ECOLOGICAL ASSESSMENT KAPUAS HULU

Understanding the Local Ecological Context to Design Appropriate Project Interventions

By GRASS (Greening Agricultural Smallholder Supply Chains)

kerja sama jerman
DEUTSCHE ZUSAMMENARBEIT

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List of Abbreviations

BUMDEs	Badan Usaha Milik Desa
FGD	Focus Group Discussions
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GRASS	Greening Agricultural Smallholder Supply Chains
KAP	Knowledge, Attitude, and Practice
PDAM	Perusahaan Daerah Air Minum

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Photo: GIZ / IDEP Foundation

1. General Overview

1.1. Executive Summary

IDEP Foundation, in collaboration with GIZ, conducted a permaculture-based field assessment to understand and plan livelihood empowerment for farmers in Kapuas Hulu who comprise the target group for the GIZ implemented GRASS project.

As a strategy to improve farmers' livelihood and establish food security at the household level and to plan for climate change adaptation and mitigation, the GRASS project will target farmers in six sub-districts in Kapuas Hulu.

The assessment focused on collection of data about biodiversity, soil health, water conservation, carbon sequestration, and climate change mitigation and adaptation in six sub-districts in Kapuas Hulu district. Overall, the assessment report provides a comprehensive overview of the agricultural system, identifying areas for improvement and proposing strategies to enhance sustainability and environmental management and to improve community livelihoods by identifying the existing potential in each location.

The assessment report in Kapuas Hulu provides valuable insights into the current state of biodiversity, ecology, sustainable agriculture, local socio-cultural practices, and the sustainable economy. The findings indicate room for improvement in community knowledge, attitude, and practical implementation.

Community knowledge regarding biodiversity, ecology, sustainable agriculture, local socio-cultural practices, and the sustainable economy is identified as an area that needs improvement. Efforts should be made to enhance awareness and understanding among the community members. This can be achieved through targeted educational programs and awareness campaigns to promote a deeper understanding of these aspects and their importance.

While the community shows some awareness and knowledge regarding biodiversity, ecology, sustainable agriculture, local socio-cultural practices, and the sustainable economy, the report suggests that further action is required. It is crucial to translate this awareness into concrete actions that contribute to the preservation and sustainable management of the area's resources. Engaging the community through capacity-building initiatives, training programs, and participatory projects can help bridge the gap between awareness and action.

The assessment report also highlights the need to align community practices with the principles of biodiversity conservation, ecological sustainability, sustainable agriculture, preservation of local sociocultural practices, and development of a sustainable economy. While the community demonstrates understanding and awareness, there is a need to strengthen their practical implementation. Encouraging and supporting community-led initiatives, providing technical assistance, and facilitating access to resources can empower the community to take actionable steps towards sustainable practices.

A multi-faceted approach is recommended to address the identified gaps and promote sustainable practices in Kapuas Hulu. This includes collaborative efforts between government agencies, non-governmental organizations, local communities, and other stakeholders. Working together can enhance community knowledge, attitudes, and practices towards biodiversity, ecology, sustainable agriculture, local socio-cultural practices, and the sustainable economy.

Overall, the assessment report serves as a valuable resource for understanding the current status and areas of improvement in Kapuas Hulu. It provides a roadmap for interventions and initiatives that can contribute to biodiversity conservation, ecological sustainability, and the development of a thriving and sustainable community in the area.

1.2. Objectives

This assessment is carried out to find out comprehensive information about ecological conditions and local communities' knowledge, practice, and attitude (KAP) as a baseline study in 6 sub-districts of Kapuas Hulu Districts described below:

1. **Biodiversity** The diversity and abundance of plant and animal species in the system, including their roles in ecological functions such as pollination, pest control, nutrient cycling, and soil formation.
2. **Soil health** The soil, including its structure, texture, nutrient content, organic matter, and microbial activity.
3. **Water conservation** The management of water resources, including rainwater harvesting, irrigation, drainage, and erosion control.
4. **Carbon sequestration** The ability of the system to capture and store carbon in the soil, plants, and other biomass.
5. **Climate change mitigation and adaptation:** The contribution of the system to reducing greenhouse gas emissions and enhancing resilience to the impacts of climate change, such as droughts, floods, and heatwaves.
6. **Knowledge, practice, and attitude (KAP)** Knowledge, practice, and attitude of the agricultural system's social, economic, and cultural aspects through the KAP method.

1.3. Methodology

Qualitative and quantitative data and information were obtained with the following methods:

1. Interviews with village governments in six sub-districts, with indigenous community representatives, and with women's groups.
2. Focus group discussions with palm oil-, rubber-, coffee- and/or cacao farmer groups.
3. Observations and field visits to agricultural land, plantations, water sources, local product processing, and local markets.
4. Secondary data collected from multiple sources.

The methodology above was focussed on the Permaculture approach. In a brief explanation, Permaculture is a concept on how to design a sustainable life. Permaculture applies traditional practices in natural management, integrated with appropriate modern technology. This is a holistic, environmentally friendly way of designing and building the human environment and helping improve people's lives, such as housing, water supply, health, waste reduction, agriculture, energy, aquaculture, rivers, forests, and livestock. .

