

Sentinel Landscapes initiative

**Stocktake and baseline data analysis for future
landscape management and monitoring in
West Kalimantan**

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Executive summary

Introduction

Long-term socio-ecological research is lacking when it comes to understanding the impacts of forest and tree cover changes on ecosystem services, diversity and social well-being. To address this gap, an evidence-based research initiative drew on several tropical long-term research sites, called 'sentinel landscapes', under the CGIAR Research Program on Forests, Trees and Agroforestry (FTA). The ambition was to monitor these sentinel landscapes and sites so as to guide future landscape management choices and development at district, regency and provincial levels, as well as enable comparisons between countries.

The main objective of this report is to introduce the large amount of data compiled and initiatives undertaken by CIFOR and partners in the Borneo sentinel landscape region between 2010 and 2017, to identify eventual gaps in socio-ecological system monitoring, and to make recommendations for future research priorities.

Context

A core region of the Borneo-Sumatra Sentinel Landscape, the Kapuas Hulu regency (31,162 km²), represents the last forest frontier in West Kalimantan province. The regency is located in the northeastern part of the



Figure 1. Aerial view of the Danau Sentarum National Park wetlands

Credit: Yves Laumonier/CIFOR

province, bordering Sarawak (Malaysia). The diversity of forest types and their importance for the hydrology of the Kapuas River led to the establishment of two national parks within the regency: Betung Kerihun National Park and Danau Sentarum National Park.

To curb extensive illegal logging occurring in the 1990s up to 2003s, and also to secure its hydrological tower function for the rest of the province, the regency was declared a 'conservation district' in 2003. In 2018 it was as registered as an official UNESCO-MAB (Man and the Biosphere Programme) biosphere zone. Various institutions and projects have since attempted to contribute to solving landscape management, conservation and development in the regency.



Figure 2. Iban woman working on traditional Bemban basketry

Credit: Alfa Simarankir/CIFOR

Kapuas Hulu's total population is 263,207, with a population density of approximately eight inhabitants per km². Ethnically and culturally the area is very diverse; Malay inhabit the wetlands and floodplains, with Dayak generally inhabiting the interior hills. The use of river transportation coupled with poor road infrastructure results in high economic costs, affecting both the price of goods and services. Approximately 70% of the population still works in agriculture.

In Kapuas Hulu, forest designated for conservation and watershed protection makes up approximately 57% of the regency. The two national parks occupy about 30% of the area. Land allocated for alternative use (APL) increased in 2013, and is now available for agricultural development, in particular for the establishment of oil palm plantations. Local farmers manage land using traditional methods, practicing swidden agriculture to grow crops such as paddy, maize, cassava, tubers and vegetables. The agricultural land, acquired by clearing forest or secondary forest, is systematically left to fallow after the paddy has been harvested. Perennial crops, mainly rubber, provide a ready source of cash and are often grown to supplement other crops such as pepper, fruits and *tengkawang* (*illipe*) nuts. The forest is vitally important for Kapuas Hulu's population, especially for food (meat, fruit and vegetables), medicines and traditional crafts (baskets and mats). In general, although economic activities in the district and rural areas are emerging, subsistence activities still play a central role, for instance, food provisioning from fallows, fishing and the gathering of forest products.

Oil palm plantations have expanded across West Kalimantan in recent years and are now advancing within Kapuas Hulu, with the establishment of oil palm plantations spreading from the west of the regency since 1998, reaching the 'biodiversity corridor' between the two national parks in the north, and spreading rapidly in the south. The potential impact that expanding oil palm plantations have on biodiversity and ecosystem functions presents a major challenge to the regency, faced with the double challenge of mitigating the impacts



Figure 3. Harvesting paddy among the weeds in Batang Lupar

Credit: Yves Laumonier/CIFOR

of economic development, and maintaining ecosystem services, preserving the environmental and social functions they provide.

Within the regency, two districts were selected as ‘sentinel sites’: (1) a traditionally managed landscape with direct influence on watersheds to the north of Danau Sentarum National Park wetlands (Batang Lupar); and (2) a contrasting area in the south with improved infrastructure along the main southern road from Sintang to Putussibau, to bring a different context (Mentebah). Any transformation within these landscapes could impact both the integrity of the wetland ecosystem and the communities living there.

Methods

The baseline sampling methodology consisted of several components:

Institutional mapping, multi-stakeholder platforms, and stakeholder engagement using the participatory prospective analysis (PPA)

approach – a semi-quantitative, expert-based approach, designed to ensure balanced integration of a diversity of perspectives, relying on the assumption that stakeholders from different backgrounds with a shared interest in the same system can interact in a way that will reveal a common vision (Bourgeois et al. 2017a).

The history of land use and land cover change (2000–2019), assessed using large-scale vegetation map classification (Laumonier et al. 2020), interpreted at a 1:50 000 scale from LANDSAT satellite data acquired in 2000, 2010 and 2019, combining computerized (ground-truth data and supervised classification) with manual interpretation.

A vegetation survey, using an equally stratified sampling design to establish a baseline for future landscape monitoring, covering natural forest, old secondary forest, old fallow, young fallow, jungle rubber and mixed gardens. The sampling unit size was 20 x 20 m for trees with diameter above 5 cm.



Figure 4. A bird view of a typical swidden landscape in Batang Lupar

Jungle rubber and tengkawang (illipe nut) forest near the river, surrounded by burn fields for food crops, shrubs and young fallows.

Credit: Yves Laumonier/CIFOR

Soil surveys, using methods prescribed by the Land Degradation Surveillance Framework (LDSF, Vågen et al. 2010), consisting of modules for soil, landform and land cover classification.

Socio-economic baseline surveys, using research and survey tools from the International Forestry Resources and Institutions program (IFRI 2013). Data were collected in ten randomly selected villages in each site, with random sampling undertaken in each village.

Results

The results of the participatory prospective analysis highlighted several plausible scenarios for development. The finally selected scenario and associated plan of action, both collaboratively made, were characterized by an explicit narrative emphasizing: policies made jointly with the community; the public participating through monitoring and supervising the planning process; improved access to education; and changes in people's behavior, toward more

environmentally sound development. A road map was developed, containing guidelines for the implementation of desired scenarios, outlining preventive and anticipatory actions to mitigate undesired scenarios.

From 80% in 1973, Kapuas Hulu's forest cover remained significant in 2019 (73%, e.g. 66% intact and 7% logged-over). Between 2000 and 2010, 15% of mixed peat swamp forest, 7% of lowland mixed *dipterocarp* forest and 7% of freshwater swamp forest were logged. The opening of forest for swidden agriculture (*ladang*, food crop fields) remains minimal. The land conversion into oil palm plantation that began around 1998 near Badau, was not at the expense of forest. Representing just 2% between 2000 and 2010, forest conversion to oil palm increased after, notably to the detriment of the mixed peat (6%) and peat (6%) swamp forests in the regency's south-west.

Comparison between sentinel sites on the north and south of the Sentarum wetlands showed significant differences. Although not much difference was seen in the number of

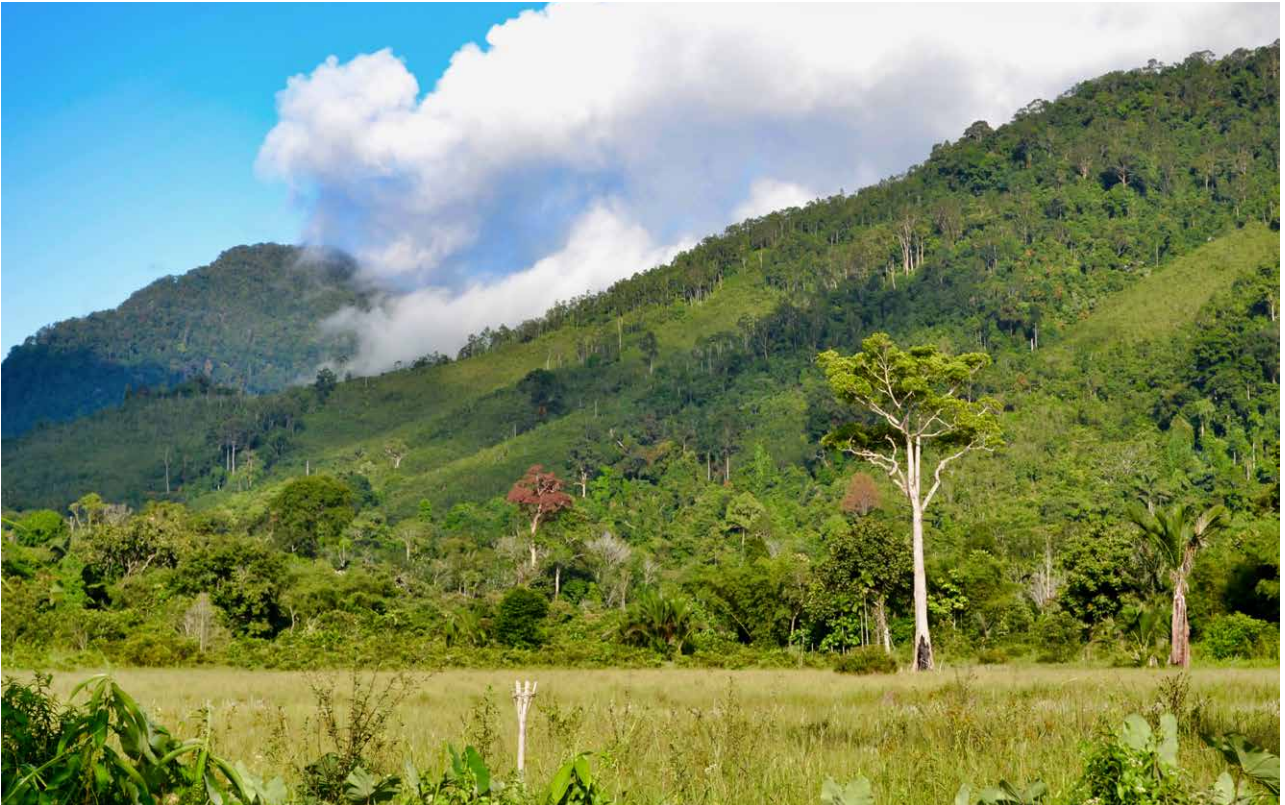


Figure 5. Landscape in Kampung Sawah, Batang Lupar

Degraded soils on slopes after swidden cultivation as indicated by the fern cover. A rare occasion of additional rain fed paddy field in the low lying areas.

Credit: Yves Laumonier/CIFOR

food crop fields or the proportion of plot size under fallow, the land tenure situation was very different in the two sites. The size of land owned without a legal document in Batang Lupar was 2.5 times higher than in Mentebah. Land was first opened in 1935 in Batang Lupar, 25 years before Mentebah (1960). The pattern of Batang Lupar field opening intensity increased and decreased every 5 to 10 years, while in Mentebah it showed to continually increase, probably in relation to rapid development along the main road. On average, plots were opened up to 3 km away from the village, and were under 3 ha in size. Dietary diversity across both sites was relatively similar. Batang Lupar households (which are more traditional) were relatively secure according to their food security score (mostly in the 3–4 range) while Mentebah (with more modern influences) showed high levels of inequality between households. Some villages experienced extreme food insecurity.

The differences in the development trajectories are linked to different cultural, socio-ecological and historical contexts. Batang Lupar sentinel site is located in the vicinity of two national parks, where land is more restricted as communities face unclear boundaries with Betung Kerihun National Park to the north and, to a lesser extent, Danau Sentarum National Park to the south. All villages are mostly inhabited by ethnic Dayak (Kantu, Iban and Tamanbaloh) who demonstrate stronger customary behaviors than Mentebah communities in the south. The communities are more dependent on forest resources for both timber and non-timber forest products. Rubber production and other agroforestry commodities are also important, like fishing; while local employment opportunities are relatively limited, mainly to government roles like education, with few employment opportunities for traders and merchants. Some communities support

the development of oil palm plantations expanding from the west, with the prospect of development and employment opportunities which have been lacking since the demise of local timber concessions. Others are less receptive, fearing the negative impacts of logging operations in the past may rematerialize under oil palm plantations. This is occasionally a source of conflict between villages, over land-use and access.

In the Mentebah sentinel site in the south, villages are mostly Malayu, especially in the flatter areas near the Kapuas river; Dayak villages are relatively remote, being on the foothills. Gold mining is an economically important activity here; communities are more dependent on it than in Batang Lupar, and much less dependent on forest resources. Dryland farming, predominately for subsistence foods, coupled with rubber production, are the main land uses. Paddy and vegetable gardens are

limited, as communities can buy agricultural produce from neighboring villages using cash earned from rubber, mining and increasingly employment with oil palm plantations, as there are generally good road networks. However, some villages have difficult access, particularly during the rainy season. The main issue facing communities and the government is the level of mining activity in the area, which has many serious environmental and social impacts, as well as impacts on agriculture practices. Mining causes sedimentation and water pollution, which are detrimental to the ecosystem and human health. However, it does provide a significant source of income, for which there are few alternatives. Timber production is now minimal, having been more prolific in the past. The Mentebah site is, in some respects, more economically developed, with income from employment and rubber outweighing subsistence farming and non-timber forest product processing.



Figure 6. Traditional gold mining activity in Mentebah

This activity has disastrous effects on the riparian forest and the quality of the river water.

Credit: Yves Laumonier/CIFOR

Conclusion

The regency of Kapuas Hulu, where the 'Borneo sentinel sites' are located, is of utmost importance as a water reservoir to the western part of the province, including the capital city of Pontianak. With forest cover of almost 73% in 2019, it represents the last forest frontier of West Kalimantan province. The area forms part of the Heart of Borneo initiative and is a reservoir of unique and intact flora and fauna similar to Sarawak landscapes where forest has been significantly damaged and habitat degradation has been more intense.

In future, to minimize deforestation and degradation of the area without jeopardizing development and public well-being, continuing to enhance the institutional capacity of partner

research organizations is recommended, working closely with local government and communities through multi-stakeholder platforms, with the aim of more productive but equitable natural resource management.

For efficient monitoring, it is crucial to revisit former biophysical and social sampling locations to assess the ecosystems' resilience potential and smallholder communities' capacity to adapt and cope with possible future shocks. Critical research pathways, built on existing data, should encompass more research on: commodity value chains, markets and economics; ecosystem functions, particularly related to the relationship between trees, soil and water; and participatory modelling to help decision-making processes, including enabling conditions for the development of 'payments for environmental services' (PES).



Figure 7. Iban woman weaving, Batang Lupar

Credit: Alfa Simarangkir/CIFOR

1 Introduction

There is a mounting appreciation of the complex inter-linkages between biological diversity and ecosystem services, and of the necessity to better consider these within land-use and spatial planning decision-making for sustainable development. The need to balance often-competing economic priorities while mitigating environmental degradation represents a leading policy challenge. Growing concerns over issues such as food security, malnutrition and increasing international demand for agricultural commodities, exacerbate this. Sustainable development is, likewise, partially impeded by a lack of sound understanding about the relationships between these drivers, as well as the limitations of existing institutional arrangements managing such complex systems.

This requires long-term socio-ecological research into these relationships, as well as research that specifically explores how these complexities can be fairly and legibly represented within resource governance systems. Long-term socio-ecological research is lacking when it comes to understanding impacts of forest and tree cover changes on ecosystem services, diversity and the well-being of indigenous communities. To address this gap, an evidence-based research initiative drew on several tropical long-term research sites, called ‘sentinel landscapes’, under the Forests, Trees and Agroforestry (FTA) research program of the CGIAR. This approach responded to a key recommendation from the 2009 Stripe Review of Social Sciences, commissioned by the CGIAR Science Council.

As defined by the FTA (2011b) research program, *“a sentinel landscape is a geographic area or set of areas bound by a common issue, in which a broad range of biophysical, social,*

economic and political data are monitored, collected with consistent methods and interpreted over the long term”. These long-term data are essential to understand socio-ecological system dynamics, and therefore to address development, resource sustainability and scientific challenges, such as linking biophysical processes to human reactions, and understanding the impacts of those reactions on ecosystems. However, the major justification for sentinel landscapes is the need for a common observation ground where reliable data from biophysical and social sciences can be tracked over time, so that long-term trends can be detected, and society can make mitigation, adaptation and best-bet choices.

At the global scale, the data generated will fit into a global analysis of networks, including other sentinel landscapes, to help understand issues and processes that could be relevant to managing tropical landscapes worldwide.

The following analysis and report are based on the data collected so far (2010–2017) by CIFOR and partners, in one of the selected landscapes of the FTA-Sentinel Landscape initiative: Borneo (focusing on Kapuas Hulu, Sintang, Melawi and Ketapang regencies, West Kalimantan). The decision to conduct this stock take was taken at workshop held under the auspices of the FTA Independent Steering Committee, in June 2018. The main objective is to introduce here the large amount of data and initiatives already collated and undertaken in the Borneo sentinel landscape region, to identify eventual gaps in what should be the most suitable data for socio-ecological system monitoring, and to make recommendations for future research priorities.

1.1 History of the 'Borneo – Sumatra Sentinel Landscape'

The premise behind the selection of sites was 'forest transition' theory¹ (Mather 1992; Meyfroidt and Lambin 2011) when several studies carried out in many countries highlighted signs of an increase in forest cover over recent decades (Perz 2007; Meyfroidt and Lambin 2009). This phenomenon is explained by the intensification of agricultural systems, the increase in urbanization and new reforestation policies, allowing spontaneous regeneration of the forest (Rigg et al. 2001). In tropical regions, with international pressure to take into account REDD programs (for reducing emissions due to deforestation and forest degradation) and, more recently, advocating the needs for 'ecosystem restoration', it becomes essential to deepen our knowledge on this still-debated forest transition theory (Perz 2007).

To exemplify the forest transition in Indonesian landscapes, and after negotiation between FTA centers and partners in Nairobi (2011), final agreement was made on a 'Borneo – Sumatra Sentinel Landscape' (FTA 2011a). Borneo would be assigned to CIFOR (who have a long research presence in Borneo) and Sumatra to ICRAF (who have a long research presence in Sumatra).

Through simple analysis of historical deforestation trends using Landsat satellite data, five regencies were selected in West Kalimantan, Borneo (Kapuas Hulu, Sintang, Melawi, Kubu Raya and Ketapang) and four in Jambi, Sumatra (Sarolangun, Merangin, Tebo and Batanghari). They represent the **Borneo Sentinel Landscape (Figure 8)**.

1 Forest Transition theory: The concept is based on observation of the historical trajectory of changes in land-use patterns in forested landscapes, the drivers of these human-induced changes. Its representation is a classic U-shaped evolution curve, from high forest cover to decreasing forest cover through degradation, then total transformation to agriculture, and sometimes to expanding tree cover again through tree plantations or agroforestry.

Within these regencies, potential **sentinel sites** of 10 x 10 km were randomly selected. The sites were excluded when situated in an area almost exclusively dominated by either 1) swamp/peat, 2) timber or oil palm plantations, 3) mining activities, 4) forest without settlements, or 5) urban or peri-urban situations. The final four selected sentinel sites represent a good illustration of the forest transition theory, from the more forested landscapes of Kapuas Hulu in West Kalimantan and Merangin in Sumatra, to the more fragmented landscapes of Sintang in West Kalimantan, and Sarolangun in Jambi, Sumatra.

Within each sentinel site (10 x10 km), a minimum of 10 villages were to be identified, first through existing base maps; their basic characteristics were later checked in the field and through discussions with local partners. In Borneo, it was sometimes difficult to find 10 villages within a 10 x 10 km square, while in Jambi, Sumatra, the density of villages was higher. In both cases, we did not limit our selection to villages, but considered hamlets (*dusun*) as well. In Borneo, we tried to ensure the balance between villages according to distance to the road and market access. In Sumatra we tried to ensure balance between traditional local villages and new settlements inhabited mainly by migrants from Java.

The ambition was that the monitoring of these sentinel landscapes and sites would guide future landscape management choices and development at the district, regency and provincial levels.

1.2 Background of the West Kalimantan sites

The dynamics between people and landscape are long established in West Kalimantan. The province has been largely deforested since colonial times, the oldest modern vegetation map (Hannibal 1950) showing forest already confined mostly to swamps on the west coast, and the interior hills and mountains. However, development has introduced changes and brought new pressures that have influenced these interactions, and that are having far-reaching

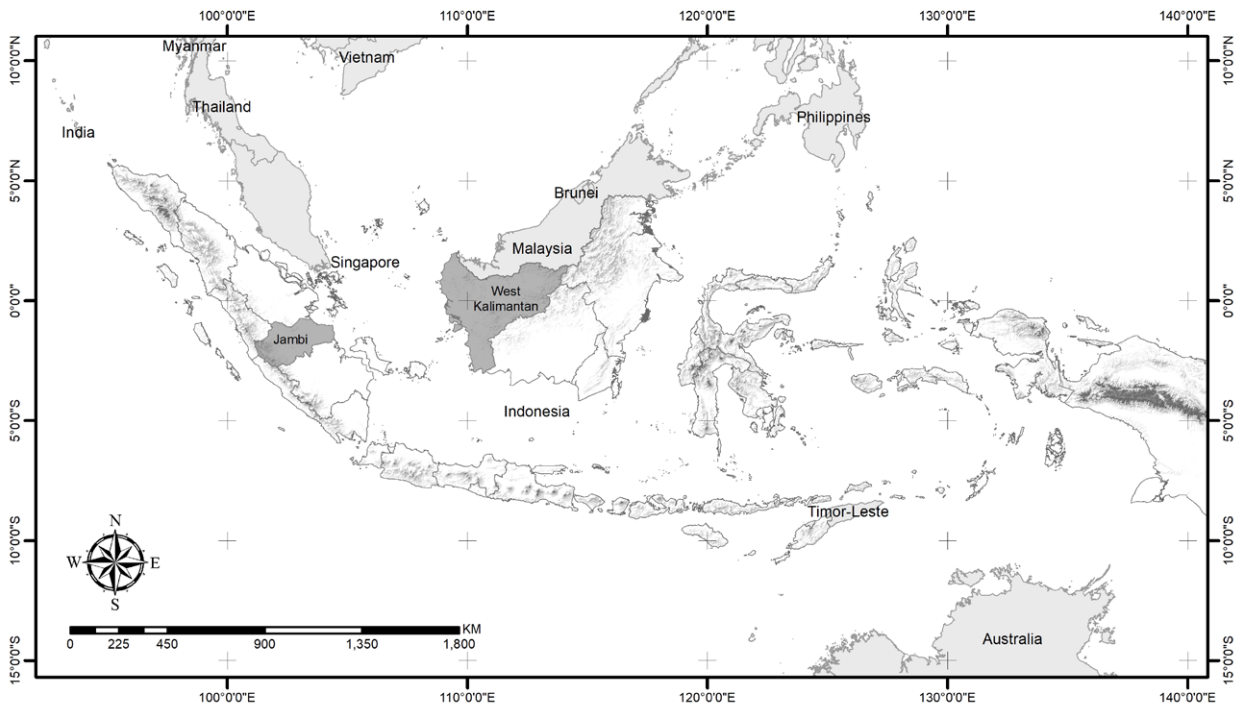


Figure 8. Borneo-Sumatra Sentinel Landscapes and Borneo sentinel site regions

impacts for both people and place. These now often convolute conditions, and have current and future implications for the viability of livelihoods (individuals, communities and the private sector) and the sustainability of natural resources use. The regencies and provincial governments have made commitments to conserve their natural resources, but the challenge is to ensure that this can be done while also creating economic development that ensures poverty alleviation and supports the needs of the local population.

