fitted with GPS collars in order that the animal can be monitor where they roam and how many population they have. Intensive surveys and monitoring are conducted by using direct and indirect methods. Patrols are also carried out by establishing special patrolling groups teaming up with the community.

The Government also launched an *ex-situ* elephant management through the Elephant Training Center, Conservation Response Unit, Flying Squad, mobilization of tame elephants to expel the wild ones from meddling with human living spaces. There is also a campaign to improve elephant habitat's sustainability by enriching the types of vegetation for the animal's food resource, and to strengthen community's social-economic environment with alternative livelihoods.

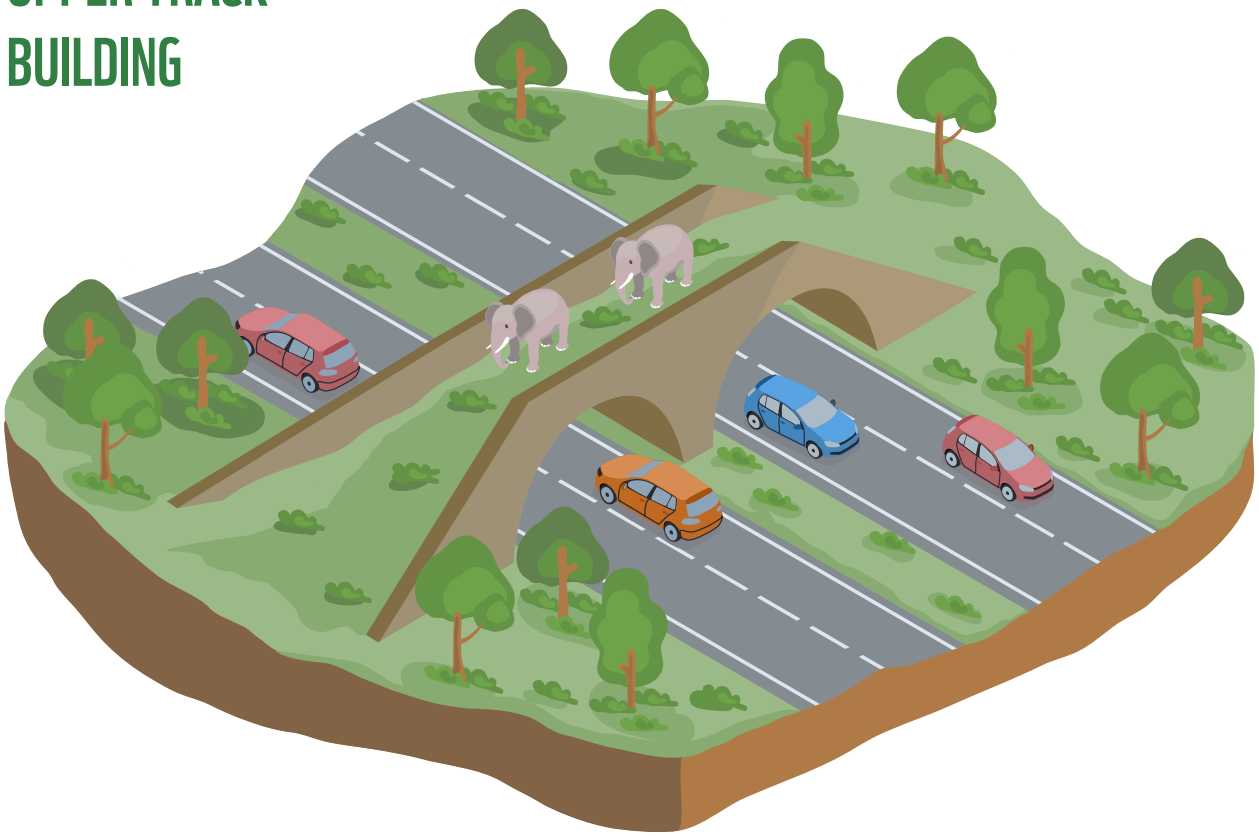
Corridor for Tigers and Elephants

The brief description above suggests that it is important for stakeholders to understand the characteristics of tigers and elephants, not only in conservation concerns, but also as an integral part of sustainable development. An overall picture of the current ecosystem shows that the natural forest has been decreasing, biodiversity destroyed, and the quality and stability of clean water supply diminishing. Local communities also lost their management areas and non-timber products for livelihoods. Destruction of forests and ecosystems has placed Indonesia on the list among the countries contributing to global warming.