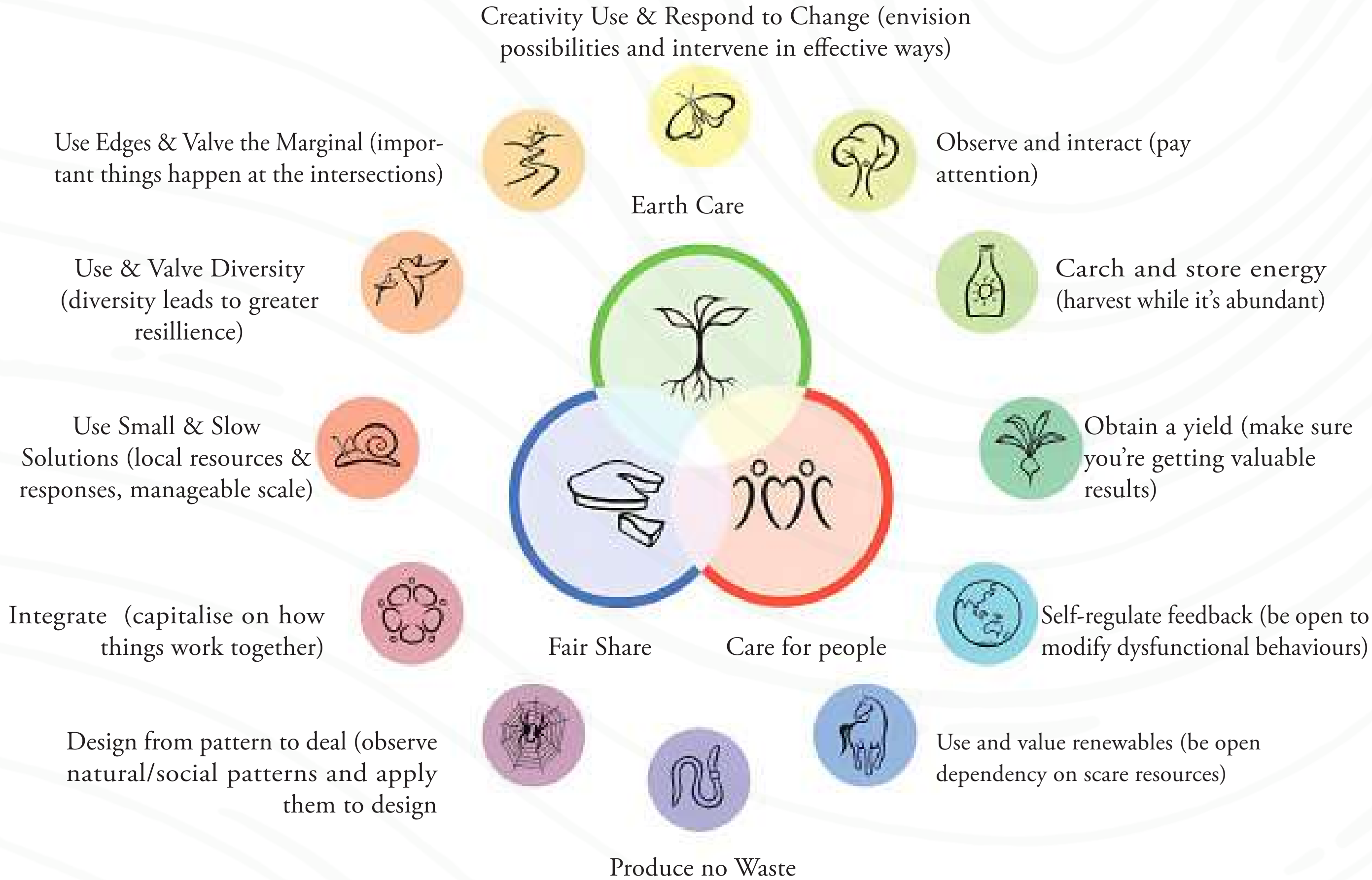

Figure 1 Permaculture Principles and Pathways Beyond Sustainability by David Holmgren (2022)

There are three ethics in Permaculture, namely:

1. Care for the earth
2. Care for the people
3. Care for the future

The Three Ethics are then interpreted into 12 Principles as guidance:

1. **Observe and interact**
   By making time to engage in how nature works and how people live, we can design solutions suitable for local conditions.
2. **Catch and store energy**
   By developing a resource storage system, especially when these resources are abundantly available, we can use its resources at the right time when we need them.
3. **Obtain a yield**
   Make sure that we get really useful results in return for the work done so far.
4. **Apply self-regulation and accept feedback**
   Stop any irrelevant/inappropriate activities to ensure the system can continue functioning effectively.
5. **Use and value renewable resources and services.** Use the resources provided by nature effectively and maximally to reduce our consumptive behavior and our dependence on non-renewable resources.
6. **Produce no waste**
   By giving value to available resources through their effective use, nothing will be left to waste.
7. **Design from patterns to details**
   By taking distance, we can observe the patterns in nature and society. This method can be the backbone of our designs and their details.
8. **Integrate rather than segregate**
   We can benefit from a mutually supportive relationship by putting everything in the right place.
9. **Use small and slow solutions**
   Small and slow-moving systems are easier to manage and deliver sustainable results.
10. **Use and value diversity**
    Diversity can reduce the vulnerability of varieties to many threats and take advantage of the uniqueness of the nature in which the variety is found.
11. **Use edges and value the marginal**
    The meeting between several things (nature and humans) is the most exciting time because it is often diverse, productive, and invaluable in the system.
12. **Creatively use and respond to change**
    We can receive positive impacts on change through careful observation and timely intervention.