Regencies associated with the Kapuas River basin exemplify the forest transition trajectories, and related issues in landscape management trade-off between conservation and development. The five regencies of **Figure 8** represent a gradient of forest degradation balanced by traditional swidden and agroforestry systems (smallholder rubber), largely impacted now by the development of monoculture plantations, mainly oil palm, and some timber pulp plantations. These landscapes encompass representative lowland forest types (well-drained mixed dipterocarp forest, *Kerangas/kerapah*, and peat swamp forest of varying peat depths),

the whole series of degradation, secondary regrowth/fallow and traditional agroforestry/swidden agriculture systems, but also the environmentally-devastating traditional gold mining that is occurring in some areas, and more recent land uses such as booming smallholder oil palm plantations. They also correspond to the Kapuas Hulu basin, and watersheds impacting the Kapuas River's flow. The Borneo sentinel landscape also includes CIFOR peat swamp research areas in Kubu Raya and Ketapang regencies (under CIFOR's SWAMP project). Oil palm plantations have been expanding for a long time (since the 1980s in Sanggau, see Potter 2015) across West Kalimantan, and are now advancing as far as Kapuas Hulu and the Danau Sentarum National Park (Yuliani et al. 2010). The potential impact of oil palm plantation expansion, on both biodiversity and ecosystem services, presents a major challenge to the regencies where forest is still prevailing; the local government is faced with the double challenge of mitigating the impacts of economic development and of maintaining ecosystem services, preserving the environmental and social functions that they provide.



Figure 9. Aerial view of gold mining impact on landscapes in Mentebah

Credit: Alfa Simarangkir/CIFOR

2 The core sentinel landscape – Kapuas Hulu regency

With forest covering 73% (Laumonier et al. 2020), Kapuas Hulu regency represents the last forest frontier of West Kalimantan province (Borneo). It is located in the northeastern part of the province, bordering Sarawak (Malaysia). The area has a long history of collaboration initiatives on transboundary management between Malaysia (Sarawak) and Indonesia, beginning in 1993 with the transboundary biodiversity conservation areas (TBCAs), biodiversity expeditions financed by the International Tropical Timber Organization (ITTO 2013) and more recent transnational cooperation under the Heart of Borneo (HoB) initiative (Muhyidin 2017; Wulffraat et al. 2017).

The diversity of unique habitats and their importance for the conservation of Borneo's biodiversity, as well as the crucial significance of the upper Kapuas River basin as a hydrological system, led to the establishment of two national parks within the regency: Betung Kerihun National Park, with a variety of lowland, hill and mountain forest ecosystems, and Danau Sentarum National Park, the only remaining extensive wetland area in Borneo, with a unique ecosystem of interconnecting seasonal lakes, peat swamps, and periodically-inundated freshwater swamp forests (Giessen 2000; Aglionby 2010). Both parks and the Kapuas River play essential roles in biodiversity conservation, environmental services and local community livelihoods, not only for inhabitants of Kapuas Hulu, but also for inhabitants who live downstream, including in Pontianak, the provincial capital. To curb massive illegal logging occurring in the area since the 1980s, reaching a peak from the 1990s until 2003 (Eilenberg 2012), and also to secure its hydrological tower function for the rest of the province, the local government declared the regency a 'conservation district' in 2003. In

2018, it was registered as an official UNESCO-MAB (Man and the Biosphere Programme) biosphere zone.

Local government, national park authorities, local communities that practice traditional swidden agriculture, the private sector, national and international NGOs, research institutions and academics are the main actors influencing the landscape configuration and composition. Competing perspectives over land are apparent between regency-level agencies focused on planning, forestry and agriculture, national park authorities, local communities and the private sector. These stakeholders have different, sometimes conflicting, interests over the limited useable agricultural land within the regency. All parties believed they had rights to the land, either due to legal permits (i.e. concessionaires) or because they had lived there for generations (before formal land rules were established) and stand by their customary rights. While most villagers had a perception of high tenure security, their land rights appeared to be threatened by the government's incomplete recognition of customary institutions, unclear regulations, and most information and key documents being held by the local elite (Clerc 2012; Shantiko et al. 2013). Current land use has been influenced by unclear or ambiguous regulations and institutions related to natural resource management, tenure conflicts, the exclusion of ecosystem services in land-use planning processes, and the agenda of large-scale businesses. Such issues have impacts on forest clearance and biodiversity loss, and threaten local communities' livelihoods and cultural identity.

To meet the need for development, land allocated for alternative use to forestry

(APL) has increased up to 19% of the regency surface in the revised spatial plan of 2011 (legalized 2013). In practice, this implies that more land is available for agricultural development, particularly for the establishment of oil palm plantations.

Various institutions and projects have contributed to addressing landscape management and land use related issues at regency level:

1. The government's local Development Planning Agency (BAPPEDA) revised what is known as the RTRWK (*rencana tata ruang wilayah kabupaten*, regency-level spatial planning/land allocation classification), as a means to accommodate different stakeholders' interests, particularly big players like: the Ministry of Environment and Forestry, represented by provincially-mandated Forest Management Units; the nationally-mandated National Park Authority; the provincially-mandated watershed management agency; the agencies of agriculture, fisheries and tourism; and the district (*kecamatan*) administration;
2. Government-supported social forestry community programs, for example, the Ministry of Forestry-launched '*hutan desa*' (village forest) program and '*hutan adat*' (customary forest) – now running in the regency – aiming to involve villagers in local forest management. Implementation of this program in Kapuas Hulu was mainly supported by Fauna and Flora International and the Germany development agency Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the latter also being involved in the Forest Management Unit program and local community capacity building through agroforestry programs;
3. The EU's CoLUPSIA initiative, a collaborative multi-stakeholder program that aimed to integrate participatory biophysical and social-spatial data collection and analysis, large-scale mapping, and science-based support through decision-making tools and processes that facilitate stakeholder engagement;

4. The long-standing work undertaken by the World Wildlife Fund on biodiversity and conservation in the national parks, increasing public awareness of the variety of plant and animal species in the area, facilitating the Heart of Borneo Initiative (HoB) agreement, and more recently promoting a 'corridor' initiative between the two national parks (Widmann et al. 2012).

2.1 Kapuas Hulu: A demographic overview

The total population of Kapuas Hulu is 263,207 (BPS 2020), and the regency has a population density of approximately eight inhabitants per km². The highest population density is in the district of Hulu Gurung (32 inhabitants/km²) while the lowest is in Embaloh Hulu (1 inhabitants/km²). The majority of the population (67%) is of productive or working age (15–64 years old).

Kapuas Hulu is ethnically and culturally very diverse. The population can be generally classified into Malay (those speaking Malayic Dayak language) who inhabit the wetlands and floodplains, and Dayak, inhabiting the interior hills (mainly Iban, Tamanbaloh, Kantu, Bukat, Kayan, Tamankapuas, Kalis and Hovongan).

While the majority have access to basic education, 29% hold no form of educational certificate (**Table 1**) and only 2% of young people graduate from higher education. A lack of teachers and poor infrastructure are contributing factors to these low levels of formal education.

Poor infrastructure can be seen in both road quality and distribution. Asphalt and concrete roads with good access throughout the year make up just 33% of all road surfaces (**Table 2**). Other road classes, i.e. those made of gravel and dirt, are passable but sometimes difficult to access, particularly during the rainy season. River transportation remains an important means of mobility and is also used for economic activities. The use of river transportation, coupled with the poor road infrastructure,

causes high economic costs and affects the price of goods and services.

Employment is diverse in the district, although 69% of the population is still involved in the agricultural sector. This is followed by social services at 9.79% and the trade sector at 9.15% (**Table 3**).

Table 1. Level of education and percentage of certificates obtained

Highest certificate	Male	Female	Total (M+F)
No certificate	29.94	28.86	29.42
Elementary school	38.55	40.42	39.46
Junior high school	17.98	15.01	16.54
Senior high school	10.95	14.31	12.58
University	2.58	1.4	2

Source: Kabupaten Kapuas Hulu dalam Angka (BPS 2020)

Table 2. Type and length of roads in Kapuas Hulu

Road classification	Length (km)	Percentage of total (%)
Asphalt	166,167	15
Concrete	200,938	18
Gravel	397,765	36
Dirt	343,460	31
Total	1,108,300	100

Source: Kabupaten Kapuas Hulu dalam Angka (BPS 2020)

Table 3. Percentage of the population by occupation

Economic sector	Percentage
Agriculture	68.46
Mining and quarrying	5.24
Processing industry	1.16
Electricity, gas and water	0.00
Construction	4.60
Trade, hotel and restaurants	9.15
Transportation and communication	0.76
Finance, insurance and corporate services	0.85
Social services	9.79

Source: Kabupaten Kapuas Hulu dalam Angka (BPS 2020)

2.2 Kapuas Hulu: An environmental, land-use and conservation overview

Kapuas Hulu, covering an area of 31,162 km², has unique environmental characteristics. The annual mean temperature is 27.2°C (mean temperature of the coldest month 22.1°C; mean temperature of the warmest month 31.9°C), and mean annual precipitation is 4,231 mm (Worldclim 2018; **Figure 10**). The whole regency has a very humid climate but long droughts occasionally occur, often during El Niño years. Lusiana (2008) and Hidayat et al. (2017) used a combination of satellite remote sensing and field observations to study the hydrological dynamics of the Kapuas basin.

Forest designated for conservation and watershed protection makes up approximately 57% of the regency, in contrast to the 26% designated across the whole of West Kalimantan. The two national parks – Danau Sentarum National Park and Betung Kerihun National Park – occupy about 30% of the regency. The area designated as production forest – including limited production forest (*hutan produksi terbatas*, HPT), forests on steeper slopes, with only trees over 50 cm in diameter permitted for cutting) and convertible production forest (*hutan produksi konversi*, HPK) – makes up about 25% of the regency. The revised spatial plan (*rencana tata ruang wilayah kabupaten*, RTRWK) for 2011 (officially endorsed in 2013) proposes that land allocated for alternative use (*areal penggunaan lain*, APL) be increased up to 19% of the regency (**Table 4**). This implies that this land is now available for agricultural development, in particular for the establishment of oil palm plantations.

As far as biodiversity assessments are concerned, the Danau Sentarum National Park area has received the most attention. Since the 1990s, it has been an active research site for ecologists researching flora and vegetation, fish, crocodiles, birds, proboscis monkeys and orangutans, as well as human resource use, including honey, fisheries, turtles, rattan, timber, culture and social and environmental economics (see review by Aglionby 2010). In contrast, the rest

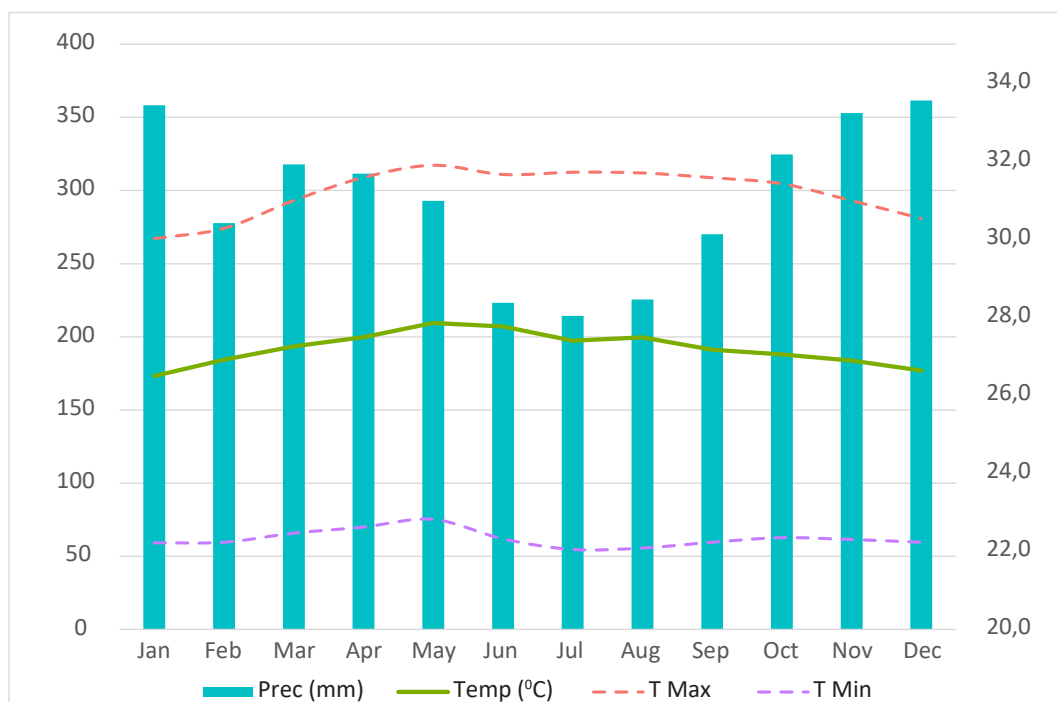


Figure 10. Annual precipitation and temperature in Kapuas Hulu regency between 1970–2000

of the regency, including the other park Betung Kerihun, has received very little attention outside of initial transboundary expeditions and baseline fauna flora data (Soedjito 1999; ITTO 2013). None of the southern hills and mountains had ever been surveyed until recently (Weihreter 2014; Labrière et al. 2016; Leonald and Rowland 2016; Boissière et al. 2017; Bakkegaard et al. 2017).

In terms of agriculture, people generally use traditional methods to manage land, practicing swidden agriculture to grow crops such as paddy, maize, cassava, tubers and vegetables. Agricultural land acquired through clearing forest and secondary forest is systematically left to a fallow period after paddy is harvested. Perennial crops, mainly rubber, provide a ready source of cash income and are often grown to supplement other crops like pepper, fruits and *tengkawang* (illipe) nuts. The forest is very important for the people of Kapuas Hulu, particularly for food (meat, fruits and vegetables), medicines and traditional crafts (baskets and mats), but also culturally (sacred forest areas and forest products used in rituals). Although economic activities are emerging across the district and in rural areas, subsistence activities, like sourcing food from fallow land, fishing and gathering forest products, still play a central role.



Figure 11. Iban man with fish net, Batang Lupar

Credit: Alfa Simarankir/CIFOR

Oil palm plantations have expanded across West Kalimantan in recent years. Kapuas Hulu is no exception; oil palm plantations have spread from the regency's west, reaching the north of Danau Sentarum National Park in 2012, the 'biodiversity corridor' between the two national parks, and now spreading rapidly in the south, with peatland near Putussibau being opened up in 2012. The potential impact of this expansion on biodiversity and ecosystem functions presents a major challenge to the regency, who must both mitigate economic development impacts while also maintain ecosystem services, preserving the environmental and social functions they provide.

Development has introduced changes and brought new pressures, which have influenced long-established interactions between the people and their landscape. These are having far-reaching impacts on both people and places. This unique, but now often fragile, situation has implications for the present and future viability of livelihoods (for individuals, communities and the private sector) and the sustainability of natural resources. With the

regency designated a 'conservation district', Kapuas Hulu's government has committed to conserving its natural resources, but the challenge is to ensure that this can be done while creating economic development that ensures poverty alleviation and supports the local population's needs.

Table 4. Kapuas Hulu forest area and status

Forest State land classification	Area (ha)	Percentage (%)
Protection forest (national park)	925,135	30
Watershed protection forest	832,390	27
Protected peat forest	1,750	0.06
Limited production forest	485,495	16
Production forest	174,440	6
Convertible production forest	109,065	3
Area allocated for other uses	600,525	19
Total	3,128,800	

Source: Ministry of Forestry 2013

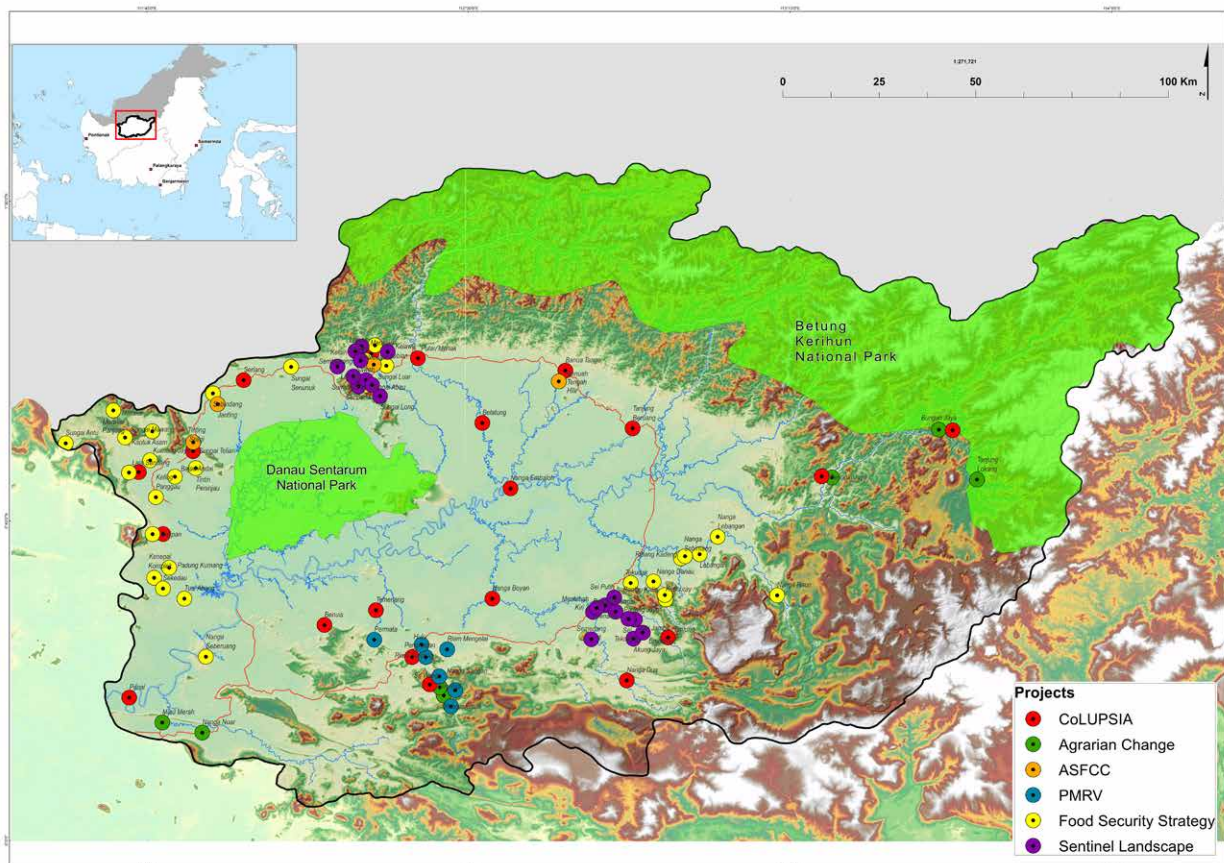


Figure 12. Socio-economic surveys by various CIFOR projects in Kapuas Hulu

2.3 Projects in the area

2.3.1 CGIAR and FTA partner projects

A number of CGIAR interventions have taken place in West Kalimantan, particularly in Kapuas Hulu regency (**Figure 12**). The projects below are CGIAR and FTA partner projects in Kapuas Hulu and other West Kalimantan regencies over the last decade.

CIFOR – Great Ape Conservation Funds: Saving the remaining orangutan population and their habitat within and surrounding the Danau Sentarum National Park, Indonesia (USFWS), 2009–2013

This project aimed to update information on the conservation status of the orangutan, conduct community/government awareness programs on reduction of forest conversion, and develop a conservation plan, collaborative monitoring system and a participatory land-use plan for the national park area.

CIRAD – Collaborative Land Use Planning and Sustainable Institutional Arrangements (CoLUPSIA), 2010–2014

This EU-funded project was implemented by the French Agricultural Research Centre for International Development (CIRAD) in partnership with CIFOR, Telapak and several local NGOs (HuMA, Riak Bumi, TOMA) and universities (Pattimura, Tanjungpura, Gadjah Mada). It aimed to contribute to reducing environmental degradation and strengthening land tenure and community rights by collaboratively integrating all stakeholders' views in land-use management and development versus conservation. Outputs revolved around stakeholder engagement for land management (including a multistakeholder platform) and assessment of possible payment of ecosystem services for biodiversity and livelihood benefits. The project focused on two Indonesian regencies: Kapuas Hulu and Central Moluccas.

CIFOR – ASEAN-Swiss Partnership on Social Forestry and Climate Change (ASFCC), 2012–2020

The focus of this SDC-funded project was to better understand swidden systems as a social forestry practice and their relevance for REDD+

and livelihoods. The aim was to understand how local knowledge, practices and social networks can be incorporated into the design of REDD+ projects, to ensure that swidden communities can participate meaningfully in and benefit from REDD+.

CIFOR – Participatory Monitoring Reporting and Verifying (PMRV), 2013–2015

The objective of the USAID/NORAD-funded PMRV project was to identify MRV systems producing credible data that are effective, verifiable, participatory and locally relevant, so that the data can be embedded into a national database. This was done by: (i) exploring new possibilities for community-based carbon monitoring; (ii) exploring community-based monitoring of the drivers of deforestation and forest degradation; and (iii) studying participation in reporting, by comparing the health and forestry sectors in Indonesia. In Kapuas Hulu the project worked in the southern part of the regency (Pengkadan village in Pengkadan Hulu district; Nanga Jemah and Sriwangi, Boyan Tanjung district).

CIFOR – Agrarian Changes, 2013–2015

The DFID-funded, CIFOR-coordinated Agrarian Changes project explored the conservation, livelihood and food security implications of land-use and agrarian change processes at the landscape scale. One of the project outputs, an associated book, provides detailed background information on seven multi-functional landscapes in Ethiopia, Cameroon, Indonesia, Nicaragua, Bangladesh, Zambia and Burkina Faso. The focal landscapes were selected as they exhibit various scenarios of changing forest cover, agricultural modification, and integration with local and global commodity markets. A standardized research protocol allowed for future comparative analyses between these sites.

CIFOR – Sustainable Wetlands Adaptation and Mitigation Program (SWAMP), 2012–2021

SWAMP is a collaborative effort by CIFOR and the US Forest Service, with support

from USAID. Tropical wetlands provide a wide range of ecosystem services, such as supporting services (nutrient cycling, soil formation, primary production), provisioning services (food, fiber, and fuel), regulating services (pollution, flood and erosion control, carbon/climate), and cultural services (education and recreational). The aim of SWAMP is to generate knowledge regarding the sustainable management of wetlands, especially peatlands and mangroves in the face of changing global climate and livelihoods of local community. Such knowledge is used to inform governments for public policy-making processes.

CIFOR – Partnerships for Enhanced Engagement in Research (PEER): Integrated watershed management for enhancing local livelihoods and biodiversity conservation in Indonesia, 2015–2018

This USAID-funded project sought to promote effective implementation of integrated watershed management (IWMA), enhancing local livelihoods, biodiversity conservation, and the research capacity of the partners involved by: (i) assessing institutional arrangements for more effective IWMA; (ii) developing approaches for implementing landscape-level biodiversity conservation; and (iii) promoting IWMA for enhancing local livelihoods supported by policy and regulation frameworks at national and local levels, based on good governance principles. Using participatory action research approach, the project focused on the capacity building of NGOs as local project partners. The project complemented current research initiatives, leveraging existing social capital and building upon key recommendations. The activities were implemented at watershed level in Kapuas Hulu (West Kalimantan), South Sulawesi and Sumbawa.

CIFOR – Governing Oil Palm Landscapes for Sustainability (GOLS), 2015–2018

The USAID Indonesia-funded GOLS program supported effective and equitable implementation of private sector commitments to monitoring land-use change and halting deforestation, helping to align public and

private policies and actions, and delivering targeted, research-based evidence to key stakeholders and practitioners. Extensive surveys on smallholder oil palm farmers were performed in Kapuas Hulu, Sintang and Sanggau agencies.

CIFOR – Knowfor 2: Food Security Strategy, 2016–2017

The second phase of this DFID-funded project on food security strategy built upon Phase 1's successful outcomes and knowledge-sharing related to forests, food security and nutrition, which contributed to expanded linkages to health, and a consolidation of research into both policy and practice. In this project, CIFOR played a strong role in terms of recent commitments to zero deforestation, and to monitoring and evaluating such systems.