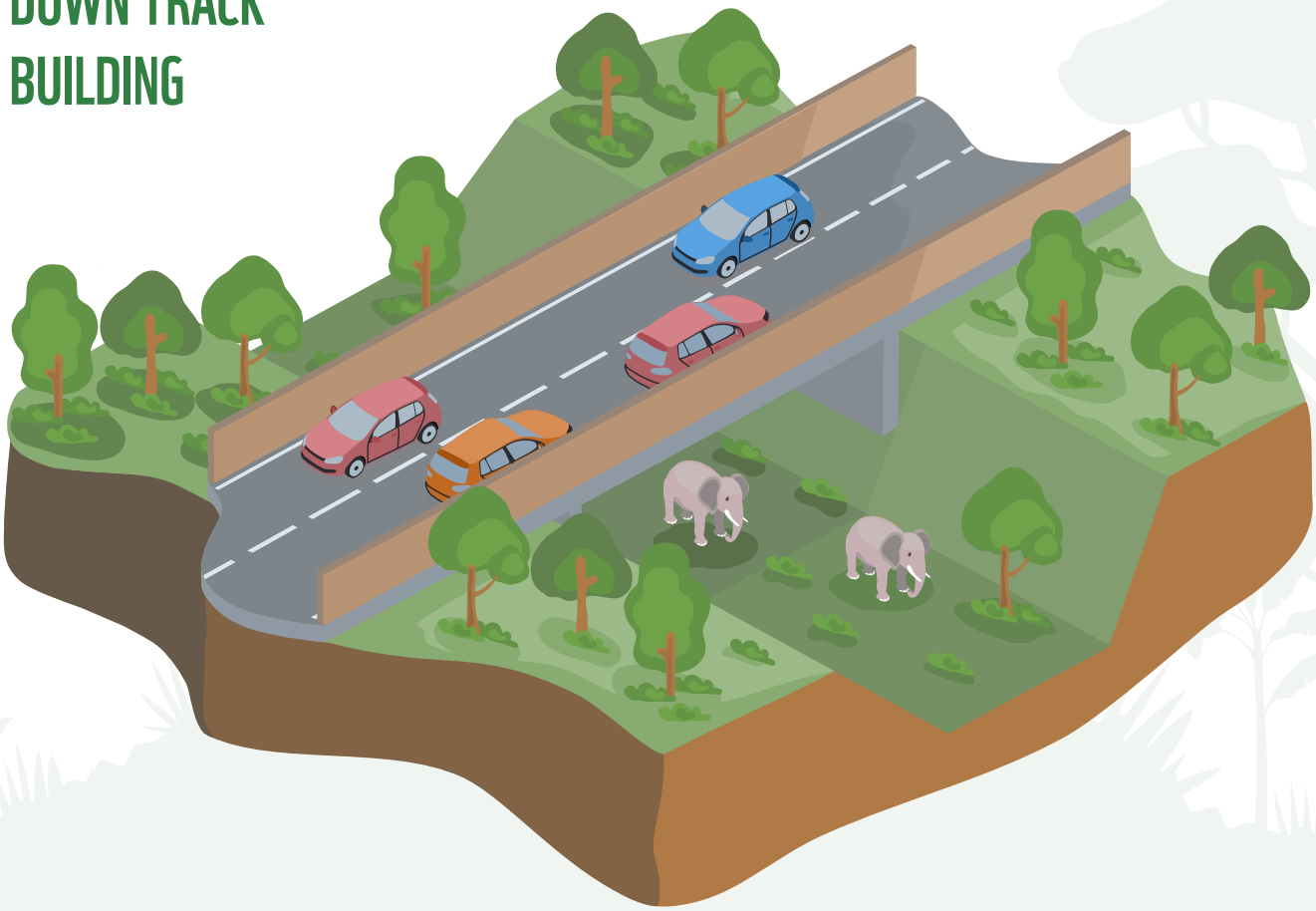
As one of the priorities for regional and economic development, toll road infrastructure also pose a new challenge deserving close attention for ecosystem conservation efforts. The four sections of newly-built toll road sections have fragmented the RIMBA Ecosystem Corridor watershed and triggered threats to the integrity of elephants and tigers' habitats. The construction of toll roads should be carried out in a planned and structured manner to help ensure connectivity the wildlife's living spaces inside the watershed. It is necessary for toll road construction to provide facilities of animal crossings through which enclaves of wildlife— despite the fragmentations— at least are still interconnected with one another. (*)