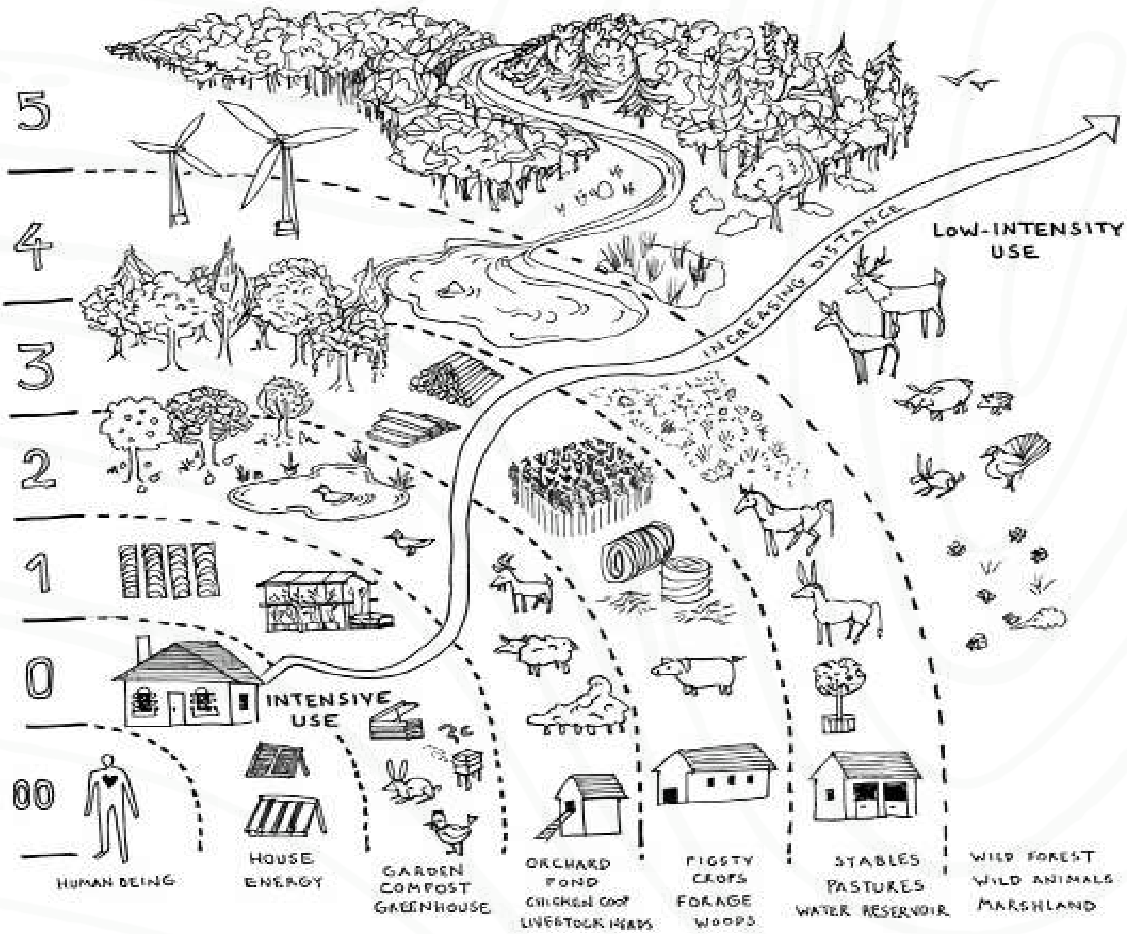

Figure 2 Permaculture Zonation System (Source: newsociety.com)

Permaculture also provides a Zonation System to guide the application of ethics and principles as following:

- Zone 1 is a household,
- Zone 2 is community such as a hamlet or village,
- Zone 3 is larger-scale of production areas,
- Zone 4 is an area before the protected areas that can be utilized, both in landscape and seascape (buffer zone),
- Zone 5 is protected areas.

When it comes to Permaculture, the assessment is conducted from the perspective of the site (environment, vegetation) and human factors (social and economic) in Kapuas Hulu.

As Permaculture is an approach to designing and managing sustainable life systems that are in harmony with nature, it emphasizes the integration of plants, animals, and humans in a holistic and interconnected way. In the context of Kapuas Hulu, the ecological assessment we carried out is designed to understand and evaluate the potential of implementing Permaculture in the area that will support the community and their needs in the long term.

The assessment begins by studying the site's environmental aspects, including its unique ecosystem, biodiversity, and natural resources. This involves identifying the existing vegetation, such as native plants, trees, and crops, and assessing their suitability for permaculture practices. The aim is to work with the natural environment, preserving and enhancing it while creating a productive and sustainable system.

On the human side, the assessment focuses on social and economic factors. This involves understanding the local community, their cultural practices, and their relationship with the land. It also includes evaluating the socioeconomic conditions of the area, such as the livelihoods of the residents and their access to resources. This information helps to identify opportunities and challenges for implementing permaculture principles that are socially and economically beneficial.

By conducting a comprehensive ecological assessment that considers both the natural environment and human factors, the aim is to develop a permaculture plan that is tailored to the specific conditions and needs of Kapuas Hulu. This plan will promote sustainable and regenerative practices, conserve natural resources, and improve the well-being of the local community.

Overall, the ecological assessment in Kapuas Hulu serves as a foundation for designing and implementing permaculture practices that support the long-term ecological and socioeconomic well-being of the area, as well as preserving its unique natural resources and cultural heritage.

2. Overview of Assessment Locations

As assigned by the GRASS Project, we have conducted an ecological assessment focusing on the three target areas for the project in Kapuas Hulu. For easier description, we divided the target areas for the assessment based on their geographical location:

1. North areas consist of Batang Lupar and Embaloh Hulu sub-districts, focusing on coffee–and cocoa— and possibly other estate crops smallholders.
2. Central areas consist of Mentebah, Bunut Hulu, and Pengkadan sub-districts, focusing on natural rubber and palm oil smallholders.
3. South areas consist of Silat Hilir sub-district, focusing on palm oil smallholders.

2.1. North Area

The assessment in the North Area was conducted in two sub-districts, namely: Batang Lupar and Embaloh Hulu.

2.1.1. Batang Lupar

The Batang Lupar Sub-district is located in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. This sub-district consists of 10 villages that contribute to the cultural diversity and local community.