CIFOR – Understanding the Drivers of Food Choice in the Context of Rapid Agrarian Change in Indonesia, 2017–2019

This project, funded by the Drivers of Food Choice competitive grants program, aimed to provide the research community, local communities, policymakers and international donors with evidence to help create a food environment more conducive to healthier food choices in rural Indonesia. The project was carried out across two Indonesian sites undergoing this process of transformation – in West Kalimantan (Kapuas Hulu) and in Papua. Both qualitative and quantitative data were collected to investigate the impacts of agrarian transitions on the diets of mothers and children. Research findings will inform more nutrition-sensitive decisions at national, local, industry and household levels.

ICRAF – Harnessing the Potential of Trees on Farms, 2018–2021

The 'Harnessing the Potential of Trees on Farms' project, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), under the International Climate Initiative (IKI), aims at better management of resources in the pressing issues of deforestation for agriculture. Agricultural land continues to grow as the world gears up to feed a population expected to

rise to at least 9 billion people by 2050. Farms management can be maximized to conserve some level of biodiversity and complement the efforts to save and restore forests with efforts to manage biodiversity and ecosystems services on farmland. The overall goal of the project is to improve the ability of countries to meet Aichi Target 7 of the United Nations Convention on Biodiversity (sustainably managed agricultural areas) by advancing the knowledge of the importance of trees on farms for biodiversity and human wellbeing. The project is carried out in Honduras, Indonesia, Peru, Rwanda and Uganda. In Indonesia, the project is carried out by CIFOR in West Kalimantan.

CIFOR - Collaborating to Operationalise Landscape Approaches for Nature, Development and Sustainability (COLANDS), 2018–2023

This five-year project is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), under the International Climate Initiative. The COLANDS project focuses on operationalizing landscape approaches in Indonesia, Ghana and Zambia. It aims to use a landscape approach to address community challenges, as well as observe implementation processes and local uptake of such an approach. The project addresses the science-implementation gap and formally operationalizes the landscape approach through wide-ranging partners and stakeholders, who will assess the conceptual framework and develop methods and tools to put the approach into practice. Actors across multiple scales, with a focus on national policy and process in the target countries, will benefit. The project will simultaneously raise awareness of the value of biological diversity, promote options and build capacity for better integrating biodiversity in national sector policies and land-use planning processes.

2.3.2 Non-CGIAR projects

WWF - Kompakh Adventure, 2014 - present

WWF was instrumental in facilitating the Heart of Borneo Global Initiative (HoB) agreement that supports coordination efforts on conservation and forest management between Indonesia, Malaysia and Brunei

Darussalam (managed by the Heart of Borneo Rainforest Foundation). Part of Kapuas Hulu falls under the HoB initiative. WWF has a long history of collecting biological and ecological data in the Betung Kerihun National Park. It also supports community empowerment activities, capacity-building programs for conservation, restoration of degraded landscapes through planting rubber, community photovoice projects, and initiated the idea and first talks on the establishment of a corridor area between the two national parks. The WWF – Kompakh Adventure collaboration was established in 2014. An eco-tourism initiative that promotes ecological principles through its ecotourism packages to both of Kapuas Hulu’s national parks and key locations in the Heart of Borneo area (Tanjung Lokang, Bungan Jaya), the collaboration uses local staff to accelerate local economic growth.

Fauna & Flora International (FFI) - REDD, 2010–2014

FFI worked on a proposal to revise Kapuas Hulu’s Forestry Spatial Plan in 2010. Unfortunately, the local government took on board none of the excellent recommendations made. Later, FFI was involved in demonstration activities for an assessment on Community Carbon Pools and training on the concept of REDD (in Ketapang and Kapuas Hulu), developing REDD demonstration activities to reduce emissions from oil palm-related forest conversion. In collaboration with Daemeter Consulting, FFI also conducted landscape High Conservation Value forest assessments in the regencies of Ketapang, Kayong Utara and Kapuas Hulu. It assessed hydrological resources, land suitability and threats to key protected species, and produced biodiversity-friendly HCV area management and monitoring recommendations. FFI conducted an extensive REDD+ initiative in the less known Danau Siawan Belida wetlands and peat swamp forests south of the Kapuas River.

Tropenbos Indonesia, 2017 - present

Tropenbos Indonesia runs activities under the Green Livelihoods Alliance in the Gunung Tarak Landscape, in Ketapang and Kayong Utara. Working closely with stakeholders like

local government agencies, private sector actors, local communities and CSOs/NGOs, Tropenbos Indonesia pursues five outcomes in governance and planning, landscape management, sustainable practice of oil palm, local government and community economy, social forestry and agrarian reform. Activities include the facilitation of village mapping, boundary reconciliation, mainstreaming High Conservation Value forest and establishing collaboration with private companies to develop ecological corridors involving their HCV areas, supporting the government in the implementation of Essential Ecosystem Areas (EEA), promoting gender inclusiveness in community empowerment, and strengthening a multi-stakeholder forum.

GIZ - FORCLIME, 2010-2020

FORCLIME focused on the relationships between national, provincial and district governments in making land and resource use decisions. A team of international and Indonesian advisors strengthened institutional capacity to manage and monitor forests where decentralization had left uncertainties in mandates between agencies and administrative levels. FORCLIME facilitated establishment of forest management units (FMUs), to bring the management of different forest categories from 'protection forest' to 'production forest' under one roof, is crucial to this reform. The establishment of FMUs involves the division of monitoring and inspection tasks from operational tasks and thus will place management responsibility closer to the field. During its final years, FORCLIME involved participatory mapping and agroforestry in one of the sentinel sites.

GIZ - Sustainable Agricultural Supply Chains in Indonesia (SASCI), 2020 - present

In collaboration with Ministry of Agriculture (Directorate General of Estate Crops), SASCI's aim is to reduce GHG emissions from deforestation and forest degradation by promoting sustainable supply chains for agricultural commodities (primarily palm oil) to smallholder farmers in Kapuas Hulu. The project promotes sustainable agriculture based on a jurisdictional approach, focusing on

participatory land-use planning and mapping, and improved agricultural production practices, including deforestation-free production and dissemination of agro-biodiversity promoting approaches. In the landscape planning process, areas with protection value (e.g. HCV, High Carbon Stock (HCS) and Essential Ecosystem Areas) are identified and mapped. Main outputs include: (i) strengthening the capacity of smallholder farmers for sustainable production of palm oil and other agricultural commodities; (ii) increasing the capacity of government organizations, civil society actors and the private sector for sustainable agricultural commodity supply chain implementation, including conflict-resolution mechanisms; (iii) strengthening national initiatives for implementation of sustainable agricultural commodity supply chains; and (iv) smallholder farmers in Kapuas Hulu have access to global markets.

Solidaridad, 2017-2019

Solidaridad collaborates with Good Return, World Education Australia and Credit Union Keling Kumang to improve the livelihoods of independent farmers in West Kalimantan (Sintang, Merpak, Sepulut, Tapang Semadak and Tapang Sambas) while protecting forest sustainability through education. Solidaridad also collaborated with Zero Mass Water to install SOURCE hydro panels that produce drinking water from sunlight and wind energies, without the need for water.

Tropical Forest Conservation Act (TFCA) Kalimantan, 2011-2019

The Government of Indonesia benefited from three TFCA swap agreements. In 2011, in partnership with WWF Indonesia and the Nature Conservancy, the United States and Indonesia signed a second TFCA agreement covering Kalimantan, reducing Indonesia's debt to the US government by USD 28.5 million in 2019. The agreement redirects this amount into a fund administered by KEHATI, for Kalimantan. The TFCA Kalimantan program focused on three areas: the Berau Forest Carbon Program in Berau (East Kalimantan), the Heart of Borneo program in Kutai Barat (East Kalimantan), and Kapuas Hulu (West Kalimantan), mostly financing NGO projects.

ADB – Sustainable forest and biodiversity management in Borneo (SFBMB), 2015–2018

The Asia Development Bank funded SFBMB project, implemented by the Directorate of Environment Services and Conservation Areas, Ministry of Environment and Forestry (DESCA), aimed to: strengthen capacity and institutions for sustainable forest and biodiversity management; design schemes for reducing emissions from deforestation and forest degradation at the local level; and develop pilot areas for sustainable financing schemes for forest and biodiversity management. The focus was on the project's pilot village of Nanga Lauk in Kapuas Hulu regency. It established REDD+ pilot demonstration sites in Nanga Lauk village in Kapuas Hulu (village forest), adopting the Plan Vivo Standard to implement REDD+ activities.

ADB – Forest Investment Program (FIP 1), 2018–2021

This project, implemented by PT Hatfield Indonesia and the Directorate General of Social Forestry and Environmental Partnerships – Ministry of Environment and Forestry as the Executing Agency, for the Asian Development Bank, invests in community-focused REDD+ activities (e.g. community-based land-use planning, community-led forest monitoring and forest fire management, community-assisted forest regeneration and maintenance, and community-based ecotourism) in four forest management units (FMUs) across two regencies (Kapuas Hulu and Sintang). Agroforestry and Assisted Natural Rehabilitation (ANR) programs will be developed with BPSKL Office of Social Forestry and Environmental Partnership, Forestry Office in West Kalimantan and the FMUs, for a total of 6,000 ha in four FMUs areas. A rubber plantation in the area of Radin Jaya village (Sintang), solar panel, micro-hydropower plant and clean water facilities, together with rehabilitation of infrastructure for ecotourism in Danau Sentarum National Park were also planned.

2.3.3 Indonesian NGOs

Several environmentally focused Indonesian NGOs were or remain active in the West Kalimantan Sentinel Landscape. These include

Alam Sehat Lestari, Swandiri Institute, KOMPAKH, Walhi Kalbar, Yayasan Dian Tama (YDT), Yayasan Palung, Yayasan Riak Bumi, Yayasan Swadaya Karya Sejahtera (YSKS), POKMASWAS, YRJA/Rangkong Indonesia, LPHD Bumi Lestari, FOKKAB, Yayasan Titian Lestari, PRCF-PlanVivo (Nanga Lauk Hutan Desa). The Tropical Forest Conservation Act (TFCA) program financed many of these NGO interventions. One of the most recent large initiatives is that of the Penabulu Foundation, detailed below.

Penabulu Foundation, 2019–2022

Responsible and Sustainable Business in Indonesia Palm Oil Plantation (RESBOUND), in West Kalimantan is a three-year ICCO-funded project between the EU and Indonesian CSOs. The project targets village communities in and around palm oil plantations, located in 10 villages in Kapuas Hulu (and 10 villages in North Sumatra), to strengthen multi-stakeholder partnership dialogues to contribute to realizing decent rural living conditions for smallholder farmers and workers on large palm oil plantations, through Community and Corporate Social Responsibility (CCSR), as means to make better use of government village funds and companies' CSR policies.

2.4 Partners' involvement in the Sentinel Landscape initiative

As no budget was available for potential local partners, their involvement was primarily through other CIFOR projects, mainly in the form of capacity building for Tanjungpura University (UNTAN) students participating in the livelihood and Land Degradation Surveillance Framework surveys. An MoU with UNTAN has been in place since 2014. Additional joint activities were initiated during CIFOR's GOLS project through biodiversity surveys (focused on birds and trees). The Bogor Agriculture University (IPB) was involved through the soil arthropod survey. FOERDIA (research agency of the MoEF) was involved in the GOLS project and is now participating in both the Trees on Farms and CoLANDS IKI projects. In the GOLS project, CIFOR had opportunity to work with PT SMART (SINAR MAS) in Semitau, Kapuas Hulu, on HCV/HCS and biodiversity in several forest fragments in oil palm concessions.

3 Methods

Within the regency, Batang Lupar and Mentebah were selected as they represent landscapes that are still traditionally managed. Batang Lupar land use has direct influence on the watersheds to the north of Danau Sentarum National Park wetlands, while Mentebah was chosen as a contrasting area in the south, with better infrastructure along the southern main road from Sintang to Putussibau, giving the area a slightly different context. Any transformation of these two landscapes could have an impact on the integrity of the wetland ecosystem and the communities living there.

The baseline sampling methodology consisted of five components. The tree/farm inventory was not planned in the same budget year as the other three components of the sampling framework, as it depended on the results of the first three outputs.

1. History of land use and land cover changes in Kapuas Hulu, 2000–2019
2. Land degradation surveillance framework (Year 1)
3. Village-level baselines (Year 1)
4. Household surveys (Year 1)
5. Tree inventories on a cohort of farms from the household survey (Year 2)

3.1 Land use and land cover changes in Kapuas Hulu, 2000–2019

The history of land use and land cover changes was assessed using as baseline a large-scale vegetation map established during the CoLUPSIA and GOLS projects (Laumonier et al. 2020). Vegetation was interpreted at a 1:50 000 scale from LANDSAT satellite data (spatial resolution of 30 m) acquired in 2000, 2010 and 2019. The

method adheres to King's recommendation (2002) to combine computerized (ground-truth data and supervised classification) with manual interpretation. Manual interpretation used the 4, 5, 3 band combination of red (0.64–0.67 μm), near-infrared (0.85–0.88 μm) and green (0.53–0.59 μm) in color composites, because variations in moisture content are better identified with this set of bands. We also used the 7, 4, 2 band combination (shortwave infrared 2.11–2.29 μm , red 0.63–0.69 μm and blue 0.45–0.51 μm) to interpret swamp vegetation areas with higher accuracy. Confusions are often made between periodically-inundated freshwater swamp forests and the wet type of *Kerangas* forest known as *kerapah*. For the land cover change analysis, we simplified the vegetation map classes into 7 classes (forest, old secondary forest, secondary regrowth, swamp secondary regrowth, agriculture/swidden, industrial plantation and other).

3.2 Land degradation surveillance framework (LDSF)

Biophysical surveys were carried out using methods prescribed by the extended land degradation surveillance framework (LDSF - Vågen et al. 2010), consisting of modules for soil and vegetation sampling, species assessment, and landform and land cover classification. As with other sentinel landscape sites, 160 plots were surveyed in 16 clusters distributed across the site. Vegetation and soils were sampled in each plot. Collected soil samples were processed at the site and then shipped to Nairobi to be analyzed in the soil spectral laboratory. For the species assessment, a botanist with local tree and shrub species knowledge was

hired, but we also systematically collected botanical samples for proper identification at the Herbarium in Bogor, Indonesia.

3.3 Socio-economic baseline

The original survey was conducted between May and September 2014. The method for collecting livelihood data was essentially based on International Forestry Resources and Institutions' research and survey tools (IFRI 2013). Data were collected in ten randomly selected villages in each site, and random sampling was performed for each village, with a total of 439 households surveyed.

Settlements were defined as being between 30 and 300 households. If a natural settlement exceeded 300 houses, it was considered as two settlements in the household survey. For Indonesian sites, 300 households across 10 settlements were randomly selected for each sentinel landscape site. For each village, 30 households were selected from the total number of household heads listed. In the case of villages having several attached hamlets (*dusun*), and therefore larger populations, hamlets were treated as separate villages.

The main data collected includes demographics, formal and informal institutions; use, access, governance and management of trees and tree products; access to markets and structure of the markets available; numbers and types of vendors; numbers and types of commodities; functional groupings; prices of traded agricultural and forest products; collective action; and social mobility within the village.

For the village level survey, the following tools were used: (i) adapted IFRI village-level surveying tools (Forest Form (Version 7.12.13), Settlement Form (Version 7.12.13); Association Form (Version 7.12.13); Product Form (Version 7.12.13)); (ii) The Stages of Progress Methodology (Krishna et al. 2006), Protocol SPM; and (iii) local market inventory, Protocol LMI.

For the household survey, 30 houses were randomly selected from the list of all households.

The main information extracted at household level was: demographic; household composition; education; migration; livelihoods; housing, water and sanitation; assets; income; main livelihood activities; remittances; credit; food security; food consumption and composition; food scarcity; social visibility; social networks; informal safety nets; use of natural resources; welfare; coping mechanisms; and mobility of the household along the poverty ladder.

Gender-disaggregated data

Gender-specific focus group discussions were organized to collect village-level data. With household-level data, both the male and female heads of households were surveyed separately in 10 out of the 30 houses in each village. For the rest of the households, either the male household head was interviewed, or both the male and female household heads were interviewed together.

3.4 On-farm tree inventory

During the second phase of the baseline data collection, it was intended for a complete tree on-farm inventory to be conducted at 20% of surveyed households, through visits to all the household's fields with a member of this household. This tree inventory was to include species, uses, management, growth parameters and location. The enumerator was to check the land-use activities at plot level and make an assessment of field management together with the household member. However, the survey tool was never designed and perhaps due to the lack of budget, the idea was abandoned. In the case of Borneo and Sumatra's sentinel landscape locations, the definition of 'farm' also raises a conceptual challenge; when it comes to areas which use traditional swidden agriculture, what exactly is, or is included in, the definition of a farm – food crop fields, fallow, or rubber trees grown in the household garden?

3.5 Landscape-level vegetation, sampling and methods of analysis

The originally prescribed sentinel landscape methodology for vegetation and tree surveys was inadequate. The information below is therefore taken from other research projects in the same area (i.e. COLUPSIA, GOLS).

3.5.1 Sampling

Based on the CIRAD-CIFOR large-scale ecological vegetation map units (Laumonier et al. 2020) we used an equally stratified sampling design (Hirzel and Guisan 2002) for each vegetation class in the sentinel site window (10 x 10 km). Vegetation classes covered were forest, old secondary forest, old fallow, young fallow, jungle rubber and various mixed gardens, and sampling unit size was 20 x 20 m for trees with diameter above 5 cm. The following subsections detail aspects of data that were analyzed.

3.5.2 Species richness, diversity indices and rarefaction curves

Species richness – the number of total species present in the sample area – is a classic

biodiversity measurement, but very sample dependent. Besides species richness, various diversity indices were also used: Shannon-Weiner (H) for species richness and evenness or equitability, Fisher's Alpha (α) (independent of sample size) and Berger-Parker (if dominant species/traits were expected to be more important). Diversity indices like Fisher's α and Berger-Parker are particularly useful to compare tree communities. Fisher's α logarithmic series model (Fisher et al. 1943) describes the number of species and the number of individuals within those species. Berger-Parker gives the fraction of total sampled individuals contributed by the most abundant species. A high Berger-Parker index means that the community has been dominated by common species in the area.

Individual rarefaction curves were analyzed. The cumulative number of species (y-axis) was plotted as a function of the cumulative number of individuals (x-axis), pooled in random (Gotelli and Colwell 2011), using 'vegan: Community Ecology Package' (Oksanen et al. 2017) in R version 3.4.4.

The aboveground biomass differences of each successional stage were tested using ANOVA



Figure 13. Secondary forests in Mentebah

Credit: Yves Laumonier/CIFOR

pairwise comparison tests. ANOVA tests whether the means of two or several groups are all equal or not, and therefore generalizes t test to three or more groups (Fisher 1950). The test was done using the vegan package (Oksanen et al. 2017) in R version 3.4.4.

3.5.3 Non-metric multidimensional scaling

Among ordination techniques, non-metric multidimensional scaling (NMDS) is often the method of choice for graphical representation of community classification in ecology, because of its flexibility and generality. This is due to: (i) its dependence only on a biologically meaningful view of the data; (ii) its distance-preserving properties (Clarke 1993). We used 'vegan: Community Ecology Package' in R version 3.4.4 (Oksanen et al. 2017).

3.5.4 Aboveground biomass

Aboveground biomass was calculated using Chave's pantropical model (Chave et al. 2014), using diameter at breast height and the total height of trees:

$$AGB = 0.0673 \times (W D \times H \times D^2)^{0.976}$$

Where D (trunk diameter at 130 cm aboveground) is in cm, H (total tree height) is in m, and WD (wood specific gravity) is in $g\ cm^{-3}$. The function returns the AGB in $Mg\ ha^{-1}$ (or ton). Total aboveground biomass was calculated for all plots and sites, along with diameter (classed into 5–10 cm, 10–30 cm, 30–50 cm, and ≥ 50 cm) using the Biomass package (Rejou-Mechain et al. 2018) in R version 3.4.4.

3.5.5 Importance Value index and indicator species

The Importance Value index, widely used in Indonesia, combines relative density, relative frequency and relative dominance of a species. It gives an overall picture of the 'ecological importance' of the species in a community. In this case, it appeared to be of interest to assess its value against concepts such as 'indicator species'.

Indicator species are defined here as individuals specific to a particular vegetation

type. To assess the indicator species in the field, the indicator value was calculated by obtaining the specificity (A) and fidelity (B) value (Dufrene and Legendre 1997). For each species i in each site group j , we computed the product of A_{ij} , which is the mean abundance of species i in the sites of group j compared to all groups in the study, by B_{ij} which is the relative frequency of occurrence of species i in the sites of group j , as follows:

Where $INDVAL$ is the Indicator Value of species i in site cluster j (Dufrene and Legendre 1997). Ecosystems having a broad geographic range will show low sensitivity, because each indicator species will probably only occur within a subset of the geographical range. The maximum of A_{ij} is $A=1$, which is when species i is only present in cluster j , while the maximum of B_{ij} is $B=1$, which is when species i is present in all plots of each vegetation class. In our analysis, site group is the vegetation class (i.e. young fallow, old fallow, secondary forest), and cluster means the number of plots in each vegetation

$$A_{ij} = N_{individuals_{ij}} / N_{individuals_i}$$

$$B_{ij} = N_{sites_{ij}} / N_{sites_j}$$

$$INDVAL_{ij} = A_{ij} \times B_{ij} \times 100$$

classes. Thus, an important quantity that complements a given list of indicators is their pooled coverage of the target site group, which is defined as *the percentage of sites where at least one of the indicators occurs*. Coverage of the site by a single indicator is equal to its sensitivity (Cáceres et al. 2012). Indicator species were calculated using Indicspecies Package (Cáceres and Jansen 2016) in R version 3.4.4.

3.6 Institutional mapping, multi-stakeholder platforms and stakeholder engagement

Participatory Prospective Analysis (PPA) is defined as "a systematic, participatory and multi-disciplinary approach to explore mid-to long-term futures and drivers of change" (Bourgeois et al. 2017a). It is based on co-elaborative scenario-building that aims

at imagining the future; a specific form of anticipatory practice that makes it possible to build plausible futures from the explicit and implicit knowledge of diverse participants (Ahlqvist and Rhisiart 2015). It is a structured semi-quantitative, expert-based approach, designed to ensure balanced integration of a diversity of perspectives, relying on the assumption that stakeholders from different backgrounds with a shared interest in the same system can interact in a way that will reveal a common vision (Jésus and Bourgeois 2003; Pretty 1995). The 'system' refers to the issue in question, which is defined by a specific question, geographic space, set of actors and time horizon in the future. The system is made up of a set of 'forces of changes' and their interactions. The process enables stakeholders to explore alternative futures, shaped by the interaction of trends and discontinuities across the various forces considered to drive the system as a whole (Bourgeois et al. 2017b).

Field implementation

Implementation of the PPA in Kapuas Hulu was covered by three workshops of one week each, following the steps below, as per Bourgeois et al. (2017a).