"Damage to elephant habitat enclaves in the form of narrowing of living spaces, reduced vegetation, loss of water resources not only has an impact on elephants' need for foods and drink, but also on the quality of elephants' reproductive abilities."

UPPER TRACK BUILDING



DOWN TRACK BUILDING



CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Road infrastructure, in the context of economic development and regional development, is vital. Construction of the road network in Indonesia is implemented under several safety guards, one of which is the *Presidential Regulation (Perpres) of the Republic of Indonesia Number 109 of 2020 on the Third Amendment to Presidential Regulation Number 3 of 2016 concerning the Acceleration of Implementation of National Strategic Projects*. In Sumatra, road infrastructure has become one of the Government's strategies to promote the island to become a priority for economic and regional development.

The problem is that, apart from the economic advantages, the increasing road building activities in Sumatra have also caused environmental disadvantages. Road's extent into kilo meters away and concrete structure has set such massively-hostile boundaries to wildlife, it causes fragmentations against the habitat ecosystems and brings about degradation against the natural capital and ecosystem services inside the RIMBA watershed terrains where tiger and elephant live in a sense of an impenetrable imprisonment. The fragmented ecosystem habitats into several confined safe havens for the animals have made it easier for humans to commit unlawful activities (land clearing for dwelling hubs, illegal logging, illegal hunting, illegal mining) all of which have triggered an increased unnecessary traffic and also relentless wildlife-human conflicts. Inside the RIMBA watershed there are several elephant's habitats, the Tesso Nilo National Park and Bukit Tigapuluh National Park, both of which have been under increasingly-high risks. Environmental pressures also comes from the presence of road networks and plantations inside elephant's habitats, which has posed adverse impacts against forest lands on which elephants, tigers, and any other wildlife species depend for livelihood resources.

The increasing number of road networks reduces the quality and quantity of natural resources and ecosystem services in the RIMBA Ecosystem Corridor watershed. Reducing vegetation cover and types reduces carbon production. The loss of vegetation which is a source of food for elephants and other herbivorous animals (especially wild boars) which are the main prey for tigers, as well as increasingly limited living space, have made these two rare animals increasingly under pressure and threatened with extinction. Water absorption capacity is decreasing, erosion of slopes and valleys and sedimentation in several large rivers are increasing, resulting in frequent flooding, and carbon reserve capacity is also being lost - all of which contribute to the earth's warming process.

Recommendations

Human activities inside the RIMBA watershed have caused damages to the quality and quantity of tigers and elephants' habitats.

An assessment on a habitat quality shows that the Bukit Barisan zone where some conservation areas lie— particularly the Bukit Tigapuluh National Park, Zamrud National Park, Berbak National Park, and Kerumutan Wildlife Reserve— has potential quality ecosystem to support tigers. Apart from their role as providers of supporting livelihood for tigers' habitat ecosystems, several conservation areas also serve as corridors that interconnect several wildlife enclaves, for example in the areas bordering Sijunjung, Kuantan Singingi, and Tebo. To the wildlife such as tiger and elephant, habitat corridor is so important it has a strategic role in supporting tigers in finding prey animals, breeding, sheltering, and roaming. Any necessity to build physical infrastructures should take into account of habitat corridor so as to enhance connectivity among wildlife enclaves

To prepare a habitat corridor is not simply to build an area that functions as a wildlife crossing, but also to determine the design and strategic location to ensure that it can function optimally. The basic consideration is that a construction of the corridor will affect the surrounding environmental conditions, including changing patterns of human activity around the corridor. Another important thing to ensure that the habitat corridors will function effectively as animal routes, in accordance with conservation objectives.