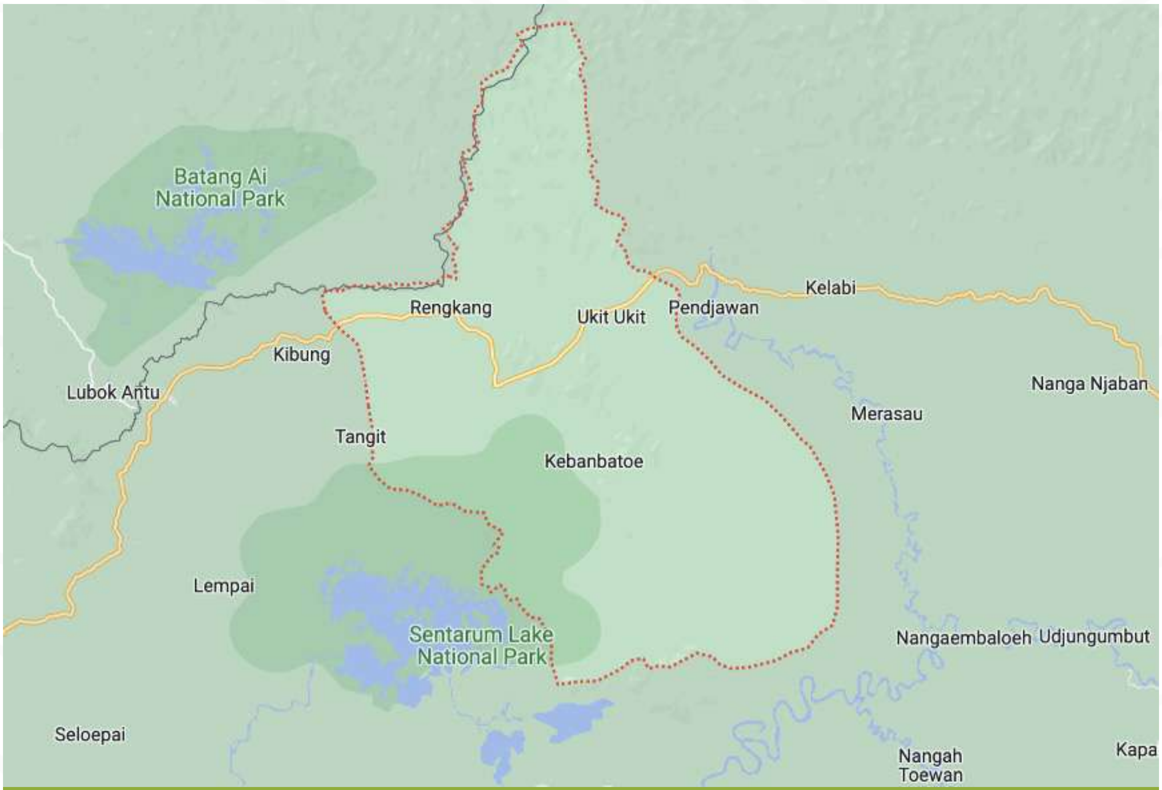

Figure 3 Batang Lupar (Source: Google)

The population of Batang Lupar Sub-district reaches 5,575 people distributed among 1,889 households. The sub-district has a land area of 1,578.68 square kilometers, encompassing various types of land and natural features.[1]

Batang Lupar Sub-district has diverse natural resources, including agriculture, plantations, and other economic activities. Agriculture is the main sector in the sub-district's economy, with crops such as rice, rubber, and palm oil as the main commodities. Furthermore, the sub-district also boasts attractive natural beauty. Several rivers flow through often pristine forests. This offers potential for exploring natural tourism.

Despite its significant potential, Batang Lupar Sub-district faces several challenges. The infrastructure needs improvement, there is limited access to healthcare and education services, and efforts towards. more sustainable economic development are necessary. All of these require the attention of the local government.

2.1.2. Embaloh Hulu

The Embaloh Hulu Sub-district is in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. This sub-district consists of 10 villages that reflect cultural diversity and local community.

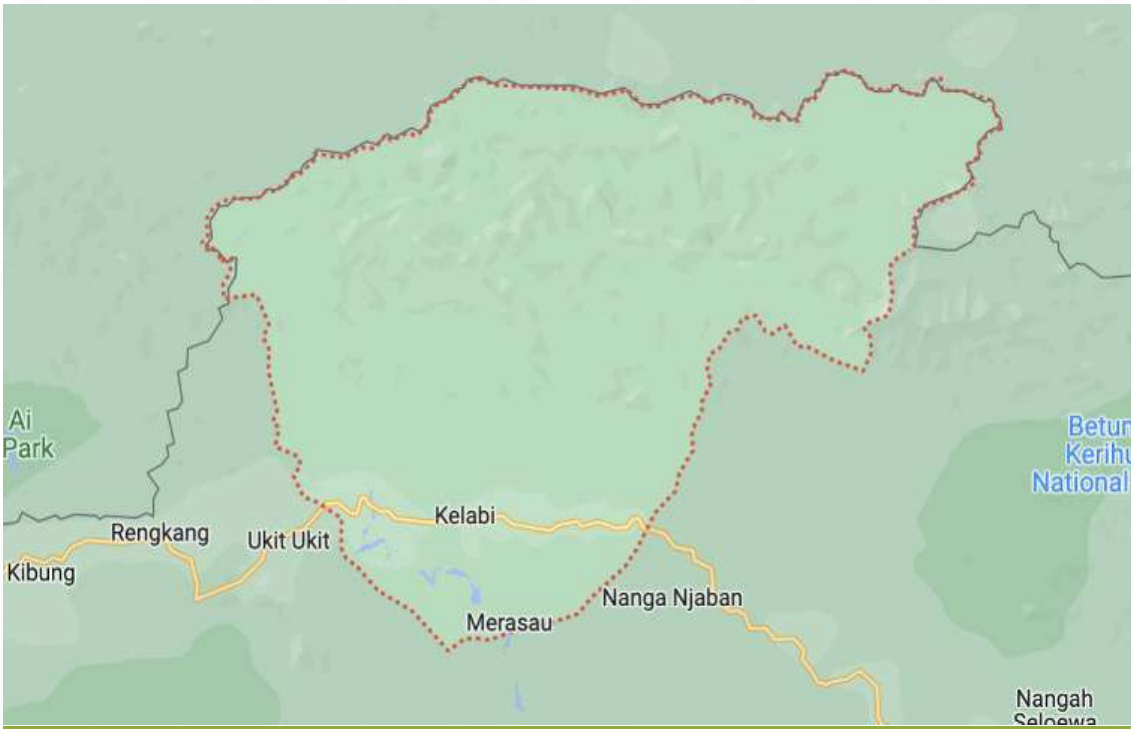

Figure 4 Embaloh Hulu (Source: Google Maps)

[1] https://gis.dukcapil.kemendagri.go.id/peta/

The population of the Embaloh Hulu Sub-district reaches 5,417 people distributed among 1,853 households. The sub-district has a land area of 3,564.15 square kilometers , encompassing various types of land and natural features.[2] Embaloh Hulu has diverse natural resources, including agriculture, fisheries, and other economic sectors. Agriculture is the dominant sector in the sub-district's economy, with rice, maize, and palm oil as the primary commodities. However, Embaloh Hulu Sub-district also faces several challenges, such as improvements to infrastructure, limited access to healthcare and education services, and more sustainable economic development.

2.2. Central Area

The assessment of the Central area was conducted in three sub-districts, namely: Bunut Hulu, Pengkadan, and Mentebah.