1. *Identification of participants.* Participants in the co-elaborative scenario building process were selected through an iterative process, following interviews of key informants from different sectors and institutions related to spatial planning. The final selection of each participant was made based on their knowledge, the needed diversity of expertise within the group, and the individual capacity for sharing and learning from others.
2. *Definition of the 'system'.* In the first participant workshop, the 'system' was defined with regards to the core question to be addressed, as well as its geographic boundaries, the time horizon of the anticipatory work, and the identification of relevant stakeholders.
3. *Identification and definition of the 'forces of change'.* In the same workshop, brainstorming and discussion were used to enable participants to agree on a list of variables they considered could influence the system in the future. Once the final list of 'forces' was identified, participants worked on common definitions to be used in the next sequence of work.
4. *Identification and selection of the 'driving forces'.* A cross-impact analysis (or structural analysis) was conducted with the participants, in order to identify the direct influences between variables and to bring structure to the system of variables (Godet 1986, 2010; Popper 2008). A binary scale was used to record the existence of a mutual influence between two variables into a matrix of influence/dependence. Visualization graphs using the levels of influence and dependence of each variable as coordinates were used to classify the variables and identify the key forces of change. This method was complemented by the use of a formula, producing a compound measurement of the strength of each force used to rank the forces.
5. *Building scenarios.* Creative brainstorming and collective discussion were used to engage participants in making contrasted, mutually exclusive hypotheses regarding the future states of each key variable. Morphological analysis (Godet 2000; Álvarez and Ritchey 2015) was then applied to identify incompatibilities between future states and build plausible, contrasted scenarios, ensuring that no scenarios would entail incompatible combinations.
6. *Elaboration of action plans.* Three public consultations, involving a diversity of stakeholders such as community groups, government officials, private companies, NGOs and academics, were conducted through direct meetings and group discussions at both sites, at village, district and regency level. The purpose was to disseminate and discuss the scenarios and identify preferences related to each scenario. Feedback was collated during the meetings by the PPA group. The results were used to develop a road map, using system mapping (Gienapp et al. 2009).

4 Results

4.1 Institutional mapping, multi-stakeholder platforms and stakeholder engagement

Identification of participants

A diverse range of participants representing stakeholders linked to spatial planning was selected to participate in the scenario-building process (Table 5). Altogether, 17 participants from Kapuas Hulu committed to engage in a series of three PPA workshops over a three-month period.

Definition of the ‘system’

The core question selected in Kapuas Hulu was, ‘what could development look like in our regency in the next 20 years?’ This broad theme was chosen instead of a more specific topic such as ‘land-use planning’ as people feared that it would be too sensitive because of the much-debated issue of oil palm development within the regency. The time horizon was set at twenty years in line with the regional medium-term development and spatial plan; a time span long enough to



Figure 14. Women involved in gold mining activities in Mentebah

Credit: Alfa Simarangkir/CIFOR

consider possible and significant changes, but short enough to justify immediate action.

Identification and definition of the ‘forces of change’

In Kapuas Hulu, participants identified 50 variables linked to the issue, covering social, economic, political, technological and ecological dimensions.

Identification and selection of the ‘driving forces’

The groups spent a substantial amount of time on critical thinking at this stage,

particularly in determining the influence of variables on each other. The results of the influence/dependence matrix allowed the selection of the key variables, according to their position in the graphs and their strengths (**Table 6**).

Building scenarios

The analysis resulted in several combinations of plausible scenarios. Similar scenarios were combined, the most contrasting scenarios were assessed and the final scenarios were mutually agreed upon. A final scenario was then defined by an explicit title and narrative (**Table 7**).

Table 5. Kapuas Hulu participants involved in the Participatory Prospective Analysis working group

Stakeholder groups	Representatives from Kapuas Hulu
Government and other public actors	Township and village government, forestry, plantation, agriculture, fisheries, mining, conservation
Parliament	Representatives of the local parliament
Community	Customary leaders (Dayak and Malay); farmers; fisherfolk
Private sector	Oil palm, timber, infrastructure development
Other	Young people, rural empowerment practitioners (NGOs)

Table 6. Results of mutual influence/dependence analysis in Kapuas Hulu

Key variables	Definition
Regency policies	Rules made by executive and legislative bodies focused on governance and development
Use of technology	Levels of ability and use of technology among the general public
Customary law and wisdom	Recognition and enforcement of rules for local and indigenous people newly settling into the customary territory, as well as procedures or practices in the use of natural resources in a particular region
Development mindset	Perspective in terms of viewing and analyzing a problem
Participation	Community participation in planning, implementing and monitoring collaborative development options
Education and skills	Average education held by the public and skills sourced from talent, experience and informal education
Legality of land	Clarity of legal status on the use of land (formal and informal)
Spatial planning policies	The procedure of spatial planning, space utilization and control of the use of space
Community empowerment policies	Local government efforts to improve the economy of local communities by leveraging the potential of local resources (e.g. tengkawang, cocoa, rubber)

Table 7. ‘Plausible future development’ scenarios for Kapuas Hulu by 2030

Scenario title	Narrative summary
1. Steps in harmony	Policies favor, and are made jointly with, the community. The public participates by monitoring and supervising the planning process. Decisions on land use take people’s aspirations into account and are acceptable in both customary and national law. Access to education improves and changes people’s behavior toward environmentally sound development. An example of this is that people can master practical and environmentally-friendly technology.
2. Throw the coin but hide the hand	Most policies do not address the essential development needs of the people. National law is widely accepted, and customary institutions and indigenous wisdom have been excluded; indigenous people have disappeared. Land use is not informed by traditional wisdom, leading to environmental destruction and the marginalization of people.
3. Panning for gold, getting stones	Conflicts in society escalate because stakeholders are excluded from the development process. Poverty and inequality also lead to public apathy; people refuse to participate in development projects. Land-use conflicts arise as customary institutions are weakened and indigenous people are divided.
4. Eating poisonous fruit	Changing regency’s policy priorities – coupled with policy maker’s opportunistic behavior that favors certain groups’ interests – has resulted in slow growth of development within the regency. Indigenous peoples and customary law are recognized but their existence serves to promote the regency’s public image. People are excluded from making decisions on land use and development.

Elaboration of an action plan

The PPA group conducted three socialization meetings and workshops at the village, regency and provincial levels to validate the results and obtain feedback. These meetings allowed participants to discuss the future actions required to at least try to avoid undesired scenarios. In Kapuas Hulu, 120 people from 20 villages and 60 district-level representatives agreed that the ‘Steps in harmony’ scenario would be the most desirable future outcome. They were prompted to consider issues that might bring about change. A road map was developed for both sites, containing guidelines for implementation of desired scenarios, but also outlining preventive and anticipatory actions against undesired scenarios.

New landscape-level institutional arrangements that can appropriately consider the diversity of stakeholders – and their different roles, interests, power and level of influence – are still needed. Potential funding schemes to sustain such institutional arrangements should also be explored; lack of funding from local institutions often hampers implementation after donor-funded projects end.

4.2 History of land use, land cover changes

Dropping from 80% coverage in 1973, Kapuas Hulu forest cover remained significant in 2019 (73%, of which 66% was intact and 7% logged-over). The changes in land use and land cover for 2000, 2010 and 2019 are given in **Figures 15 to 17**, and briefly analyzed below.

Natural forest

In 1973, intact forest in Kapuas Hulu stood at 2.5 million ha (Gaveau et al. 2016). This decreased to 2.2 million ha by 2000. Between 2000–2010, 15% of mixed peat swamp forest, 7% of lowland mixed dipterocarp forest and 7% of freshwater swamp forest area were logged. Over the following decade (2010–2019) industrial logging stopped, although illegal logging – which is more difficult to monitor on remote sensing images – continued, especially in the districts of Putussibau Selatan and Kalis. The area of natural forest that had been opened up for swidden agriculture (*ladang*, food crop fields) was just 2% between 2000–2010 and remained minimal (less than 1%) in the following decade. The conversion of land to

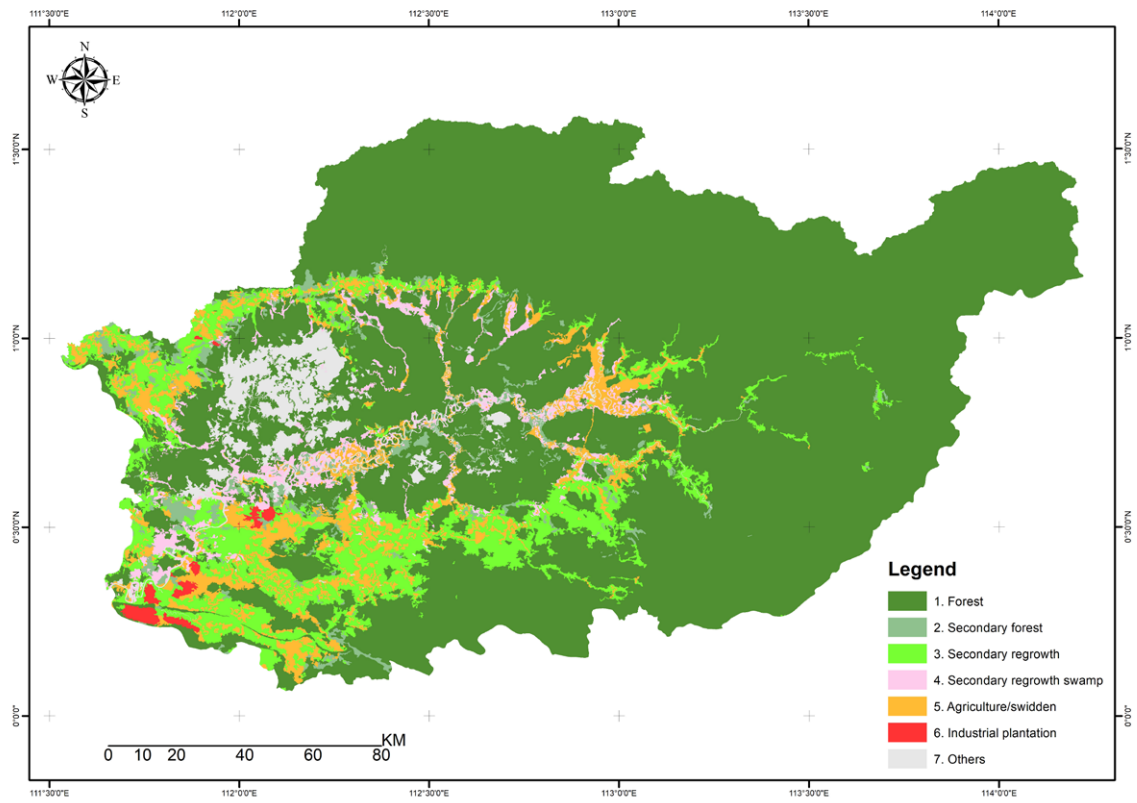


Figure 15. Kapuas Hulu vegetation maps 2000

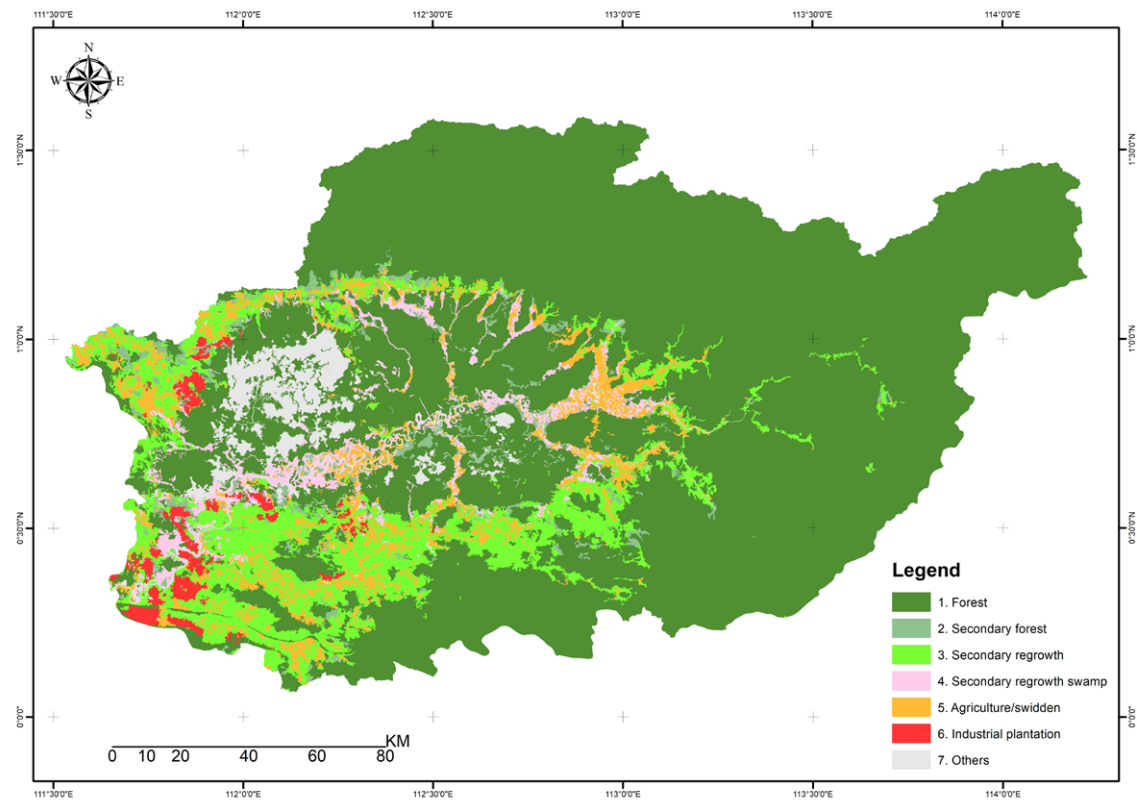


Figure 16. Kapuas Hulu vegetation maps 2010

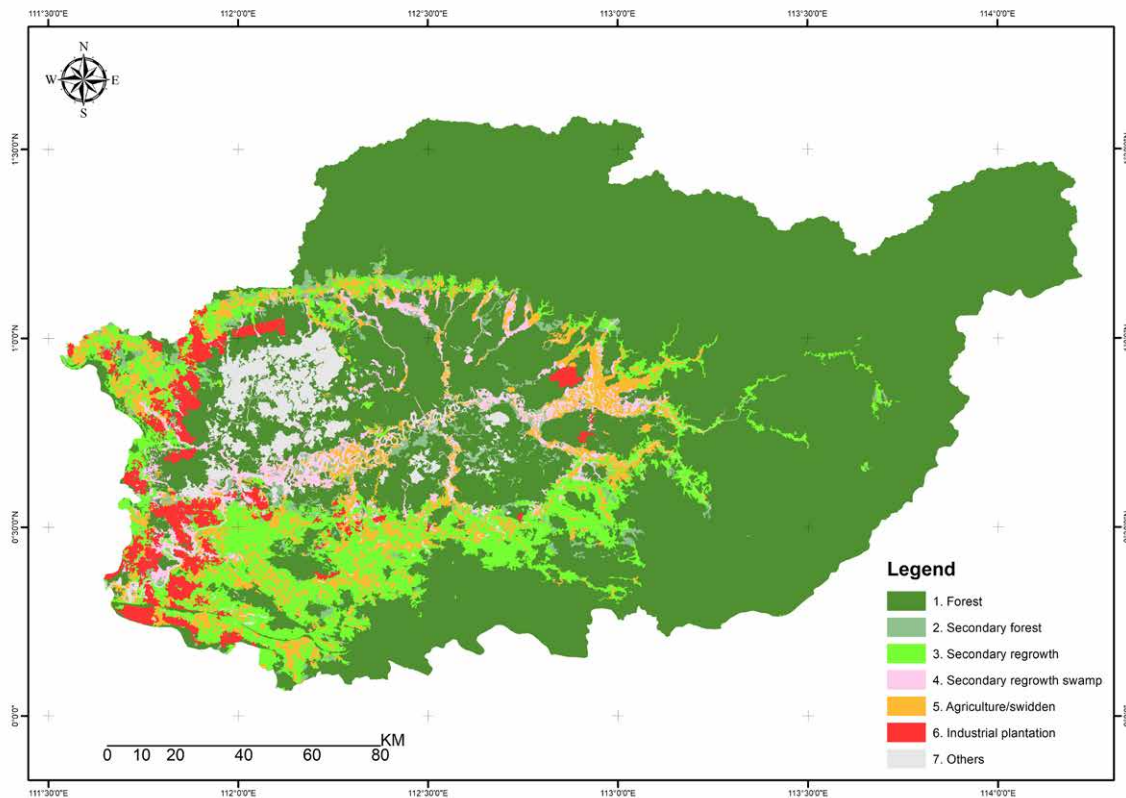


Figure 17. Kapuas Hulu vegetation maps 2019

oil palm plantations that started around 1998 near Badau, was initially not at the expense of natural forest (affecting just 2% of natural forestland between 2000–2010), however the amount of forest that was converted to oil palm increased after, notably to the detriment of mixed peat (6%) and peat (6%) swamp forests in the south-west of the regency.

Secondary forest (successional stages, fallows)

Between 2000 and 2010, 5% of the secondary forest areas converted to oil palm plantations, mainly on the expense of secondary *kerapah* (12%) and freshwater swamp forests (4%). Over the same period, 8% of the secondary freshwater swamp forest and 5% of the secondary *kerapah* forest degraded into low swampy secondary regrowth. In the following decade, a further 6% of secondary forest was converted to plantations, essentially again from secondary *kerapah* and secondary mixed peat swamp forests, and also from the mosaic of old fallows on mineral soils. In addition, between 2000 and 2010, 5% of the old fallows became

young fallow, shrubs, grassland or fernland through the swidden agriculture cycle, while in 2000–2019 just 2% of old fallow was converted into agricultural land.

Agriculture

The conversion of traditional agricultural land (food crop fields and smallholder rubber) into industrial plantation decreased slightly from 5% between 2000–2010 to 3% between 2010–2019. Around 7% of mixed gardens and 6% of food crops fields were converted between 2000–2010; between 2010–2019 another 6% of food crop fields became oil palm plantation.

Conversely, agricultural land changing to secondary regrowth decreased from 13% between 2000–2010 to 4% between 2010–2019. Specifically, it was 19% of food crops fields and 12% of smallholder plantations (mainly pepper) that reverted to young fallow, shrubs, grassland or fernland between 2000–2010, with another 17% between 2010–2019.



Figure 18. Forest, old and young fallows in Batang Lupar

Credit: Yves Laumonier/CIFOR

4.3 Socio-economics, livelihoods, well-being and nutrition

This section provides a summary of the main findings of the sentinel landscape socio-economic survey in the two districts concerned in Kapuas Hulu. Although belonging to the same regency, Batang Lupar and Mentebah districts have different socio-economic and cultural characteristics that may differently influence land management and economic development at each respective site.

Table 8. Village and number of households in Batang Lupar

Village	Number of households
Entebuluh	7
Kelawik	21
Keluin	10
Libung	25
Sawah	21
Sei Sedik	17
Sembawang	6
Sungai Iring	5
Sungai Long	7
Sungai Luar	20
Total	139

4.3.1 Batang Lupar

Batang Lupar is located in the northern part of Kapuas Hulu, at the border of the Malaysian state of Sarawak (Lupar River actually flows to Malaysia Sarawak). The socio-economic survey was conducted in ten randomly selected villages. **Table 8** shows the name of the villages and the number of households sampled. The area is culturally, ecologically and biologically significant, covering a biodiversity-rich forested corridor between the two national parks (Betung Kerihun National Park in the north and Danau Sentarum National Park in the south). The region is also socially and economically important; villagers have a longstanding cultural connection with the landscape as a source of livelihoods. Ethnically, local inhabitants are mostly Dayak Iban inland and Malayu in the wetlands.

In general, people in Batang Lupar live in longhouse villages, which consist of a long building containing separate family 'apartments', as well as public spaces for social life. In Dayak Iban language these partitions are called *bilik*. Each compartment represents one household, which may consist of one or more families. Originally organized



Figure 19. Late afternoon gathering in a longhouse in Batang Lupar

Credit: Alfa Simarangkir/CIFOR

in that way to better protect the village, this longhouse living arrangement offers communal living advantages like a sense of togetherness and strong social relations.

Land use

In a total area of 1,994 ha, 992 farmland plots belonged to 139 households and 925 (93%) were under cultivation; total cultivated area amounted to 1,897 ha. The majority of landowners in Batang Lupar (98%) did not have legal land ownership documentation, in the form of land certificates. The majority of plots in Batang Lupar, (63% or 622 plots, equating to 1,284 ha) were under male ownership. Women owned 316 plots (32%), totaling 654 ha, while for 54 plots (5%) or 55 ha, data was unavailable.

Histogram and density plots (see **Figures 20a and 20b**) show positive trends in the villages in terms of the number of new plots opened up each year. The first village to open up land was Entebuluh in 1935, followed by Sawah and Kelawik villages around 1940–1945. Between 1955–1960, 7 new villages settled in the area and 40 plots were cleared for farming (**Figure 20b**). Cleared land size was around 3 ha on average, and mostly within 3 km from the village.

Every 10 years after, a peak in land opening is observed. This pattern may be linked to land rotation in the swidden system, where fallow land is left for years then reused. The largest surface of land use in this village was young fallow, while food crops, mixed gardens and jungle rubber garden areas were relatively similar in size. Recently, the interval between peaks in the land-opening pattern has shortened; more plots have been cleared in recent years (2000–2014), suggesting greater population pressure on available land area.

Food security

The food security indicators used in the survey were the Household Dietary and Diversity (HDDS), Food Consumption Score (FCS), and Food Security Score (FSS) (Ballard et al. 2013; WFP and FAO 2008; Wiesmann et al. 2009). HDDS and FCS are highly correlated, so FCS results are not presented here.

HDDS is an important food security indicator as it measures the diversity of diet (Kennedy 2010). The consumption of food was collected using a 24-hour dietary recall (Swindale and Bilinsky 2006). Questions were directed towards the household members doing the cooking and focused only on food consumed

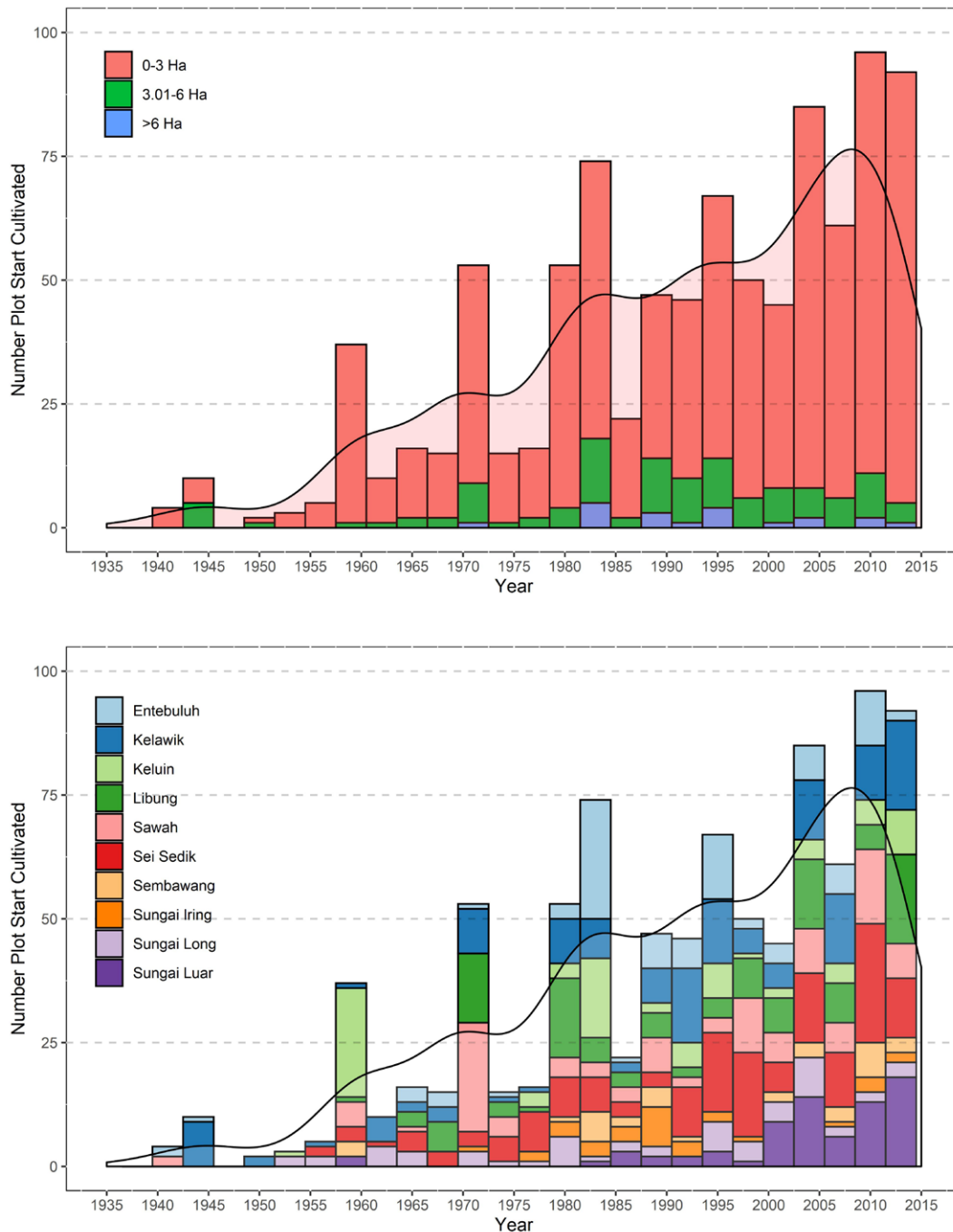


Figure 20. Distribution of newly-opened food crop fields in Batang Lupar, classified by (a) plot size and (b) village

at home. HDDS scores fall between 0–10, where a higher score means higher food diversity; good dietary diversity is >6, medium dietary diversity is 4.5–6, and low dietary diversity is <4.5 (Swindale and Bilinsky 2006).