It is recommended that animal crossings for habitat corridor should be built across the road over Bukit Batabuh (Kasang Village, Kuantan Mudik District). Some small rivers run through the area with a bridge under which can function as a disguised animal crossing. There are three bridges in the area which are recommended for use as animal crossings. The problem is that there several constructions for human shelter nearby the bridge. Technically, the bridge is also not high enough for animals to cross. What is worse, plantations and HTIs that also create a high frequency of vehicle traffic passing through the bridge.

The increasing road networks have contributed to worsening the quality and quantity of natural capital and ecosystem services in the RIMBA watershed. The declining cover and types of vegetations— mostly caused by excessive conversion of forest lands into other uses— have also led to the loss of carbon production and carbon storage. The loss of vegetation (the resource of food for elephants) and other herbivorous animals (especially wild boars the main prey for tigers) and increasingly confined living spaces, have made these two rare animals under pressure and threatened to catastrophic extinction.

Soil's capacity for water absorption capacity has been decreasing, erosion of slopes and valleys and sedimentation in several large rivers increasing which results in the frequent flooding, and capacity of carbon reserve lost— all of which leads to the earth's warming process. Rivers over which there are bridges are important in preparing animal crossing facilities. The under-bridges section can function as a kind of tunnel for animals to pass through, with several conditions. Firstly, there is a lot of lush vegetation around the bridge so it is not conspicuous to humans that scare the animals. This requires reforestation efforts and relocation of human residing fasilities in the area around the bridge. Secondly, it is neceesary to ensure that the area around the bridge is sterile from human presence and activities. Thirdly, during the rainy season the under-bridge section will not get flooded so that animals can still cross it. Moreover, to build underpasses and flyover bridges specifically for animal crossing facilities could be an option other than modifying the under-bridge section for animal crossing.

There are sother some upporting steps that must be taken to optimize the effectiveness of animal crossings— whether by using the under-bridge section, underpasses, or flyovers. These steps include installing traffic signs indicating the presence of animals, regulations or laws to stop forest encroachment and illegal hunting along with strict law enforcement, more optimal monitoring of protected areas, and to empower the community's socioeconomic capacity, and to promote some champions among the community so to act as a driver for animal crossing management when the location of the habitat corridor is on land that intersects with community's domestic and commercial dwelling hubs. It is also important to strengthen the governance of the animal crossing facilities, especially to determine who will be responsible for taking care the facilities to ensure the continuation of the management. Without ones to take care of, animal crossing facilities will lack of monitoring system, a situation that puts the facilities into dangerous circumstance. Various modes of conservation crime would manipulate the absence of governance as an entry point for poor management of habitat corridors and the already built animal crossing facilities. (*)

DYNAMICS OF LAND COVER AND LAND USE IN THE RIMBA ECOSYSTEM CORRIDOR WATERSHED 2022-2030

LAND USE	CHANGES IN HECTARES	%
Plantation	884,316.66	18.09
Forest plantation	72,182.34	9.17
Settlement	33,552.08	10.33
Mangrove forest	2,112.87	2.19
Shrub	-382,558.89	-57.85
Dryland forest	-268,459.88	-9.45
Swamp forest	-178,673.12	-16.83
Open land	-101,820.34	-71.68
Dryland farming	-41,704.70	-54.22
Swamp	-33,456.37	-31.59
Rice fields	-24,030.74	-9.11
Water body	-15,767.65	-8.42
Savanna	-8,358.93	-3.51
Swamp shrub	-1,249.54	-34.58

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