2.2.1. Bunut Hulu

The Bunut Hulu Sub-district is located in Kapuas Hulu Regency, West Kalimantan. This sub-district consists of 15 villages spread across an area of 1,445.81 square kilometers. With a population of 15,545 individuals distributed among 4,981 households, the subdistrict density is 10.75 person/km². [2]

Figure 5 Bunut Hulu (Source: Google)

2 https://gis.dukcapil.kemendagri.go.id/peta/

Bunut Hulu possesses rich natural potential with beautiful landscapes and diverse natural resources. The area is surrounded by lush and fertile forests, creating breathtaking views for visitors. The presence of these forests also contributes to the rich biodiversity in this area. The livelihood of the people in Bunut Hulu Sub-district is mainly dominated by agriculture and plantations. The residents primarily rely on traditional farming, such as rice, maize, beans, and tubers, as their primary source of income. Palm oil and rubber plantations are also important economic sectors in this sub-district. Despite its vast area, infrastructure development in the sub-district still needs improvement. Limited transportation access challenges the community to connect with nearby towns and economic centers. However, the local government is continuously working to enhance the quality of infrastructure by constructing better roads and transportation facilities. Bunut Hulu Sub-district also has attractive tourism potential. Its natural beauty, including rivers traversing the area and towering mountains, offers opportunities for visitors to enjoy nature-based activities such as hiking, camping, and admiring the scenic panorama. With abundant natural potential, the subdistrict has promising economic and tourism development prospects.

2.2.2. Pengkadan

The Pengkadan Sub-district is located in a strategic area in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. This sub-district comprises **11 villages** that enrich the cultural diversity and local community. With a total population of 9,697 people distributed among 3,294 households, with a density of 30.75 people/km², Pengkadan serves as the center of life and activities for the surrounding community. The land area of Pengkadan Sub-district reaches 315.37 square kilometers, encompassing various types of land and natural features.[3] The area has diverse natural resources, including agriculture, fisheries, and other economic activities. Agriculture is the main sector in the sub-district economy, with palm oil, rice, and vegetables as the primary commodities.

Figure 6 Pengkadan (Source: Google Maps)

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3 https://gis.dukcapil.kemendagri.go.id/peta/

4 https://gis.dukcapil.kemendagri.go.id/peta/

2.2.3. Mentebah Sub-district

The Mentebah Sub-district is located in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. This sub-district has a land area of 758.15 square kilometers. Mentebah consists of 8 villages scattered throughout the sub-district. Based on the latest data, the population of Mentebah sub-district reaches 11,286 people, distributed among 3,496 households. [5]

Figure 7 Mentebah (Source: Google Maps)

Mentebah is one of the sub-districts in Kapuas Hulu Regency that plays an important role in the local economy and society. The sub-district's area has diverse natural resources, including agriculture, plantations, and other activities. Mentebah sub-district also has tourism potential with its natural beauty, which is still pristine and rich in biodiversity.

With a relatively large land area, Mentebah Sub-district provides opportunities for the development of the agricultural and plantation sectors as the mainstays of the economy. The residents in this district generally depend on agricultural products such as rice, vegetables, and fruits for their livelihoods. Although it has great potential, Mentebah Sub-district also faces several challenges, such as poor infrastructure, limited access to healthcare services, and low education.

5 Ibid.

2.3. South Area

The assessment of South area was conducted in one sub-district, namely: Silat Hilir.

2.3.1. Silat Hilir

The Silat Hilir Sub-district is located in Kapuas Hulu Regency, West Kalimantan Province, Indonesia. This sub-district consists of 13 villages that represent cultural diversity and the local community.

Figure 8 Silat Hilir (Source: Google)

The population of Silat Hilir Sub-district reaches 21,073 people distributed among 6,711 households, with a density of 24.26 people/km². The sub-district has a land area of 868.63 square kilometers, encompassing various types of land and natural features.[6]

Silat Hilir has diverse natural resources, including agriculture, fisheries, and other economic sectors. Agriculture is the main sector in the sub-district economy, with crops such as rice, palm oil, rubber, and vegetables as the primary commodities.

[6] https://gis.dukcapil.kemendagri.go.id/peta/

3. Findings Conclusion

3.1. North Area: Ecological Condition

In the North Area, we assessed a sample of three villages, including Menua Sadap in Embaloh Hulu Sub-district and Labian and Mensiau in Batang Lupar Sub-district. Using the ecological parameters to collect data on vegetation, native plants, climate, soil, water sources, and carbon sequestration, the findings are with:

3.1.1. Vegetation Conditions, Types, and Functions

The vegetation in the area is highly diverse and consists of five layers of vegetation that indicate biodiversity. Regarding that, from a score of 1-5, the vegetation diversity score in the North Area is 5. The following are the five layers of vegetation mentioned:

1. Emergent Trees (e.g., Ficus and local trees) usually function for ecological and sociocultural purposes. In total, the vegetation in this layer is estimated to be 5% of the total vegetation.
2. Canopy trees (e.g., palm oil, rubber, *durian*) usually function for economic and sociocultural purposes. In total, the vegetation in this layer is estimated to be 70% of the total vegetation.
3. Trees (e.g., *kratom, asam kandis*, *rambutan*, *engkuis*) usually function for sociocultural and ecological purposes. In total, the vegetation in this layer is estimated to be 10% of the total vegetation.
4. Shrubs (e.g., banana, *sengkubak*, and other local plants) usually function for sociocultural and economic purposes. In total, the vegetation in this layer is estimated to be 10% of the total vegetation.
5. Ground Cover (e.g., *maram*/forest snake fruit, vegetables, rice, *taro*) usually function for sociocultural and ecological purposes. In total, the vegetation in this layer is estimated to be 5% of the total vegetation.

3.1.2. Native Plants Types

On native plants, we have observed, interviewed, and discussed with the community to identify as many plants as possible, followed by their functions, including socio-cultural, economic, ecological, and health. The following are the results.