Figure 22 shows the histogram and density plot of HDDS within Batang Lupar’s villages, with HDDS scores ranging between 1–9. 114 households (82%) in Batang Lupar had good dietary diversity, and 22 (16%) had medium

dietary diversity; few villages – Sawah, Libung, Sungai Luar and Sei Sedik – fell within the low dietary diversity category (below 3%). Overall, categorization shows that most households across this site consume more than 6 types of foods in a day.

The FSS is used to assess household food security status (Ballard et al. 2013; Efsa 2008). The score is based on the level of food security within a household, ranging from 1 to 10. A high

score means the household is food insecure. Households are considered more food insecure when, in the previous month, they experience food shortages or lacked enough money to buy food. **Figure 23** shows that most of Batang Lupar households have low FSS (scores 2 and 3 having the highest frequency), meaning that, generally, food security levels are good. Looking at income levels, there was no clear relationship between income and FSS scores; some low-income households scored 0 in terms of FSS, while some richer households had FSS of 7 and 9 (demonstrating high insecurity). This points to factors other than income being more influential on food security.

Farm typology

All of Batang Lupar's households are connected to farming. Based on the survey, 16 variables were identified to characterize their farms.



Figure 21. Rubber tree in jungle rubber garden in Batang Lupar

Credit: Yves Laumonier/CIFOR

Principal Component Analysis (PCA) was used to explore the potential household outliers for the contributing variable; PCA was iterated 3 times until it has no outlier and produced significant contributing variables. 104 households were selected, as well as 7 variables with the highest contribution for the farm typology classification. Variables focused on *household*: (1) household size; (2) number of adults; (3) household labor capacity; as well as *farm characteristics*: (4) number of plots; (5) farm size; and *economic variables*: (6) Intensification Benefit Index (IBI); and (7) Progress out of Poverty (PPI) Index (Righi et al. 2011; Madry et al. 2013; Alvarez et al. 2014; Harris 2019). Food security and nutrition variables did not contribute enough to be included.

Following the PCA, an Agglomerative Hierarchical Clustering (AHC) algorithm was used to cluster the selected households. **Figure 24** shows the biplot of the first and second aspect of the PCA, displaying 3 clusters of farm types. The horizontal axis covers 55% of the variation, while the vertical axis covers 28%. **Table 9** shows average values of each variable, for farm typology in Batang Lupar.

There were 37 households grouped in Cluster 1. Characteristics of this cluster were small household size and fewer adults, thus less labor capacity compared to other household clusters. This group also had high PPI, meaning that they were more likely to live below the poverty line. Cluster 2, consisting of 45 households, was the largest cluster. This cluster had the largest households, most adults per household, and greatest labor capacity. Average farm size in this cluster was also far bigger than in other clusters. The IBI variable of this cluster also had the highest average (0.72). This means that the ratio between personal daily income (USD/person/day) and economic returns from agriculture (USD/ha/year) is high. Cluster 3 consisted of 22 households. The value for the number of households, household size, and the number of adults in this cluster was close to the average value for all Batang Lupar farms. This cluster had the lowest values for farm characteristics, with an average of 3 plots and farm sizes averaging 2.78 ha. The IBI of this cluster was below average, meaning this cluster benefited less from farm income.

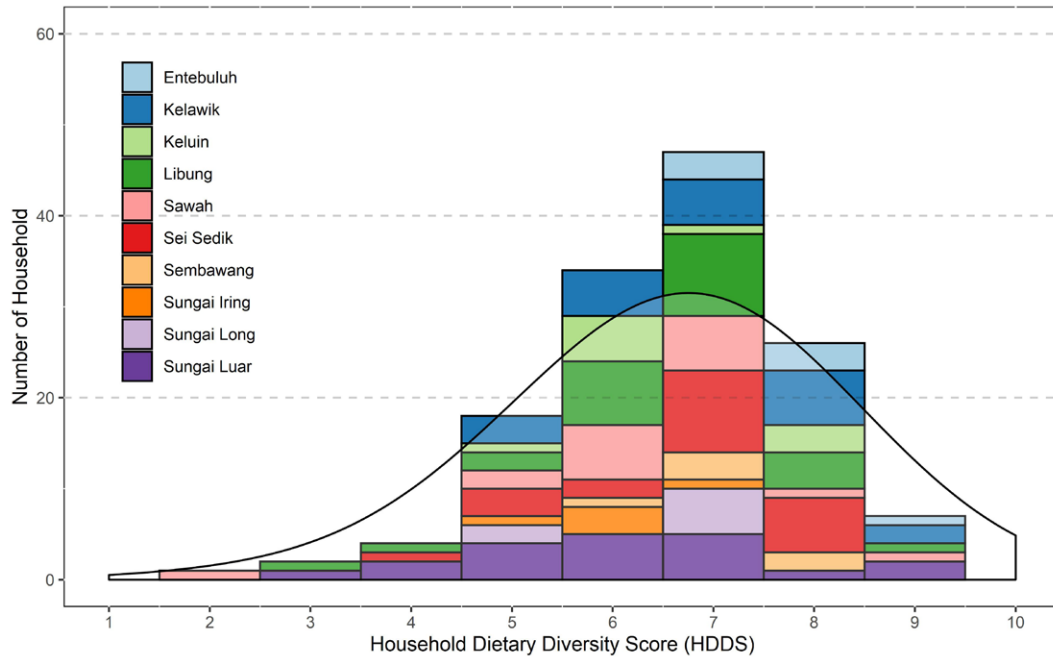


Figure 22. Histogram and density plot of households in each village in Batang Lupar, classified according to household dietary diversity

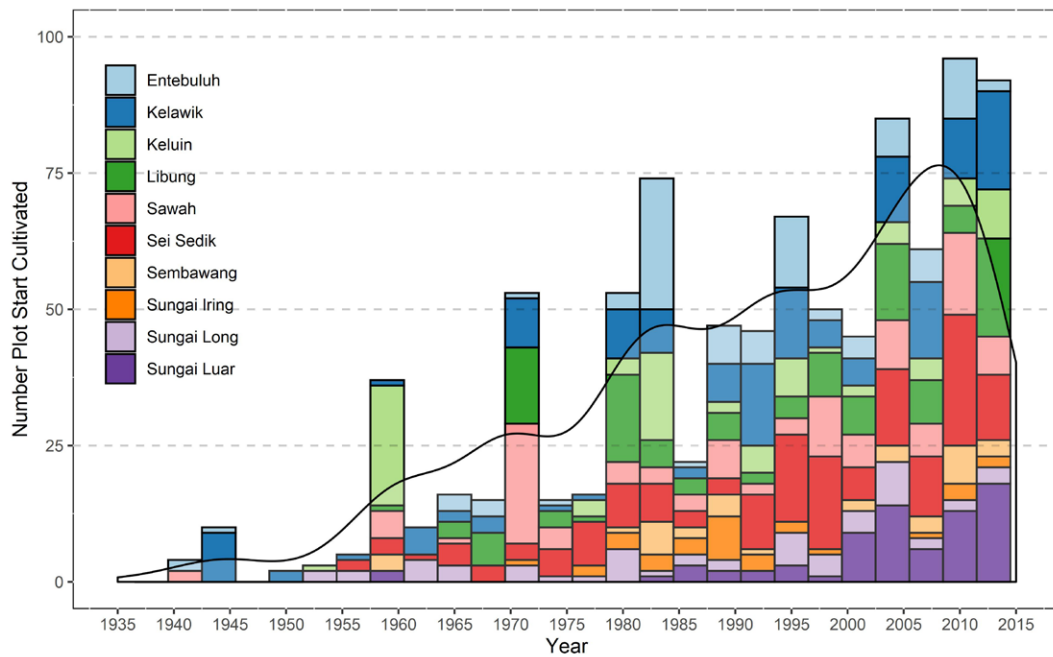


Figure 23. Histogram and density plot of households in Batang Lupar, with food security status (FSS) classification by village

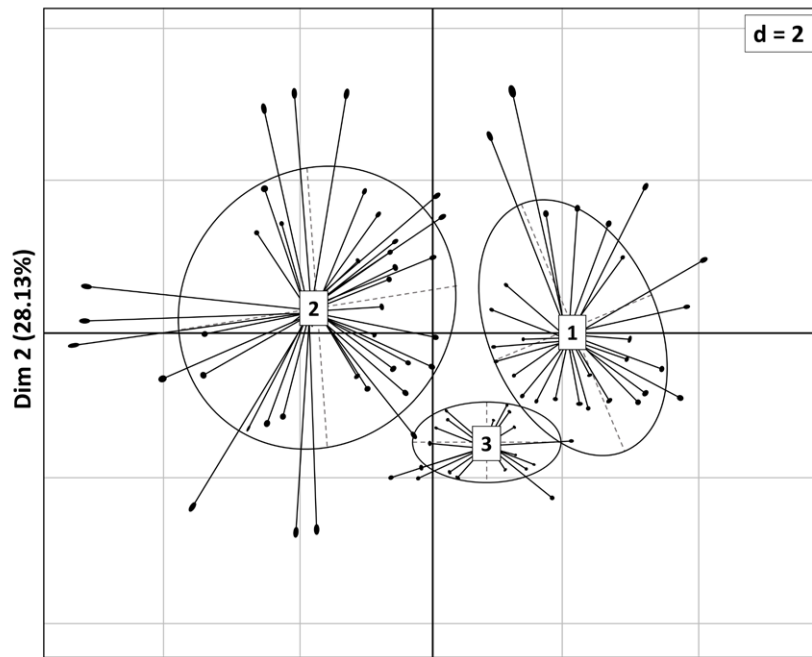


Figure 24. Biplot results in Batang Lupar

Table 9. Average values of clusters in Batang Lupar

Variable	Cluster			Total average
	1	2	3	
Number of households	37	45	22	35
Household size	2.76	5.42	4.50	4.28
Number of adults	1.92	4.04	3.09	3.09
Household labor capacity	2.18	4.39	3.57	3.43
Number of plots	4.68	7.60	3.00	5.59
Farm size (ha)	4.54	13.53	2.78	8.06
Intensification Benefit Index (IBI)	0.52	0.72	0.17	0.53
Progress out of Poverty (PPI)	40.16	27.31	27.82	31.99

4.3.2 Mentebah

Mentebah is located in the southern part of Kapuas Hulu regency. **Table 10** shows the ten randomly selected villages where households were sampled (n=300). This site represents a variety of social and economic differences, when compared to Batang Lupar. Mentebah is divided by a main road, running from Pontianak, Sintang to Putussibau, that lies between the swamps to the village’s north and the hills to its south and east. The road is relatively good and accessible throughout the year, although access to villages further away from the main road is more challenging during the rainy season.

Table 10. Village name and number of households in Mentebah

Village	Households
Akung Jaya	30
Bangan Permai	30
Emotong	30
Menarin	30
Mentebah Kiri 2	30
Padang Jaya	30
Sei Jambu	30
Sei Putih	30
Sei Tekuyung	30
Semedang	30
Total	300



Figure 25. Degraded swidden landscapes on steep slopes and poor soils in Mentebah

Credit: Yves Laumonier/CIFOR

The main ethnic group in this area is Malay, which is the second largest ethnic population in Kapuas Hulu. They identify as ‘Senganan’, originating from Kapuas Hulu as well as Sintang. This is significant because Malay from Senganan are considered different from Malay from Sambas and Pontianak; language is classified as ‘Malayic Dayak’.

In terms of land use, smallholder rubber plantations (not jungle rubber gardens) dominate this area, and swidden agriculture is still practiced. Traditional gold mining activities are relatively intensive, both in the river and on land. Land-based investment and concessions have been allocated throughout this area in the past, beginning with logging

concessions and continuing now with oil palm companies. Although the logging concessions are now inactive, local people continue with logging activities, benefiting from the good road access to Putussibau and Sintang.

Land use

In Mentebah, 948 plots of land were owned by 300 households, totaling 1,158 ha; 886 (93%) plots were cultivated. Overall, cultivated plots amounted to 1,095 ha. The proportion of land owned without legal ownership documents in Mentebah was 81% (765 ha). The majority (68%) of plots were male-owned (644 plots totaling 840 ha); 178 plots (19%) or 192 ha were owned by women.



Figure 26. Periodically waterlogged "Kerapah" forests in Mentebah

Credit: Yves Laumonier/CIFOR

Figure 27 illustrates the trend in numbers of plots opened between 1960 and 2014. The first land opening was in 1960. The trend shows an exponential growth every year thereafter, especially after 1994. Only once did the number of land openings decrease, around 2010. After this, land plot openings increased in number again until 2014. The graph does not show any pattern of swidden agriculture cycles, so it is more likely that this intensification pattern is due to population increase.

Figure 27a shows the trend of land plots opened, classified according to size. Most of the fields were opened within 3 km of the house, with very few opening further than 3 km from the village, and on average less than 3 ha in size. Looking at land use type, rubber gardens within 3 km of the village made up the largest land use; there were much fewer food crop fields than mixed garden, rubber garden, old fallow and young fallow plots.

Figure 27b shows the trend of plots opening each year, by village. The earliest plot opening was in Mentebah Kiri in 1960, followed by Bangan Permai in 1965. In general, the number of plots opened after 1994 increased significantly for all villages. Before 1994,

an average of two land plots opened in each village, with some villages having little agriculture activity, such as Akung Jaya and Sei Tekuyung. After 1994, the average number of plots opened for each village raised to 5 on average, with the highest number from Akung Jaya (n=78), Emotong (n=67), and Sei Tekuyung (n=86) villages.

Food security

There were 256 households (85%) in Mentebah classified as having a good dietary diversity, 43 (14%) households with medium dietary diversity, and a small number of households with low dietary diversity (below 3%). Overall, the categorization showed that most of the households in this site consumed more than 6 types of foods in a day.

Figure 28 shows the Histogram and density plot for HDDS, by village in Mentebah. Overall, the graph shows that HDDS among households in each village was balanced, with the average score coming in at 6–8. Most households have 6 types of foods a day. However, each village did have some households in the low HDDS category.

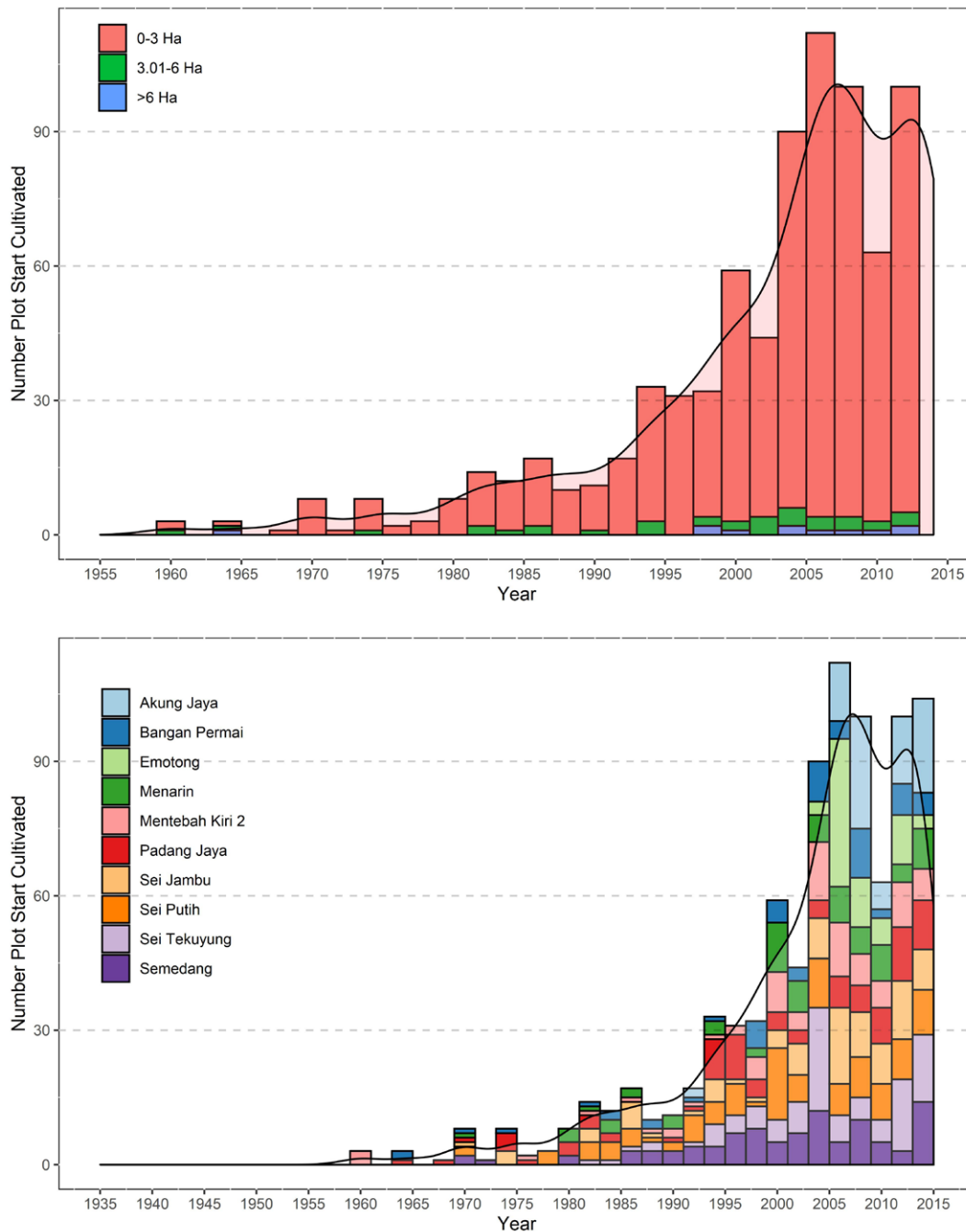


Figure 27. Histogram and density plot of land under cultivation in Mentebah, (a) by surface under cultivation, and (b) by village

Figure 29 shows the FSS distribution, by village. FSS distribution across Mentebah peaks at 1, 3, 6, 8, 9 and 10 on the scale, indicating unbalanced social-economic conditions, with some villages showing a mixture of high and low FSS. Income level was no assurance of household food security; FSS for high-income households ranged between 1 and 9. It can be assumed, therefore, that in Mentebah food security

appears to be influenced by factors other than income.

Farm typology

Not all households practiced farming; those households without farms were excluded from the analysis. PCA analysis showed 96 households which were not outliers, and 8 variables with the highest contribution to farm

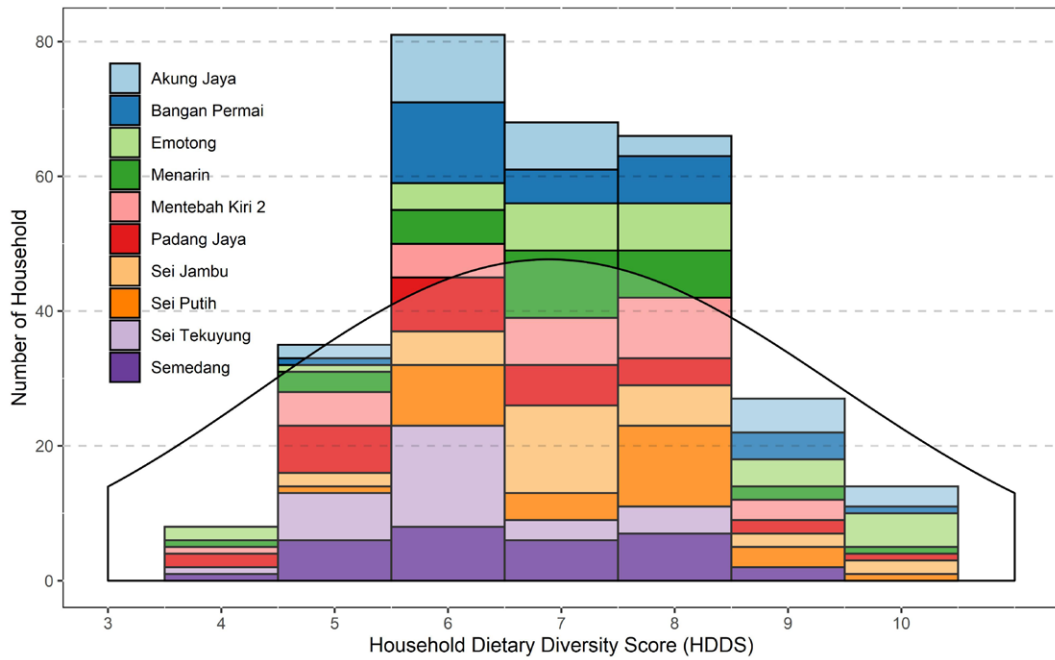


Figure 28. Histogram and density plot of HDDS, per village in Mentebah

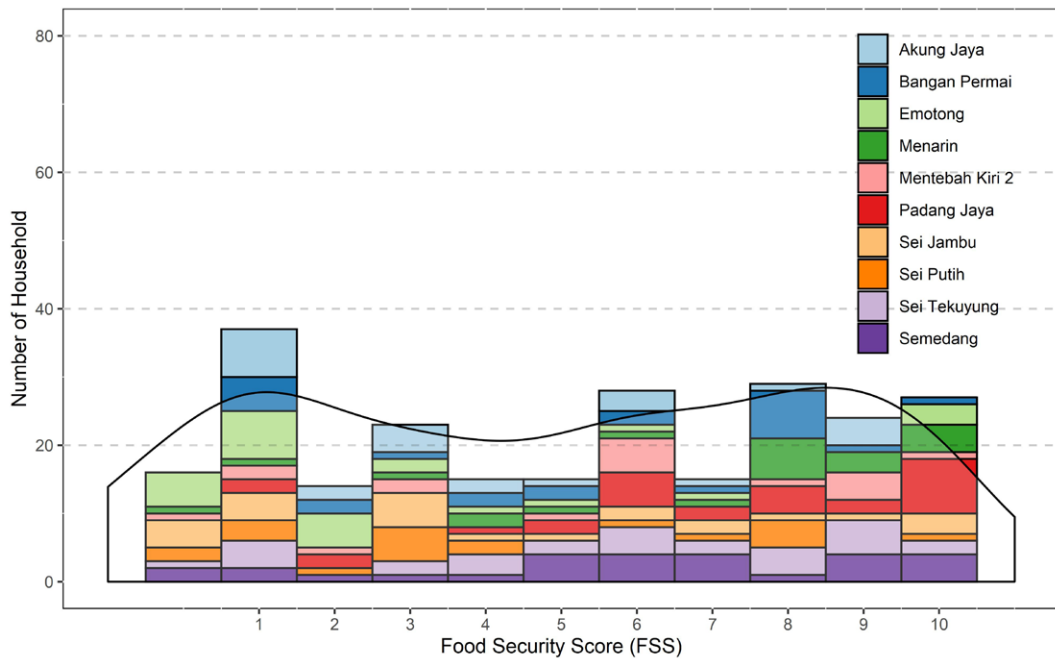


Figure 29. Histogram and density plot of FSS, per village in Mentebah

typology classification for Mentebah site. Variables were *household variables*: (1) household size, (2) number of adults, and (3) household labor capacity; *farm characteristics*: (4) number of plots and (5) farm size; and *economic variables*: (6) Household Domestic Asset (HDA) Index, (7) Intensification Benefit Index (IBI), and (8) Progress out of Poverty (PPI) Index. Food

security and nutrition variables did not have a significant influence.

Cluster 1 was the smallest in size and consisted of 37 households (Figure 30). The average of household variables in this cluster was similar to the ‘total average’ value for all farms in Mentebah (Table 11), while IBI and PPI Index results were also higher compared

to the other two clusters. Based on the PCA results, IBI and PPI Index results had weak correlation, meaning that even households with high IBI scores were more likely to live below the poverty line.

The center (average value) of Cluster 1 is in the second quadrant, Cluster 2 in the fourth quadrant, and Cluster 3 in the third quadrant. The horizontal axis explains 42% of the variation and the vertical axis explains 27%.

Cluster 2, the biggest, consisted of 168 households. This cluster had the smallest average farm size (1.9 ha). The centroid for Cluster 2 was close to the zero-coordinate, meaning almost every household variable for this cluster was close to the total average of all households' variables. The average farm size in this cluster was smaller than in the other two clusters. The PPI value was similar to that seen for Cluster 1, indicating that having either a farm of any size resulted in a high PPI score for the household.

Cluster 3, with 84 households, was the wealthiest cluster, having the lowest PPI and highest HDA scores. Other than farm-related

variables, this cluster had the highest values in each category. Farm size and number of plots were in between, compared to Cluster 1 and 2.

Overall, farm typology in Mentebah was harder to interpret due to the very diverse socio-economic conditions and the fact that many households have mixed-income sources (farm and off-farm).

4.3.3 Comparing Batang Lupar and Mentebah

Comparing based on land use

When comparing Batang Lupar and Mentebah, there were no significant differences in terms of the number of land plots opened. The total number of opened plots was similar in both sites, but the area of land opened for cultivation was 1.7 times bigger in Batang Lupar (1,897 ha) than in Mentebah (1,095 ha). Fallow land area in Batang Lupar (67 ha) was about the same in Mentebah (62 ha).

The land tenure situation is different for the two sites. The percentage of plots owned without

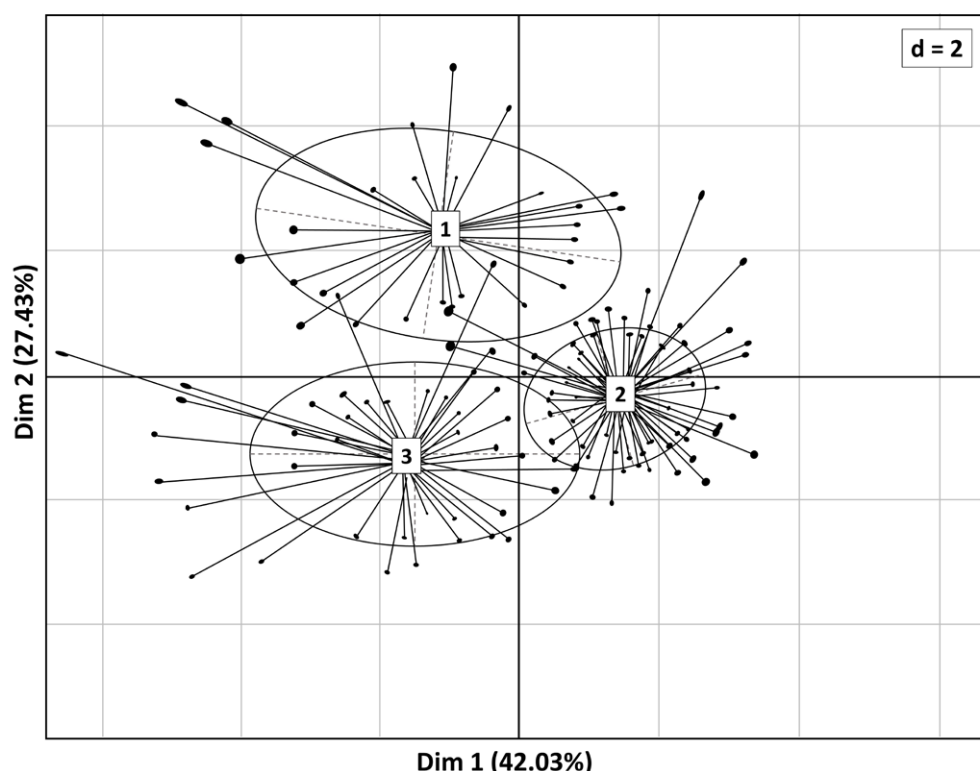


Figure 30. Biplot of Mentebah data where households are classified into 3 clusters

Table 11. Average values of farm typology variables for Mentebah

Variable	Cluster			Total average
	1	2	3	
Number of households	37	168	84	96
Household size	4.568	3.619	6.214	4.49
Number of adults	3.054	2.286	4.226	2.95
Household labor capacity	3.630	2.775	4.970	3.52
Number of plots	5.405	2.565	3.131	3.09
Farm size	9.846	1.917	3.207	3.31
HDA Index	78.516	53.223	80.418	64.37
Intensification Benefit Index (IBI)	0.608	0.156	0.141	0.21
Progress out of Poverty (PPI)	36.946	36.500	24.226	32.99

legal ownership documentation was about the same in each site, but the size of the land plots owned without legal documentation was 2.5 times higher in Batang Lupar (1,996 ha) than in Mentebah (765 ha).

There were no significant differences in terms of gender, when looking at plot ownership. Land ownership in the area is interchangeable between men and women, for diverse family reasons. The percentage of plots owned by males in both sites was about the same, while women owned plots 1.7 times more in Batang Lupar (32% of all plots) than in Mentebah (19% of all plots). The percentage of land owned without information on the owner's gender was 2.6 times less in Batang Lupar (5%), compared to Mentebah (13%).

Land for farming was first opened in 1935 in Batang Lupar, 25 years before the first plot was opened in Mentebah (1960). Land openings continued on a positive trend in both sites, however this trend was steeper in Mentebah. Despite the positive trend seen in both locations, there were some differences. The pattern of swidden plot opening in Batang Lupar increased and decreased every 5 to 10 years (see Section 3.1); however, in Mentebah, this trend continuously increased, except in 2010. Between 2005 and 2010, twice as many plots opened in Mentebah as in Batang Lupar.

An increase in the number of plots opened each year was seen in both sites, but while Batang Lupar continued to display more of a tradition of swidden agriculture, Mentebah was more associated with rapid development.

This rapid increase in plot openings in Mentebah could change the landscape and cause other socio-economic dynamics within this landscape.

Distribution of plots opened, by distance and plot size, showed that plots opened under 3 km and under 3 ha dominate both sites. In terms of distance, this shows that either people at both sites are getting older, or access to open plots further than 3 km remains difficult. In term of plot size, most households were cultivating small areas (less than 3 ha) of land.

Comparing based on food security and nutrition

Dietary diversity was almost identical in the two sites. Over 80% had high dietary diversity and less than 3% had low diversity in each site. No household at either site ate just 1 type of food in a day. In Batang Lupar, a minimum of 2 and a maximum of 9 types of food were eaten, while in Mentebah the range was between 3 and 10. Overall, HDDS scores were relatively similar, but varied more in Mentebah than in Batang Lupar.

FSS scores showed interesting results for both sites. Batang Lupar households were relatively secure, based on their FSS (with scores mostly in the 3–4 bracket) while Mentebah displayed high inequality; this site had the most high and low FSS scores.

The lowest FSS scores in Batang Lupar were seen in Sei Sidik village (where 5 households scored 0), while the highest score was seen

in the village of Sawah (where 1 household scored 10). The graph peaked between 3 and 4, where the villages of Kelawik, Libung, Sungai Luar, and Sawah dominated, with around 5 households in each village.

In Mentebah, the distribution of FSS score was spread evenly from the lowest score of 1 to the highest score of 10. 27 households had an FSS score of 10; Sei Tengkuung (11 households) and Menarin (13 households) had the highest proportion of high scores. The villages of Akung Jaya (7 households), Bangan Permai (5 households), and Emotong (7 households) had the lowest FSS scores. The village of Padang Jaya had 4 households experiencing critical food insecurity.

We can conclude that there was no significant relationship between FSS and income level; every income level displayed a variety of food security scores in both locations.

Site comparison based on farm typology

Farm typology showed that variables contributing as discriminant variables were the same in both sites. The only different was that HDA was included in Mentebah. **Figure 10** and **14** show that the relationship between each variable was about the same in each site.

The number of clusters at each site was the same (3 clusters), but the centroid location of the cluster differed. **Figure 10** and **14** show that the Cluster 2 centroid in Batang Lupar corresponded with Cluster 1 centroid in Mentebah (in the second quadrant). These clusters were characterized by farm size, number of plots, and IBI. Batang Lupar had just one cluster with low IBI scores (Cluster 3) while Mentebah had two clusters with low IBI scores (Cluster 2 and 3). This shows that even though Cluster 3 is significantly different to Cluster 2 in terms of IBI scores, PPI scores for both clusters were the same in Batang Lupar. The situation was different in Mentebah; two clusters (2 and 3) had low IBI scores, but there were significant differences in PPI scores.

The differences in IBI and PPI values help understand that clusters can be wealthy (i.e. have low PPI scores) and still have different IBI scores. This could be because Batang

Lupar households were not overly dependent on cash income. In Mentebah, whether clusters scored similarly for IBI (i.e. Clusters 2 and 3) or differently (Cluster 1 and 2, or 1 and 3), they all varied in terms of PPI score. This could be due to the diversity of household income sources, when the farm was not the only source of livelihood.

4.4 Diversity of vegetation and tree species

4.4.1 Floristics

Non-metric multidimensional scaling (NMDS) ordination for Batang Lupar and Mentebah

NMDS results for Batang Lupar and Mentebah (**Figure 31**) showed a clear distinction in species composition, with low stress value = 0.182 (meaning that NMDS analysis performs well in displaying the position of communities in reduced dimensions). The ANOSIM result was $R=0.24$, $P<0.001$. The ANOSIM R result of 0.24 means there were differences, with some overlaps. Both locations shared a few similar species (an R value closer to 1 means groups are highly different).

NMDS in Batang Lupar

It is useful to analyze the species composition of forest plots at different succession stages in Batang Lupar (**Figure 32**). Undertaking NMDS in Batang Lupar using ecological distance showed that the positions of secondary forest, young fallow and old fallow plots were distinct, confirming their difference in terms of species composition. The ANOSIM value $R=0.4$ means that there was difference, with some overlap in terms of species composition data (old fallow overlapping with young fallow). This overlapping of species composition reflects the successional process of appearance/disappearance of cohorts of species.

NMDS in Mentebah

The successional stages of forest in Mentebah were classified into young fallow, old fallow and old secondary forest. **Figure 33** shows distinct clustering. Species composition among young

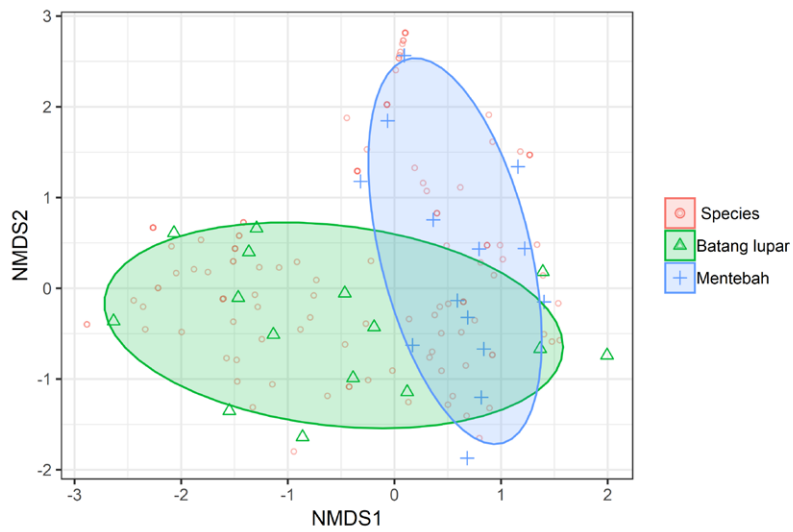


Figure 31. NMDS results of plots in Batang Lupar and Mentebah

The NMDS results show a clear distinction between species composition in Batang Lupar and Mentebah, but both locations still share a few similar species (NMDS stress: 0.182).

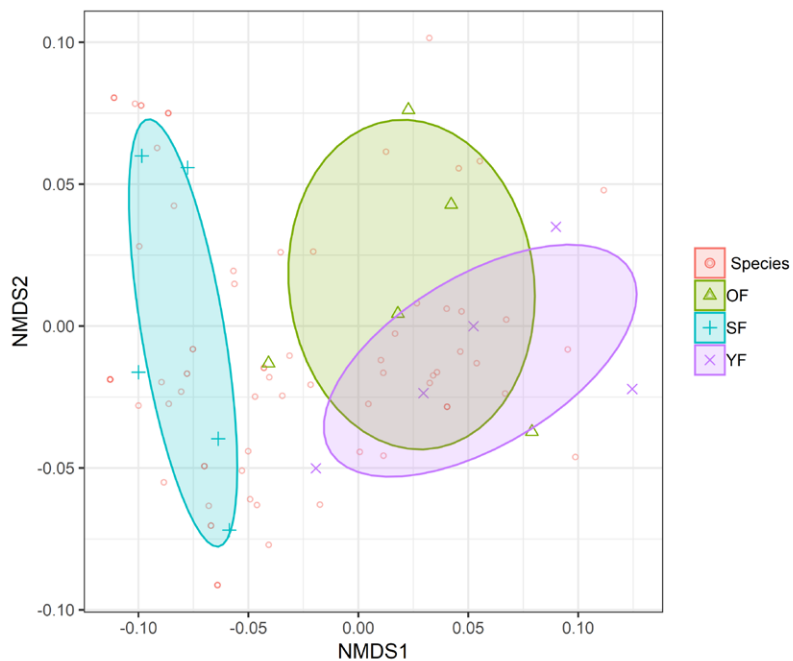


Figure 32. NMDS results for Batang Lupar

SF: secondary forest, OF: old fallow, YF: young fallow. The distinction between secondary forest, old fallow and young fallow is well established.

fallow is much more similar to old fallow than to old secondary forest. ANOSIM value $R=0.34$ means that there were differences, with some overlap in terms of species composition data (old fallow overlapping with young fallow).

These NMDS results confirm the presence of different forest types that can be further

described in terms of structure and species composition. The NMDS of different forest types and successional stages showed that old and young fallow in Mentebah and Batang Lupar were not very different, while old secondary forests in Mentebah and Batang Lupar were significantly different. The floristics of each successional stage will be described further.

4.4.2 Tree species richness and diversity

A total of 804 individual trees, belonging to 513 species ($\varnothing \geq 5$ cm), among 101 genera and 51 families were enumerated across 30 plots in Batang Lupar and Mentebah. A comparison of the species richness of the successional stages of both sites is given in **Figure 34**.

Rarefaction curves for tree species

The rarefaction curve (**Figure 35**) leveled faster for Batang Lupar young fallow ($n = 82$). Thirty plots (1.2 ha in total) were surveyed for secondary forest, young and old and fallow. The richest plots in terms of species were Mentebah's old secondary forest, while Mentebah's young fallow scored lowest on this aspect.

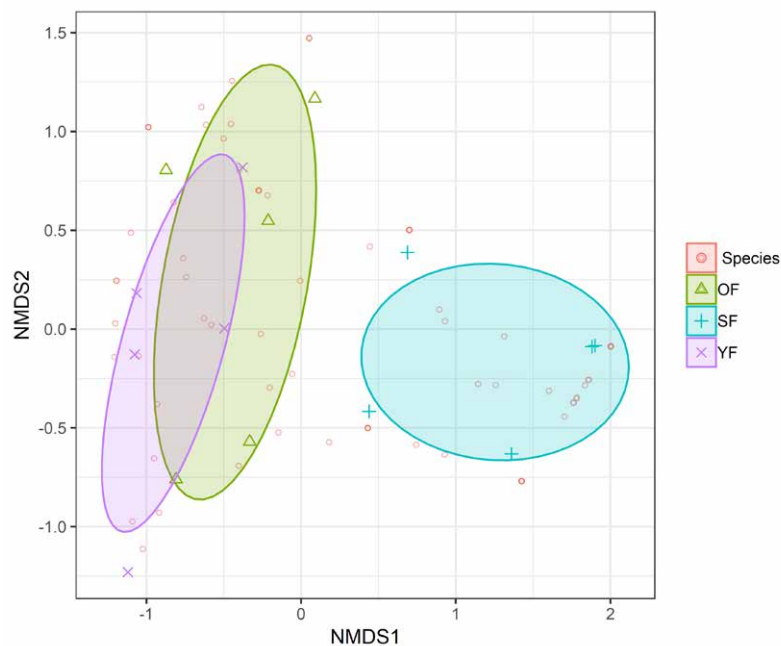


Figure 33. NMDS ordination results for Mentebah

SF: secondary forest, OF: old fallow, YF: young fallow.

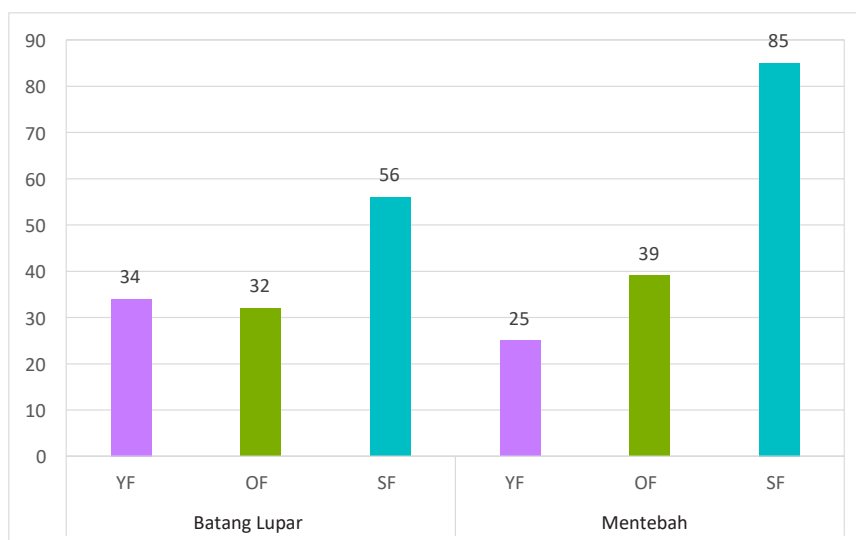


Figure 34. Comparison of species richness for successional vegetation stages in Mentebah and Batang Lupar

YF: young fallow, OF: old fallow, SF: secondary forest.

Batang Lupar – tree species richness and diversity

In Batang Lupar, the Euphorbiaceae family had the most species (6) followed by Anacardiaceae (5); Phyllanthaceae (5); Burseraceae, Fabaceae, Lauraceae and Myrtaceae (4 species each); Calophyllaceae, Hypericaceae, Moraceae and Sapindaceae (3); Annonaceae, Clusiaceae, Cornaceae, Melastomataceae, Myristicaceae, Pentaphylacaceae and Rubiaceae (2). 24 families had just a single species in the study area. Based on forest succession stage (Table 12), 82 individuals were recorded in young fallow, belonging to 34 species among 30 genera and 25 families; 112 individuals belonging to 32 species among 30 genera and 26 families were recorded in old fallow; while in

secondary forest, 163 individuals belonging to 56 species among 46 genera and 33 families.

The Shannon-Weiner index (H') revealed that the highest diversity of tree species was found in secondary forest (3.75), with the lowest diversity seen in old fallow (3.25).

Mentebah – tree species richness and diversity

In Mentebah, the Dipterocarpaceae family had the most species (18), followed by Lauraceae and Moraceae (8 species each); Euphorbiaceae, Myristicaceae and Phyllanthaceae (6); Sapindaceae (5); Anacardiaceae, Annonaceae, Malvaceae and Myrtaceae (4); Cornaceae, Elaeocarpaceae, Hypericaceae, Sapotaceae

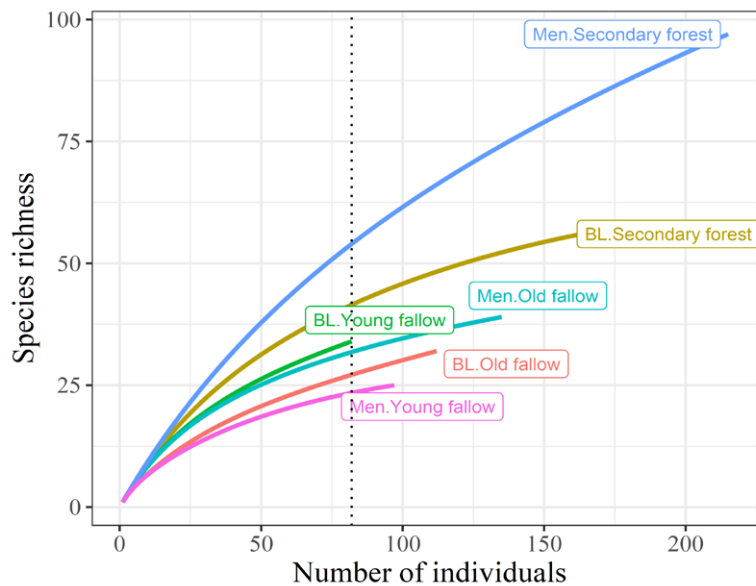


Figure 35. Rarefaction curves for tree sampling in Batang Lupar and Mentebah

Table 12. Batang Lupar floristic richness, number of individual trees and diversity indices

Variables	Batang Lupar		
	Young fallow	Old fallow	Secondary forest
No. of individuals	82	112	163
No. of species	34	32	56
No. of genera	30	30	46
No. of families	25	26	33
Density (ha)	410	560	815
Basal area (m ² /ha)	7.3	10.5	30.2
Shannon-Weiner	3.25	2.72	3.75
Fisher's α	21.77	14.97	30.15
Berger-Parker	0.11	0.34	0.06

(3); Apocynaceae, Burseraceae, Ebenaceae, Fabaceae, Lecythidaceae, Polygalaceae, Rubiaceae (2); 20 families had just a single species in the study area.

In young fallow plots, 97 individuals belonging to 25 species among 22 genera and 20 families were recorded (Table 13). 135 individuals belonging to 39 species among 30 genera and 23 families were recorded in old fallow plots, while secondary forest plots had 192 individuals belonging to 85 species among 55 genera and 32 families.

The Shannon-Weiner index (H') showed that the highest diversity of tree species was found in secondary forest (4.16), with the lowest diversity seen in young fallow (2.58). The Berger-Parker value was highest in young fallow explaining the lower diversity of species.

4.4.3 Importance Value index

Batang Lupar – Importance Value index

The species with the highest Importance Value index in Batang Lupar young fallow (Table 14) was *Ixonanthes petiolaris*. This species is found in primary forest, but more frequently in secondary regrowth on hillsides and ridges. In

Table 13. Mentebah – floristic richness, number of individual trees and diversity indices

Variables	Mentebah		
	Young fallow	Old fallow	Secondary forest
No. of species	25	39	85
No. of genera	22	30	55
No. of families	20	23	32
No. of individuals	97	135	192
Density (ha)	485	675	960
Basal area (m ² /ha)	2.50	7.50	35.30
Shannon-Weiner	2.58	3.31	4.16
Fisher's α	10.91	18.38	58.38
Berger-Parker	0.31	0.09	0.06

old fallow, *Adinandra dumosa* was the most striking. This species is known to adapt best to open conditions, poorly aerated soil and restricted supply of nutrients, and often occurs in secondary lowland to montane vegetation. Old secondary forest was best represented by *Shorea macrophylla*, one of the fastest growing Shorea species (Surianegara et al. 1994).