3.1.2.1. Plant Types

Based on our observation, we have found 32 native plants in the sample locations in the North Area spread over agricultural areas, watersheds, forest (Betung Kerihun and Danau Sentarum National Park), and residential areas. Most of them are listed in their local language, as we have limited information on their name in English. Further data collection with adequate sources of information is needed to comprehend these findings. The native plants found are as follows:

The native plants found are as follows:

1. *Engkaras* (Agarwood)
2. *Tarap* or *Banda*
3. *Pasak Bumi*/*Tongkat Ali* (Longjack)
4. Indigo Tree
5. *Kepapak*
6. *Sibau*
7. *Laki*
8. *Simpur Air* (Dillenia suffruticosa)
9. *Salam* (Syzygium polyanthum)
10. *Kelalai*
11. Local paddy
12. *Purik*/*Kratom* (Mitragyna speciosa)
13. *Cempedak*
14. *Rambutan*
15. White pepper
16. Ginger
17. Turmeric
18. Kayu Putih (Melaleuca)
19. Petai (Bitter Bean)
20. Resak (Vatica)
21. Lengkan
22. Local corn
23. Tuba (Deris)
24. Sengkubak
25. Buah Keras (Mahogany)
26. Senggang
27. Lembak
28. Embang
29. Bunut
30. Bemban
31. Temau
32. Aras
33. Local cucumber
34. Daun Simpur (Dillenia)

3.1.2.2. Plant Functions

We have identified the functions of some of the plants only due to the limited time and the information we have collected from the community during the assessment process in the field. The identified functions are as follows.

3.1.2.3. Sociocultural

1. Kepapak: yellow color for natural dye.
2. Resak: its bark speeds up fermentation of alcohol.
3. Senggang: used for weaving.
4. Bemban: used for weaving.
5. Aras leaves: can be used as soap.
6. Sengkubak: used as food seasoning.

3.1.2.4. Economic

1. Palm oil: sold commercially.
2. Engkaras (Agarwood): sold commercially.

3.1.2.5. Ecological

1. Tuba roots: used for pest control.

3.1.2.6. Health Functions

1. *Pasak Bumi/Tongkat Ali* (Longjack): used for back pain and malaria treatment.

Apart from the plants, we found two types of native fish with their functions during our assessment:

1. *Tomang:* Economic function for consumption.
2. *Arwana:* Economic function as a source of income.

Photo: GIZ / IDEP Foundation

3.1.3. Climate Condition

The climate condition, its changes, and impacts can be identified in the following table.

<table>
<tr><th>Existing Climate</th><th>Pattern Changes</th><th>Impacts</th></tr>
<tr><td>Altitude: 40m</td><td>N/A</td><td rowspan="4">Pests:
Monkeys and leafhoppers are two of the main pests identified as a threat.

Diseases:
Viruses, fungi, and bacteria cause several diseases.

Yields:
The commodity yields decreased.

Change in planting calendar:
The planting season has been delayed by half a month. Currently, it's happening in September - October instead of late August.

Natural disaster:
Floods occur more frequently.

Change in crops grown:
Due to the floods, farmers shifted their traditional crops to commercial crops, such as rubber and palm oil, as the plants can survive despite floods.</td></tr>
<tr><td>Temperature: 26°C - 29°C (coolest)</td><td>Weather:
The temperature is increasing, and it is getting hotter.</td></tr>
<tr><td>Rainfall: 3,300 mm/year (average in Kapuas Hulu)</td><td>1. The rainy season lasts longer than the dry season. During the rainy season, temperatures can reach 30°C - 33°C for 7-8 months (generally in Kapuas Hulu).
2. Increased rainfall: 5,000mm/year (generally in Kapuas Hulu)</td></tr>
<tr><td>Wind: West and South</td><td>Wind:
Strong (winds from the west occur from September to November, while outside those months, the wind direction shifts from South, East, to North).</td></tr>
</table>

Table 1 Climate condition in the North Area

3.1.4. Soil Condition

Soil conditions in the North Areas can be identified in the following table.

Soil Condition	Findings
pH	4.5 to 5
Structure	Sandy loam
Main texture	Clay
Nutrient content	Low
Organic matter	15% - 20%
Microbial activity	Low
Permeability	Slow
Aeration	Moderate (50% per hour)

Table 2 Soil condition in the North Area

3.1.5. Water Sources

Water sources in North Areas can be identified in the following table.

Water Sources	Findings
Rainwater harvesting	Practiced but not fully utilized, mainly at the household level.
Irrigation	Not available
Drainage	Not available
Erosion control	Not available
Types of water sources	1. Water from the hills 2. Sentarum Lake
Physical appearance of water quality	3. Color: Reddish brown 4. Turbidity: Murky 5. Odor: Acidic

Table 3 Water sources in the North Area

3.1.6. Carbon Sequestration

Due to the limited time of assessment, we used focused-group discussions (FGD) to identify and then estimate carbon sequestration and stock in the North Area using two villages as samples, Menua Sadap representing Embaloh Hulu Sub-district and Labian representing Batang Lupar Sub-district. There is still a lack of data and information to be collected in some fields. Hence, further detailed assessment is needed to complete the calculation. However, as an initial overview of the potential carbon sequestration and stock in this area, we attempted to estimate it using allometric equations based on the available data from FGD results and assumptions developed based on references from existing literature. The unmeasured carbon pool in this case, is presumed to be determined through the relationship between above-ground tree biomass and other carbon pools already established from prior research or studies in Kalimantan or other locations in Indonesia, along with additional information gathered from various sources.

Below, we present the allometric equations and references that we employed:

a. The Above Ground Biomass (AGB) was calculated using the allometric equation developed by Udayakumar et al (2016) for the tropical dry forests:
   - AGBdry = exp (2.2014 x LN (DBH) - 1.0615)

   Where AGBdry = Above ground dry biomass of tree (kg); DBH = diameter at breast height (cm); 2.2014 and - 1.0615 are constants.
b. Below Ground Biomass (BGB) was calculated using the following formula (MacDicken 1997, Hangarge et al 2012):
   - BGB (Kg/tree) = AGB (Kg/tree) x 0.26
c. Total Biomass (TB) is the sum of the AGB and BGB (Sheikh et al 2011):
   - TB = AGB + BGB (kg/tree)

Generally, 50% of biomass of any plant species is considered as carbon (Pearson et al 2005). Therefore, the weight of carbon in the tree was estimated by multiplying the biomass of the tree by 50% (Birdsey 1992)

   - Carbon Storage = Biomass x 50% or Biomass/2 (kg/tree).

a. To determine the weight of CO2 sequestered in the tree, multiply the weight of carbon in the tree by 3.6663 (Vishnu and Patil 2016).

b. The weight of CO2 sequestered in the tree per year was determined by dividing the weight of carbon dioxide sequestered in the tree by age.