Mentebah – Importance Value index

The species with the highest Importance Value index (Table 15) in Mentebah's young fallow was *Cratoxylum glaucum*; this species usually grows in acid peat soils and in Kerangas forest on leached sandy soils. In old fallow, as it was for Batang Lupar, *Ixonanthes petiolaris* was most important. Old secondary forest was dominated by *Shorea beccariana*, commonly seen growing in deeply leached soils in lowlands and on shale or sandstone ridges (Surianegara et al. 1994).

A search for indicator species – species whose presence, absence or abundance reflect a specific environmental condition – showed significant possible indicator tree species for Mentebah and Batang Lupar (Figure 36). In Batang Lupar, *Crypteronia cumingii* (and the other tree species for which $A = 1$) was the best indicator, because it was limited to and can only be found in Batang

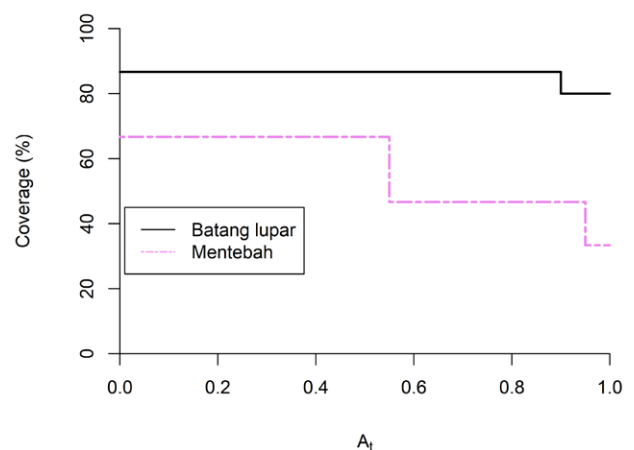


Figure 36. Tree 'coverage' for Batang Lupar and Mentebah

Lines for indicator species represent the coverage level of the species in the site. For each A_t value, valid indicators were determined, to compare the lower boundary of the 95% confidence interval for A with A_t .

Table 14. The ten most 'important' species of in young fallow (YF), old fallow (OF) and secondary forest (SF) in Batang Lupar

No.	Species	Density	Frequency	Dominance	IVI	Site
1	<i>Ixonanthes petiolaris</i>	5	3	0.205	26.357	YF
2	<i>Syzygium fastigiatum</i>	1	1	0.233	19.219	YF
3	<i>Adinandra dumosa</i>	4	3	0.114	18.922	YF
4	<i>Pternandra cordifolia</i>	7	2	0.080	18.135	YF
5	<i>Syzygium sp.</i>	3	2	0.148	17.948	YF
6	<i>Canarium caudatum</i>	9	1	0.068	17.714	YF
7	<i>Flacourtia sp.</i>	2	2	0.105	13.795	YF
8	<i>Bellucia pentamera</i>	5	2	0.033	12.495	YF
9	<i>Macaranga gigantea</i>	4	3	0.014	12.056	YF
10	<i>Dillenia suffruticosa</i>	6	1	0.026	11.146	YF
1	<i>Adinandra dumosa</i>	38	3	0.913	84.099	OF
2	<i>Crypteronia cumingii</i>	7	4	0.147	22.328	OF
3	<i>Syzygium sp.</i>	4	3	0.220	20.852	OF
4	<i>Cratoxylum glaucum</i>	6	2	0.056	12.557	OF
5	<i>Bellucia pentamera</i>	4	3	0.018	11.238	OF
6	<i>Litsea elliptica</i>	7	1	0.050	10.914	OF
7	<i>Artocarpus kemando</i>	6	1	0.051	10.063	OF
8	<i>Antidesma leucopodum</i>	5	1	0.044	8.814	OF
9	<i>Ixonanthes petiolaris</i>	3	2	0.032	8.724	OF
10	<i>Calophyllum tacamahaca</i>	2	2	0.049	8.660	OF
1	<i>Shorea macrophylla</i>	10	2	1.208	28.570	SF
2	<i>Tristaniaopsis whiteana</i>	8	1	1.089	24.159	SF
3	<i>Chionanthus nitens</i>	10	3	0.660	20.712	SF
4	<i>Hevea brasiliensis</i>	4	2	0.330	10.355	SF
5	<i>Dialium platysepalum</i>	8	2	0.111	9.184	SF
6	<i>Palaquium dasyphyllum</i>	4	4	0.086	8.754	SF
7	<i>Symplocos fasciculata</i>	7	1	0.157	8.110	SF
8	<i>Knema kunstleri</i>	7	2	0.067	7.838	SF
9	<i>Santiria laevigata</i>	4	2	0.136	7.150	SF
10	<i>Calophyllum pseudomole</i>	1	1	0.312	6.991	SF

Lupar sites (Table 16). *Crypteronia* species are quite rare and found scattered in primary rainforest. In Mentebah, the best indicator was *Artocarpus nitidus* and *Elaeocarpus floribundus*, both of which have edible fruits. Although both of these (and the rest of the tree species which $A = 1$) could be good indicators for Mentebah, they are quite infrequent in numbers ($B < 0.3$).

Percentage of indicator species

Figure 37 demonstrates that a larger number of species with higher specificity – that could therefore be considered good indicators eventually – were found in old secondary forest than in young fallow and old fallow (in both Batang Lupar and Mentebah). This indicates that 'older' succession stages have more diagnostic value.

Table 15. The ten most 'important' species of young fallow (YF), old fallow (OF) and secondary forest (SF) in Mentebah

No.	Species	Density	Frequency	Dominance	IVI	Site
1	<i>Cratoxylum glaucum</i>	30	2	0.172	69.546	YF
2	<i>Glochidion rubrum</i>	12	3	0.039	27.264	YF
3	<i>Vitex pinnata</i>	10	3	0.039	25.280	YF
4	<i>Ixonanthes petiolaris</i>	4	3	0.022	15.843	YF
5	<i>Barringtonia pendula</i>	5	2	0.017	13.332	YF
6	<i>Endospermum diadenum</i>	3	2	0.027	13.324	YF
7	<i>Vernonia arborea</i>	2	2	0.026	12.076	YF
8	<i>Cratoxylum arborescens</i>	2	2	0.024	11.566	YF
9	<i>Alstonia scholaris</i>	4	1	0.022	10.895	YF
10	<i>Nephelium ake</i>	3	2	0.011	10.035	YF
1	<i>Ixonanthes petiolaris</i>	8	4	0.193	25.871	OF
2	<i>Artocarpus odoratissimus</i>	11	2	0.155	22.017	OF
3	<i>Cratoxylum arborescens</i>	7	2	0.185	21.037	OF
4	<i>Bellucia pentamera</i>	12	3	0.084	19.818	OF
5	<i>Homalanthus populifolius</i>	11	2	0.092	17.835	OF
6	<i>Ilex cissoidea</i>	10	1	0.112	16.621	OF
7	<i>Endospermum diadenum</i>	4	3	0.069	12.917	OF
8	<i>Vitex pinnata</i>	6	3	0.031	11.869	OF
9	<i>Macaranga gigantean</i>	6	2	0.055	11.672	OF
10	<i>Cratoxylum glaucum</i>	3	2	0.046	8.836	OF
1	<i>Shorea beccariana</i>	2	1	1.004	16.174	SF
2	<i>Litsea sp.2</i>	6	2	0.511	12.175	SF
3	<i>Shorea laevis</i>	11	3	0.248	11.950	SF
4	<i>Shorea sagittata</i>	6	2	0.451	11.328	SF
5	<i>Hopea myrtifolia</i>	4	2	0.432	10.009	SF
6	<i>Ryparosa caesia</i>	5	2	0.329	9.070	SF
7	<i>Cratoxylum arborescens</i>	2	2	0.399	8.501	SF
8	<i>Santiria rubiginosa</i>	8	2	0.151	8.109	SF
9	<i>Shorea dasyphylla</i>	2	1	0.382	7.365	SF
10	<i>Cryptocarya sp.</i>	7	1	0.190	7.244	SF

Batang Lupar

Based on the sampling intensity in this study, the five best indicator species in Batang Lupar were: *Crypteronia cumingii*, *Flacourtia* sp, *Syzygium* sp, *Adinandra dumosa* and *Calophyllum tacamahaca*. In old fallow, the IVI index order of each species was 2nd, 11th, 3rd, 1st and 10th of 32 species. *Calophyllum tacamahaca* was also present in secondary forest, with an IVI index order of 21st of 56 species. It is noteworthy that the best indicator species in

Batang Lupar was not *Adinandra dumosa* but *Crypteronia cumingii*, even this latter species dominated the entire site of Batang Lupar (IVI = 84.1). This is because IVI only examines the sum of species dominance, abundance and frequency; indicator species analysis, however, looks into the relationship between occurrence and abundance of species, to determine specific species that can be used to represent habitat types. An indicator species may have a high IVI value, but that high IVI value does not mean that a species is necessarily a good indicator of habitat.

Table 16. List of potential indicator species in Mentebah and Batang Lupar and IUCN assessment for each indicator species

Site	Species	A	B	stat	p.value	IUCN
Batang Lupar	<i>Crypteronia cumingii</i>	1	0.4	0.632	0.001***	-
	<i>Flacourtia sp.</i>	1	0.333	0.577	0.002**	-
	<i>Syzygium sp.</i>	1	0.333	0.577	0.002**	-
	<i>Adinandra dumosa</i>	0.762	0.4	0.552	0.013*	E
	<i>Calophyllum tacamahaca</i>	1	0.266	0.516	0.001***	-
	<i>Chionanthus nitens</i>	1	0.266	0.516	0.003**	-
	<i>Baccaurea polyneura</i>	1	0.2	0.447	0.014*	-
	<i>Buchanania sessilifolia</i>	1	0.2	0.447	0.012*	-
	<i>Knema kunstleri</i>	1	0.2	0.447	0.012*	-
	<i>Pternandra cordifolia</i>	1	0.2	0.447	0.017*	-
	<i>Shorea macrophylla</i>	1	0.2	0.447	0.01**	-
	<i>Canarium caudatum</i>	0.914	0.2	0.428	0.018*	-
	<i>Baccaurea minor</i>	0.75	0.2	0.387	0.037*	-
	<i>Symplocos fasciculata</i>	0.930	0.133	0.352	0.048*	-
<i>Santiria laevigata</i>	0.914	0.133	0.349	0.043*	LC	
Mentebah	<i>Artocarpus nitidus</i>	1	0.266	0.516	0.001***	-
	<i>Elaeocarpus floribundus</i>	1	0.266	0.516	0.002**	-
	<i>Glochidion rubrum</i>	0.928	0.266	0.498	0.004**	-
	<i>Santiria rubiginosa</i>	0.822	0.266	0.468	0.011*	-
	<i>Barringtonia lanceolata</i>	1	0.2	0.447	0.011*	-
	<i>Dacryodes costata</i>	1	0.2	0.447	0.011*	LC
	<i>Hopea myrtifolia</i>	1	0.2	0.447	0.011*	-
	<i>Knema percoriacea</i>	1	0.2	0.447	0.015*	-
	<i>Nephelium ake</i>	1	0.2	0.447	0.011*	-
	<i>Shorea sp.</i>	1	0.2	0.447	0.011*	-
	<i>Vatica micrantha</i>	1	0.2	0.447	0.011*	-
	<i>Xanthophyllum stipitatum</i>	1	0.2	0.447	0.011*	-
	<i>Homalanthus populifolius</i>	0.967	0.133	0.359	0.049*	-

Endangered (E), Least Concern (LC), Least Concern/Lower Risk (LR/LC), Near Threatened (NT), Vulnerable (V) (IUCN 2019)

Mentebah

Based on the sampling intensity, in Mentebah the 4 best indicator species were present not only in secondary forest, but also in old and young fallow. In secondary forest, these were *Artocarpus nitidus*, *Elaeocarpus floribundus*, *Santiria rubiginosa* and *Barringtonia lanceolata*; out of 85 species in the IVI index, these species ranked 66th, 41st, 8th and 19th. In old fallow, *Artocarpus nitidus* was the only indicator species, with an IVI order of 25th out of 39 species. In young fallow, *Artocarpus nitidus* was also the only indicator species, with an IVI order of 15th out of 25 species.

Indicator species results for Mentebah showed that IVI value alone is insufficient to decide about the most representative species of a site.

4.4.4 Structure

Tree diameter distribution and disturbance intensity

As expected, young fallow at both sites showed the highest density for the small diameter class of trees (**Figure 38**). In Batang Lupar, density values per diameter classes are very similar for old fallow,

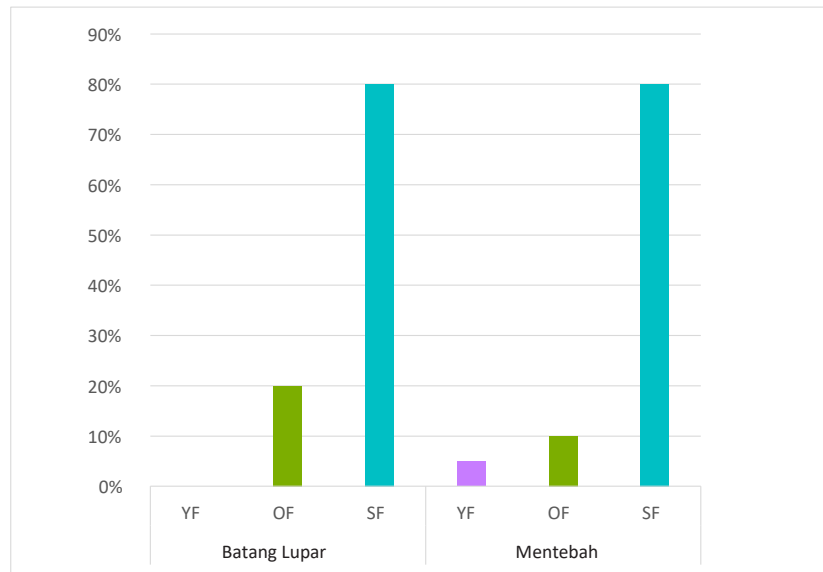


Figure 37. The percentage of potential indicator species relative to the forest succession stage

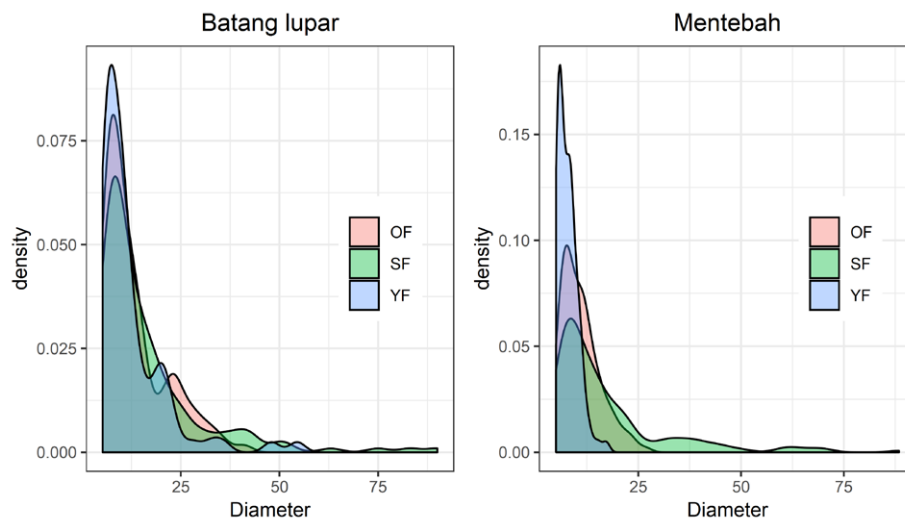


Figure 38. Diameter density distribution in each site

YF= young fallow, OF= old fallow, SF= secondary forest.

secondary forest and young fallow, while in Mentebah, differences are striking. The number of trees recorded in each successional stage in Batang Lupar was also higher, compared to Mentebah.

The level of disturbance – mainly because of timber extraction for housing and the local market – is evidenced by the pattern of diameter class distribution (**Figure 40**). The shape of the diameter distribution histogram in Mentebah indicates that disturbance is higher there; people use more wood from the old fallows as the (previously logged) forest is difficult to access nowadays, with former logging roads gradually disappearing.

Aboveground biomass

Average biomass in young and old fallows in Batang Lupar was higher than those in Mentebah (**Table 17**). Trees with diameters above 50 cm were frequently found in young fallows in Batang Lupar, often because they were considered too hard to cut (*Koompasia*) or because they had food value (*Artocarpus*).

The total amount of biomass was similar in both locations (**Figure 41**). As expected, biomass was higher in old secondary forest, but young and old fallow in Batang Lupar are much denser and have higher biomass value, compared to Mentebah.

Aboveground biomass comparison

ANOVA pairwise comparison tests for young fallow, old fallow and secondary forest biomass (Figure 43), showed that in Batang Lupar, young and old fallow were not significantly different, while in Mentebah they were. Aboveground biomass was quite high in secondary forest sites, compared to old and young fallow, thus indicating that old secondary forest sites had carbon sequestration value.



Figure 39. A traditional wooden press to extract the tengkawang (illipe nut) oil from the nuts

Credit: Alfa Simarangkir/CIFOR

4.5 Key differences in the socio-ecological trajectories of Batang Lupar and Mentebah sites

The differences in development trajectories are linked to different socio-ecological and historical contexts. Batang Lupar sentinel site is located in the vicinity of two national parks, where land is more restricted, as communities face unclear boundaries with Betung Kerihun National Park to the north and, to a lesser extent, Danau Sentarum National Park to the south. All villages are mostly inhabited by ethnic Dayak (Kantu, Iban and Maloh) who demonstrate stronger customary behavior than Mentebah communities in the south. The communities are more dependent on forest resources for both timber and non-timber forest products. Rubber production and other agroforestry commodities are also important, like fishing; while local employment opportunities are relatively limited, mainly to government roles like education, with few employment opportunities for traders and merchants. Some communities support the development of oil palm plantations expanding from the west, with the prospect of development and employment opportunities which have been lacking since the demise of local timber concessions. Others are less receptive, fearing the negative impacts of logging operations in the past may rematerialize under oil palm plantations. This is occasionally a source of conflict between villages, over land-use and access.

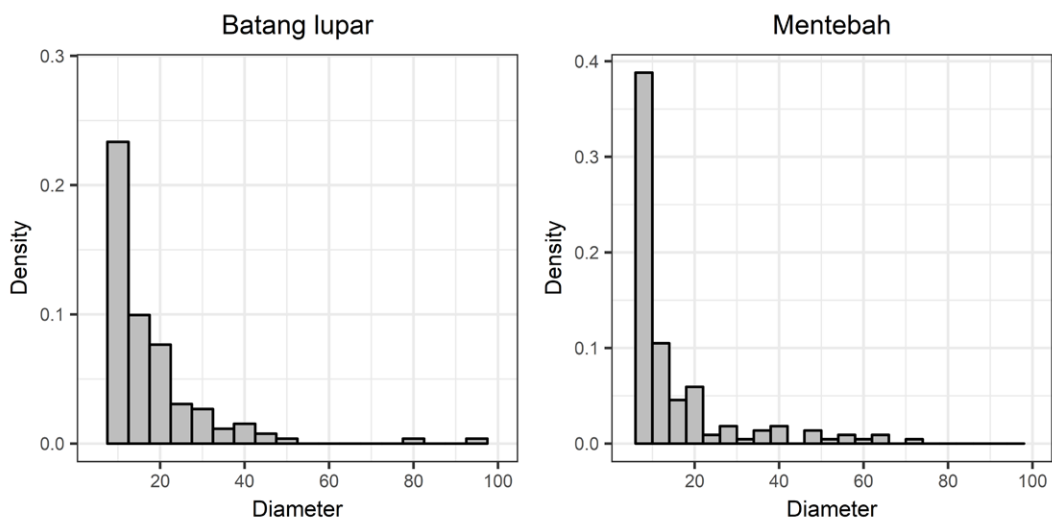


Figure 40. Diameter frequency distribution in Batang Lupar and Mentebah

Table 17. Total aboveground biomass per plot (in C Mg ha⁻¹)

Site	Fallow period	Diameter				Total
		Ø 5 - 10 cm	Ø 10 - 30 cm	Ø 30 - 50 cm	Ø 50+ cm	
Batang Lupar	Young fallow	0.664	4.549	5.03	3.627	13.87
	Old fallow	0.886	9.283	6.409		16.578
	Secondary forest	1.205	12.071	17.746	38.453	69.475
Mentebah	Young fallow	1.11	0.899			2.009
	Old fallow	1.074	7.045			8.119
	Secondary forest	1.646	14.103	23.34	35.246	74.335

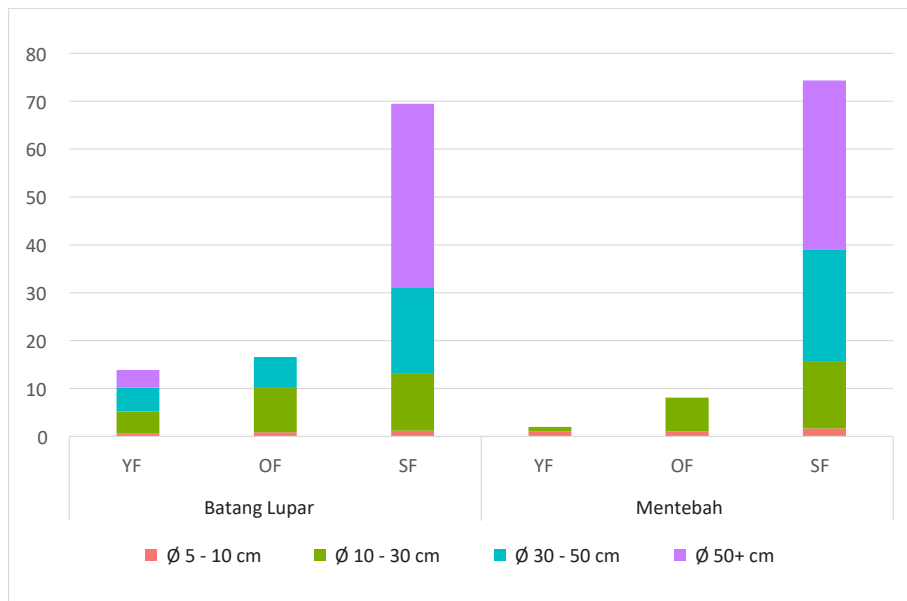


Figure 41. Total aboveground biomass in Batang Lupar and Mentebah



Figure 42. Iban men extracting fiber from bark to make ropes

Credit: Alfa Simarangkir/CIFOR

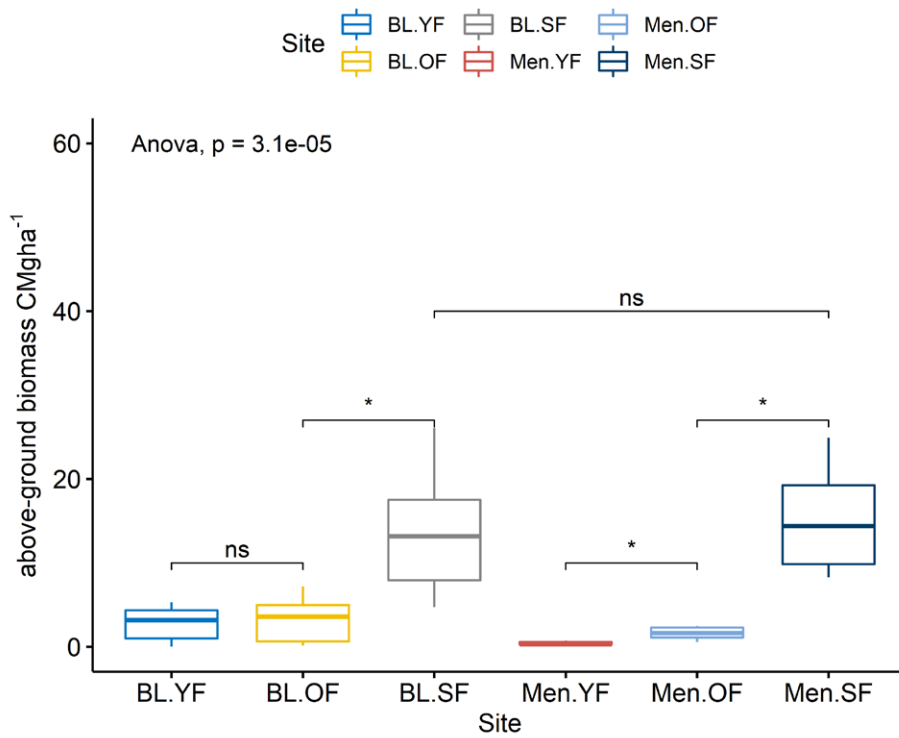


Figure 43. ANOVA biomass comparisons for Batang Lupar and Mentebah

(p-value=0.000031) BL: Batang Lupar, Men: Mentebah, YF: young fallow, OF: old fallow, SF: secondary forest.



Figure 44. Iban man working on traditional Bemban basketry

Credit: Alfa Simarangkir/CIFOR



Figure 45. Oil palm concession with remnant peat swamp forest in Mentebah

Credit: Yves Laumonier/CIFOR

In the Mentebah sentinel site in the south, villages are mostly Malayu, especially in the flatter areas near the Kapuas river; Dayak villages are relatively remote, being on the foothills. Gold mining is an economically important activity here; communities are more dependent on it than in Batang Lupar, and much less dependent on forest resources. Dryland farming, predominately for subsistence foods, coupled with rubber production, are the main land uses. Paddy and vegetable gardens are limited, as communities can buy agricultural produce from neighboring villages using cash earned from rubber, mining and, increasingly, employment by oil palm plantations, as there are generally good road networks. Some

villages do have difficult access, however, particularly during the rainy season. The main issue facing communities and the government is the level of mining activity in the area, which has serious environmental and social impacts, as well as impacts on agriculture practices. Mining causes sedimentation and water pollution, which are detrimental to the ecosystem and human health. However, it does provide a significant source of income, for which there are few alternatives. Timber production is now minimal, having been more prolific in the past. Mentebah is, in some respects, more economically developed, with income from employment and rubber outweighing subsistence farming and non-timber forest product processing.

5 Conclusion

Although lessons learnt from other research and development projects could have been reviewed in more detail before this sentinel landscape was established, this compilation and preliminary analysis of CIFOR data for one of the sentinel landscape observatory has, at least, set the baseline for future monitoring of forests, trees, smallholder farms, industrial agriculture and settlement dynamics in this region of Borneo. The regency of Kapuas Hulu, where the Borneo sentinel sites are located, is of utmost importance as a water reservoir to the western part of the province, including the capital city of Pontianak. With forest cover of almost 80% in 2019, the regency represents the last forest frontier of West Kalimantan province. It is part of the Heart of Borneo initiative and a reservoir of unique and intact flora and fauna similar to that of Sarawak landscapes where forest has been significantly damaged and habitat degradation has been more intense. The very diverse forest types and socio-ecological conditions in Kapuas Hulu highlight weaknesses in the original sampling, and a necessity to increase these to a minimum of

4 to 5 windows of 100 km², for this area of approximately 30,000 km².

In the future, to minimize deforestation and degradation in the area without jeopardizing development and public well-being, continuing to enhance the institutional capacity of partner research organizations is recommended. Working closely with local government and communities through multi-stakeholder platforms will continue to be crucial, but for efficient monitoring, it is central to revisit former biophysical and social sampling locations to assess the ecosystems' resilience potential and smallholder communities' capacity to adapt and cope with possible future shocks. Critical research pathways, built on existing data, should encompass more research on: commodity value chains, markets and economics; ecosystem functions, mainly related to the relationship between trees, soil and water; and participatory modelling to help decision-making processes, including enabling conditions for the development of 'payments for environmental services' (PES).

6 References

- Aglionby J. 2010. *Danau Sentarum National Park, Indonesia: A historical overview*. Borneo Research Bulletin 41:20–35.
- Ahlgvist T and Rhisiart M. 2015. *Emerging pathways for critical futures research: Changing contexts and impacts of social theory*. *Futures* 71:91–104.
- Alvarez S, Paas W, Descheemaeker K, Tiftonell P and Groot J. 2014. *Constructing typologies, a way to deal with farm diversity: General guidelines for the humidtropics*. Report for the CGIAR Research Program Humidtropics. Oyo, Nigeria: IITA (International Institute of Tropical Agriculture).
- Álvarez A and Ritchey T. 2015. *Applications of general morphological analysis*. *Acta Morphologica Generalis* 4(1):1–40.
- Bakkegaard, R.K., Hogarth N.J., Bong I.W., Bosselmann A.S., and S. Wunder. 2017. *Measuring forest and wild product contributions to household welfare: Testing a scalable household survey instrument in Indonesia*. *Forest Policy and Economics* 84 (2017) 20–28.
- Ballard T, Kepple A and Cafiero C. 2013. *The food insecurity experience scale: Development of a global standard for monitoring hunger worldwide*. FAO Technical Paper Version 1.1. Rome: FAO (Food and Agriculture Organization of the United Nations).
- Berkhout F and Hertin J. 2002. *Foresight futures scenarios: Developing and applying a participative strategic planning tool*. *Greener Management International* (37):37–52.
- Boissière M, Herold M, Atmadja S and Sheil D. 2017. *The feasibility of local participation in Measuring, Reporting and Verification (PMRV) for REDD+*. *PLoS ONE* 12(5): e0176897. <https://doi.org/10.1371/journal.pone.0176897>
- Bourgeois R, Liswanti N, Mukasa C, Zamora A, Herawati T, Monterroso I, Mshale B, Banjade MR, Mwangi E and Larson A. 2017a. *Guide for co-elaboration of scenarios: Building shared understanding and joint action for reform and security of forest tenure*. Bogor, Indonesia: CIFOR.
- Bourgeois R, Penunia E, Bisht S and Boruk D. 2017b. *Foresight for all: Co-elaborative scenario building and empowerment*. *Technological Forecasting and Social Change* 124:178–88.
- [BPS Kapuas Hulu] Badan Pusat Statistik Kabupaten Kapuas Hulu. 2020. *Kabupaten Kapuas Hulu*. Kapuas Hulu, Indonesia: BPS Kapuas Hulu.
- Cáceres M and Jansen F. 2016. *Package Indicspecies*. CRAN.
- Cáceres M, Legendre P, Wiser S and Brotons L. 2012. *Using species combinations in indicator value analyses*. *Methods in Ecology and Evolution* 3(6):973–82.
- Chave J, Réjou-Méchain M, Búrquez A, Chidumayo E, Colgan M, Delitti, W, Duque A, Eid T, Fearnside P, Goodman R et al. (2014). *Improved allometric models to estimate the aboveground biomass of tropical trees*. *Global Change Biology* 20(10):3177–3190. <https://doi.org/10.1111/gcb.12629>
- Clarke K. 1993. *Non-parametric multivariate analyses of changes in community structure*. *Australian Journal of Ecology* 18(1988):117–43.
- Clerc J. 2012. *Unpacking tenure security: Development of a conceptual framework and application to the case of oil palm expansion on customary land in Kapuas Hulu district, West Kalimantan, Indonesia*.

- Working paper no. 102. Bogor, Indonesia: CIFOR.
- Dufrene M and Legendre P. 1997. *Species assemblages and indicator species: The need for a flexible asymmetrical*. Ecological Monographs 67(3):345–66.
- [FAO] Food and Agricultural Organization of the United Nations. 2008. *Methods used to assess household food insecurity*. Rome: FAO. 296–302.
- Fisher RA, Corbet AS, and Williams CB. 1943. *The relation between the number of species and the number of individuals in a random sample of an animal population*. The Journal of Animal Ecology 12(1):42–58.
- [FTA] CGIAR Research Program on Forests, Trees and Agroforestry. 2011a. *Borneo – Sumatra sentinel landscape*. Accessed 6 April 2020. <https://www.foreststreesagroforestry.org/fta-sentinel-landscapes/borneo-sumatra-sentinel-landscape/>
- [FTA] CGIAR Research Program on Forests, Trees and Agroforestry. 2011b. *What are sentinel landscapes?* Accessed 6 April 2020. <https://www.foreststreesagroforestry.org/research/sentinel-landscapes-phase-1/>
- Gaveau D, Husnayaen SD, Arjasakusuma S, Ancrenaz M, Pacheco P and Meijaard E. 2016. *Rapid conversions and avoided deforestation: Examining four decades of industrial plantation expansion in Borneo*. Scientific Reports 6(September):1–13.
- [GFAR] Global Forum on Agricultural Research. 2014. *A glossary of terms commonly used in futures studies*. Rome, Italy: GFAR Secretariat.
- Giessen W. 2000. *Flora and vegetation of Danau Sentarum: Unique lake and swamp forest ecosystem of West Kalimantan*. Borneo Research Bulletin 31:89–122.
- Gienapp A, Reisman J and Stachowiak S. 2009. *Getting Started: A Self-Directed Guide to Outcome Map Development*. Seattle, WA: Organizational Research Services.
- Godet M. 1986. *Introduction à la prospective*. Futures 18(2):134–157.
- Godet M. 2000. *The art of scenarios and strategic planning*. Technological Forecasting and Social Change 65:3–22.
- Godet M. 2010. *Future memories*. Technological Forecasting and Social Change 77:1457–1463.
- Gotelli NJ and Colwell RK. 2001. *Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness*. Ecology Letters 4(4):379–91.
- Hannibal LW. 1950. *Vegetation Map of Indonesia*. Jakarta: Kolff.
- Harris D. 2019. *Intensification benefit index: How much can rural households benefit from agricultural intensification?* Experimental Agriculture 55(2):273–87.
- Hidayat H, Teuling A, Vermeulen B, Taufik M, Kastner K, Geertsema T, Bol D, Hoekman D, Haryani G, Van Lanen H et al. 2017. *Hydrology of inland tropical lowlands: The Kapuas and Mahakam wetlands*. Hydrology and Earth System Sciences 21(5):2579–2594
- Hirzel A and Guisan A. 2002. *Which is the optimal sampling strategy for habitat suitability modelling*. Ecological Modelling 157(1):331–41.
- [IFRI] International Forestry Resources and Institutions. 2013. *International Forestry Resources and Institutions (IFRI) Network: Research Methods*. www.ifriresearch.net
- [ITTO] International Tropical Timber Organization. 2013. *Promoting biodiversity conservation in Betung Kerihun National Park (BKNP) as the trans-boundary ecosystem between Indonesia and the state of Sarawak Malaysia (Phase III)*. Yokohama. ITTO.
- Jésus F and Bourgeois R. 2003. *Reconciling actors' preferences in agricultural policy towards a new management of public decisions*. Introduction: A Book for What? A Book for Whom? Bogor, Indonesia: CGPRT Centre.
- Kennedy G, Ballard T and Dop MC. 2010. *Guidelines for measuring household and individual dietary diversity*. Rome: FAO.
- King RB. 2002. *Land cover mapping principles: A return to interpretation fundamentals*. International Journal of Remote Sensing 23(18):3525–45.
- Krishna A, Lumonya D, Markiewicz M, Mugumya F, Kafuko A and Wegoye J. 2006. *Escaping poverty and becoming poor in 36 villages of Central and Western Uganda*. Journal of Development Studies 42(2):346–70.
- Lusiana B, Widodo R, Mulyoutami E, Nugroho DA and van Noordwijk M. 2008. *Assessing the hydrological situation*

- of Kapuas Hulu Basin, Kapuas Hulu Regency, West Kalimantan. Working paper no. 57. Bogor, Indonesia: World Agroforestry Centre. 67.
- Laumonier Y, Hadi DP, Pribadi UA and Narulita S. 2020. *Kapuas Hulu Ecological Vegetation Map 1:50 000*. Bogor, Indonesia: CIFOR. Accessed 13 March 2020. <https://doi.org/10.17528/CIFOR/DATA.00202>
- Leonald L and Rowland D. 2016. *Drivers and effects of agrarian change in Kapuas Hulu Regency, West Kalimantan, Indonesia*. DOI: 10.17528/cifor/005867
- Madry W, Mena Y, Roszkowska-Madra B, Gozdowski D, Hryniewski R and Castel J. 2013. *An overview of farming system typology methodologies and its use in the study of pasture-based farming system: A review*. Spanish Journal of Agricultural Research 11(2):316–26.
- Mather AS. 1992. *The forest transition*. Area 24(4):367–79.
- Meyfroidt P. and Lambin E. 2011. *Global forest transition: Prospects for an end to deforestation*. Annual Review of Environment and Resources 36(1).
- Meyfroidt P and Lambin E. 2009. *Forest transition in Vietnam and displacement of deforestation abroad*. Proceedings of the National Academy of Sciences of the United States of America 106(38):16139–44.
- Muhyidin A. 2017. *When the forest is depleted: Resource governance in the border regions of Kapuas Hulu in West Kalimantan, Indonesia*. ASEAN-Canada Working Paper Series No. 5. Singapore: Centre for Non-Traditional Security Studies - RSIS.
- Oksanen A, Blanchet G, Friendly M, Kindt R, Legendre P, Mcglinn D, Minchin P, Hara R, Simpson G, Solymos P, Stevens M and Szoecs E. 2017. R Package ‘Vegan’ [Software].
- Perz S. 2007. *Grand theory and context-specificity in the study of forest dynamics: Forest transition theory and other directions*. The Professional Geographer 59(1):105–14.
- Popper R. 2008. *Foresight methodology*. In Georghiou L, Cassingena J, Keenan M, Miles I and Popper R, eds. The Handbook of Technology Foresight. Cheltenham, UK: Edward Elgar. 44-88.
- Potter L. 2015. *Managing oil palm landscapes: A seven-country survey of the modern palm oil industry in Southeast Asia, Latin America and West Africa*. Occasional paper. Bogor, Indonesia: CIFOR.
- Pretty J. 1995. *Participatory learning for sustainable agriculture*. World Development 23(8):1247–63.
- Rejou-Mechain M, Tanguy A, Piponiot C, Chave J and Herault B. 2018. *Package ‘BIOMASS.’*
- Rigg J. 2001. *More than the soil: Rural change in SE Asia*. London: Routledge.
- Righi E, Dogliotti S, Stefanini F and Pacini G. 2011. *Capturing farm diversity at regional level to up-scale farm level impact assessment of sustainable development options*. Agriculture, Ecosystems and Environment 142(1–2):63–74.
- Shantiko B, Fripp E, Taufiqoh T, Heri T and Laumonier Y. 2013. *Socio-economic considerations for land-use planning; The case of Kapuas Hulu, West Kalimantan*. Bogor, Indonesia: CIFOR.
- Soedjito H., 1999. *Flora dan fauna Taman Nasional Betung Kerihun, Kalimantan Barat*. Report WWF Indonesia - PHPA - LIPI - ITTO.
- Surianegara I, Lemmens R and Prosea Project. 1994. *Plant Resources of South-East Asia: Major Commercial Timbers*. Timber Trees. No 5(1). Wageningen: Pudoc Scientific Publishers.
- Swindale A. and Bilinsky P., 2006. *Household Dietary Diversity Score (HDDS) for measurement of household food access: Indicator guide*. Food and Nutrition Technical Assistance Project, Academy for educational Development, 11.
- Vågen TG, Winowiecki L, Walsh MG, Desta LT and Tondoh JE. 2010. *Land Degradation and Surveillance Framework (LSDF): Field Guide*. Tropical Agriculture (December):14. [WFP and FAO] World Food Programme and the Food and Agriculture Organization of the United Nations. 2008. *Food Consumption Score: Construction of the FCS*. Rome: World Food Programme. 1–102.
- Weihreter E. 2014. *Traditional knowledge, perceptions and forest conditions in a Dayak Mentebah community, West Kalimantan, Indonesia*. Working paper no. 156. Bogor, Indonesia: CIFOR.

Wiesmann D, Bassett L, Benson T and Hoddinott J. 2009. *Validation of the World Food Programme's food consumption score and alternative indicators of household food security*. IFPRI discussion paper 00870. 1–105.

Worldclim. 2018. *Global Climate Data*. <https://worldclim.org/>

Wulffraat S, Greenwood C, Faisal KF, Sucipto D, Chan H, Beukeboom H, Souliisa N and

Kinasih A. 2017. *The Environmental Status of Borneo 2016 Report*. Jakarta: Heart of Borneo Programme.

Yuliani EL, Indriatmoko Y, Salim MA, Farid IZ, Muhajir M, Prasetyo LB and Heri V. 2010. *Biofuel policies and their impacts on local people and biodiversity: A case study in Danau Sentarum*. Borneo Research Bulletin 41:109–144.

7 Annex

Annex 1. Analysis of the sentinel landscape process and future potential

It was not difficult to raise interest among the main stakeholders in this sentinel landscape initiative because of previous collaborative work with local institutions and NGOs. However, it was complicated to achieve effective participation without a budget. It was challenging to convince the local government to use our detailed mapping and spatial analysis results to revise their spatial plan, because the identified changes to the land allocation categories directly impact on the legality of large concession implementation in many areas (i.e. former production forest should now be reclassified as protection forest). In terms of lessons learned on what worked and what didn't:

- There was no analysis of existing lessons learned, impacts and opportunities for collaboration at the beginning of the initiative (a draft made by Sheil and Meijaard was not provided);
- The situations in Sumatra and Borneo are too similar; it would have been more informative to include an additional sentinel landscape site in Eastern Indonesia where socio-ecological conditions differ dramatically;
- Partners were not involved at the beginning of the process, and there was no development of official partnerships and protocols with relevant in-country partners, with the consequences that the partners did not show much interest (or lost it quickly after realizing there was no budget); links with partners and donors were not secured;
- The 'participatory' workshops did not really prove useful (for instance, the methodological workshop was intended to share and make decisions on the best methods, however all methods had already been decided on, and these were not challenged);
- There were inconsistent levels of assistance for local teams across the world (e.g. some sites received training, others did not);
- Data and feedback were not given to potential users upon completion (e.g. via workshops);
- There was poor cooperation between FTA centers (due to a sense of competition);
- The preconized use of remote sensing was very basic as was the recommended method for vegetation and tree diversity;
- No second measurement was possible upon completion, making livelihood data less useful;
- The IFRI questionnaire was too extensive, taking up to three hours for each household to complete. It is advisable to break up the questionnaire into two sessions to avoid respondent fatigue;
- For some Iban communities in the northern part of Kapuas Hulu (West Kalimantan), communication was an issue. Without local partner speaking the dialect, it would have been impossible;
- More training is required for local partners if the survey is to be repeated;
- Linking biophysical and socio-economic data remains challenging as household data is not linked to farm boundaries; in the case of swidden it is even more complicated to decide on a 'farm boundary'. Vegetation protocol from LDSF was insufficient, meaning another dataset for vegetation was used for this report.

Future potential

- Improve integration of existing data from various projects in the area; this should lead to better long-term monitoring of landscape dynamics, ecosystem services, animal and plant population studies;
- Collect more data on forest and nutrition, agroforestry, trees, and traditional ecological knowledge; this will be useful in making a case for traditional agriculture as opposed to oil palm monoculture;
- Train and build capacity to increase local use of data;
- Increase awareness and advocacy work around the FTA's achievements within the landscape;
- Initiate new sentinel landscapes in Eastern Indonesia or cover different agro-ecological zones in Indonesia; baseline data exists for the Moluccas;
- Develop a LTSER (Long Term Socio-Ecological Research) regional network with partners in Southeast Asia, equivalent to the European LTSER.

Annex 2. Summary of LULC change

Vegetation cover (ha) in Kapuas Hulu reGENCY for 2000, 2010 and 2019, based on Laumonier et al. (2020) vegetation classes.

Landcover	2000	2010	2019
1. Lowland forest (<300 m)	453 070	412 553	404 832
2. Logged-over lowland forest	94 573	109 879	108 237
3. Mosaic of old fallow secondary lowland forest	31 252	29 405	26 820
4. Hill forest (300-800 m)	895 093	887 101	886 513
5. Logged-over hill forest	18 228	25 493	25 847
6. Mosaic of old fallow secondary hill forest	4 440	4 918	4 918
7. Mosaic of young fallow secondary forest (<1000 m)	145 083	147 176	127 195
8. Shrubs and low fallow regrowth (<1000 m)	160 112	195 441	197 025
9. Grassland/fernland (<1000 m)	7 135	8 052	3 151
10. Submontane forest (800-1300 m)	273 475	273 475	273 475
11. Submontane depleted forest (including landslide areas)	973	973	973
12. Lower montane forest (1300-1800 m)	33 001	33 001	33 001
13. Upper montane forest (>1800 m)	179	179	179
14. Secondary regrowth forest (<i>belukar</i>) (>1000 m)	567	567	567
15. Grassland/fernland (>1000 m)	27	27	27
16. <i>Tall Kerangas</i> forest on sandstone	98 193	98 032	97 887
17. <i>Low Kerangas</i> forest on sandstone	8 094	8 072	8 063
20. <i>Tall Kerapah</i> forest	45 520	43 500	41 902
21. <i>Low Kerapah</i> forest	17 783	17 512	17 240
22. Secondary <i>Kerapah</i> forest	11 494	9 834	8 126
23. Riparian forest (gallery forest)	57 377	55 703	55 406
24. Fresh water swamp forest	51 592	47 474	44 690
25. Logged-over fresh water swamp forest	28 535	24 923	23 463
27. Mosaic of secondary fresh water swamp forest	22 045	20 910	20 136
28. Secondary regrowth swamp forest	42 546	41 131	40 440
29. Swamp shrubs	39 709	42 770	42 006
30. Swamp grassland	5 627	7 216	5 531
31. Mixed peat swamp forest	145 472	133 655	124 335
32. Logged-over mixed peat swamp forest	44 735	47 780	43 686
34. Mosaic of secondary mixed peat swamp forest	6 696	7 883	7 394
35. Peat swamp forest	84 258	83 103	77 850
36. Depleted peat swamp forest	5 816	6 836	6 556
37. Open peat swamp forest, pole forest or padang forest	1 240	1 292	1 292
42. Food crops fields	42 886	35 232	46 782
43. Agroforestry (including smallholder rubber garden)	135 639	123 059	121 612
47. Irrigated paddy field	1 946	2 029	2 105
52. Newly opened land for oil palm estate	11 440	21 688	36 650
53. Oil palm estate	62	19 130	57 904
54. Rubber estate	3 075	887	185
55. Bare soil (mining area)	1 480	1 905	5 542
56. Bare soil (Danau Sentarum dry season)	51 854	52 420	52 977
58. Settlement	1 179	1 206	1 561
59. Water	57 057	57 133	56 478
Total	3 140 556	3 140 556	3 140 556

FTA WORKING PAPER

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This publication is part of the Sentinel Landscape network initiative established in eight sites around the world representative of widely different biophysical and socioeconomic contexts. Here we present and summarize the results of the research and baseline studies carried out in West Kalimantan, Borneo. Within the Kapuas Hulu regency, two districts were selected as 'sentinel sites': (1) a traditionally managed landscape with direct influence on watersheds to the north of Danau Sentarum National Park wetlands (Batang Lupar); and (2) a contrasting area in the south with improved infrastructure along the mainsouthern road from Sintang to Putussibau, to bring a different context (Mentebah).

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