Using the formula, a general overview of estimated carbon sequestration and stock from plant is provided in the following table as preliminary data.

Tree Species per location	Average Age	Average DBH (cm)	Above ground biomass (kg/tree)	Below ground biomass (kg/tree)	Total biomass (kg/tree)	Carbon (kg/tree)	CO2 sequestered (kg/tree)	Tree count	CO2 sequestered of all trees (kg)	CO2 sequestered/ year (kg)	CO2
Menua Sadap (Embaloh Hulu)											
Rubber	12.5	19.477[7]	238.411	61.987	300.398	150.199	550.674	45,800	25,220,884.64	2,017,670.77	2,017.67
Kratom	3.5	9.650[8]	50.856	13.223	64.079	32.039	117.466	12,300	1,444,827	412,808	412.81
Palm Oil	2	12.000[9]	82.105	21.347	103.452	51.726	189.644	0	0	0	0
Cocoa	4	27.500[10]	509.790	132.545	642.335	321.168	1,177.497	800	941,997.71	235,499.43	235.50
Sacha Inchi	1	0.318[11]	0.028	0.007	0.035	0.018	0.064	1,150	73.78	73.78	0.07
									Sub-total	**2,666,051.71**	**2,666.05**
Labian (Batang Lupar)											
Rubber	12.5	19.477	238.411	61.987	300.398	150.199	550.674	437,500	240,920,022.46	19,273,601.80	
Kratom	3.5	9.650	50.856	13.223	64.079	32.039	117.466	15,000	1,761,984.18	503,424.05	503.42
Palm Oil	2	12.000	82.105	21.347	103.452	51.726	189.644	1,845	349,892.41	174,946.21	174.95
Cocoa	4.0	27.500	509.790	132.545	642.335	321.168	1,177.497	0	0	0	0
Sacha Inchi	1	0.318	0.028	0.072	0.100	0.050	0.183	0	0	0	0
									Sub-total	**19,951,972.06**	
									Estimated total of carbon sequestered from plants	**22,618,023.76**	

Table 4. Estimated total of carbon sequestered from plants in the North Area

7 The field-acquired biophysical parameter data indicate that stands in age class I (5 – 10 years) have an average diameter of 16.620 m and a stand height of 12.307 m. Age class II (11 – 15 years) exhibits an average diameter of 19.477 m and a stand height of 14.283 m, while age class III (16 – 20 years) has an average diameter of 23.019 m and a stand height of 15.048 m (Galih Pratiwi, Bandi Sasmito, Nurhadi Bashit, 2021).

8 The research findings indicate an average tree height of 3.08 m along the riverbanks and 2.57 m on the mainland, with an average stem diameter of 11.46 cm along the riverbanks and 9.65 cm on the mainland (Mia Rahmadaniati, 2019).

9 We assumed that the diameter of a 2-year-old oil palm tree is 12 cm. This is based on information from the Regulation of the Minister of Agriculture of the Republic of Indonesia (2013), which states that the diameter of a 1-year-old oil palm tree reaches 6 cm. The assumption is that if it is 2 years old, it is highly likely to have a diameter of 12 cm.

10 The height of 19-year-old cocoa plants ranges from 6 to 7 meters with stem diameters ranging from 48 to 55 cm, while those aged 3 to 6 years reach a height of 2 to 3 meters with stem diameters ranging from 25 to 30 cm (Anisa Fajar Kumala Wardani, 2019).

11 The circumference of a 1-year-old tree trunk is 1 cm (information from the Sacha Inchi seed seller @fefarm). This means that its diameter is 0.318 cm.

As for peatlands, the estimation of carbon sequestration is calculated using the formula employed by Wahyunto and I Nyoman N. Suryadiputra (2008) in their research entitled *Peatland Distribution in Sumatra and Kalimantan - Explanation of its data sets including source of information, accuracy, data constraints and gaps*:

- **Below ground carbon store (KC) = B x A x D x C**

Where KC = carbon store, in tons; B = Bulk density (BD) of peat soil in gr/cc or ton/m3; A = Area of peat soil, in m2; D = Peat thickness, in m; C = Carbon content (C-organic) as a percentage (%).

Peatland Locations	Bulk Density (BD)[12] in ton/m^3	Area of Peat Soil (A) in m^2	Peat Thickness (D) in m	Carbon Content (C)[13]	Carbon Store (KC) in ton
Menua Sadap (Embaloh Hulu)	0.23		4.73[14]	0.3624	85,035.39
Labian (Batang Lupar)	0.23		6.16[15]	0.3624	340,716.50
Estimated total of carbon sequestered from peatlands					**425,751.89**

Tabel 5. Estimated total of carbon sequestered from peatlands in the North Area

12 Bulk density = 0.23 ton/m3, referring to the average volume weight of peat in Kalimantan at the Hemic level, as cited from " Peatland Distribution in Sumatra and Kalimantan - Explanation of its data sets including source of information, accuracy, data constraints, and gaps" by Wahyunto and I Nyoman N. Suryadiputra (https://www.wetlands.or.id/PDF/Atlas%20Review.pdf)

13 C = 36.24, referring to the carbon/organic carbon content in Kalimantan at the Hemic level, as cited from "Peatland Distribution in Sumatra and Kalimantan - Explanation of its data sets including source of information, accuracy, data constraints, and gaps" by Wahyunto and I Nyoman N. Suryadiputra (https://www.wetlands.or.id/PDF/Atlas%20Review.pdf)

14 We use an average measured thickness of 473 cm (4.73 m) in peatlands around KHG Sungai Embalon - Sungai Palin, assuming it includes Embaloh Hulu Sub-district, North Areas, as reported in the "Kapuas Hulu peat remapping final report: Mapping peat extent and depth of 16 Peat Hydrological Units within the Kapuas Hulu Basin", p. 41 (Remote Sensing Solutions, 2019)

15 Ibid, p. 23

Based on the information of the estimated carbon sequestered/stock contributed by plants and peatlands in North Areas, the following charts display how the carbon is distributed on average, either based on location or carbon pool.

Distribution average of carbon sequestered/stock
Based on location in the North Area

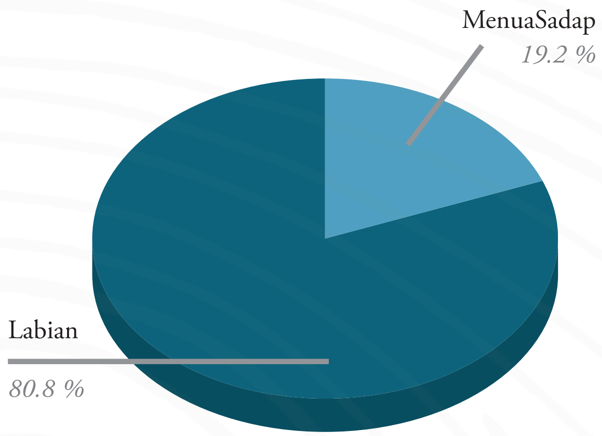

Figure 9 Distribution Average of Carbon Sequestered/stored based on Location in the North Area

Distribution average of carbon sequestered/stock
Based on location in the North Area

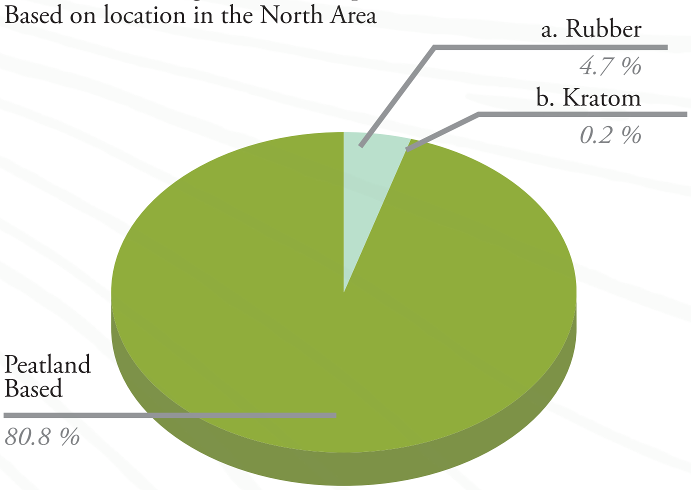

Figure 10 Distribution Average of Carbon Sequestered/stored based on Carbon Pool in the North Area

3.1.7. Other Findings in the North Area

We also found others data that related to social-economic condition in the North area as follows:

1. On average, individuals possess land with an area of 1.7 hectares.
2. 80% of the land is privately owned.
3. 60% of the population has a family dependency of 1-3 individuals.
4. 40% of the community has an income less than 750,000, 30% between 750,000 and 2,500,000, and 30% have an income above 2,500,000.
5. 70% of the population relies on well water for their daily needs.
6. 50% of the community uses rainwater for drinking purposes.

3.1.8. Conclusion of Ecological Conditions in the North Area

Using the ecological parameters findings on vegetation, native plants, climate, soil, water sources, and carbon sequestration in the North Area, following are the conclusions.

3.1.8.1. Vegetation Condition, Type, and Function

1. The North Area already have five layers of vegetation. Meanwhile, the community has also participated in planting or maintaining the five layers, including palm oil as the main crop, which leads the areas to keep the biodiversity. However, these five layers are mostly grown in a wild manner.
2. The community has also planted local plants for conservation purposes.
3. Local food crops are maintained by the community in the shrub layer and ground cover layer.
4. The community in the areas have not engaged yet in seed saving and nursery development.
5. The community also has not utilized their yard for planting purposes, such as managing home gardens.

3.1.8.2. Native Plants

1. The Area is abundant in native plants.
2. The soil condition in the North Area is much more fertile than in the Central and South Areas.
3. The planted crops are more resistant to pests and diseases due to the presence of native plant.

3.1.8.3. Climate Conditions

1. Compared to the Central and South Areas, the temperature in the north is significantly cooler
2. There is an increase in rainfall.
3. The weather is unpredictable.
4. Changes in temperature, rainfall, weather patterns, and other factors directly impact the environment. This can be observed through the appearance of specific pests and diseases in a particular location, which affects harvests, planting calendars, and the types of crops grown.
5. The impacts are not only environmental but also economic and social.
6. The prevalence of plant pests and diseases has risen, leading to reduced yields. In the North Area, pests such as monkeys and leafhoppers have emerged, while diseases caused by viruses, fungi, and bacteria are also prevalent. Decreased crop yields significantly affect the economic aspect of the community in the North Area.
7. Compared to Central and South Areas, natural disasters such as floods occur less frequently in the North Area due to the preserved diversity of native plants, hence, water recedes faster during heavy rainfall.
8. In terms of sociocultural and ecological aspects, the abundance of local crops in the North Area has declined due to the increase in rainfall, which limits the cultivation of certain plants to only in dry season. Additionally, the entry of specified-commodity companies into the North Areas have also influenced what crops will be planted by farmer groups in the areas. This situation has brought an impact on farming methods and types of crops planted, which also affects the declining of local crops.

3.1.8.4. Soil Conditions

1. In the North Area, the soil pH ranges from 4.5-5 while neutral pH is 6-7, indicating acidic soil conditions. As a result, the nutrients in the soil cannot be optimally absorbed by plants, hindering their growth and development.
2. Organic content in the North Area is the highest, ranging from 15-20% while the minimum standard is 5%. This affects the soil structure and texture in the North Area, which are better compared to the Central and South Areas.
3. Regarding nutrient content and microbial activity, the northern region has low level. Yet the soil has a high organic content, its fertility is still low due to the lack of microorganisms that convert organic matter into nutrients.
4. Permeability in the North Area is slow, indicating that the soil cannot retain nutrients effectively.
5. Aeration in the North Area is moderate, indicating good air circulation within the soil which will bring a positive impact to the plants.
6. Overall, it can be concluded that the soil conditions in the North Area as a whole are much better compared to soil conditions in the Central and South Areas due to its high organic content and adequate aeration. Even so, such soil conditions still need several efforts such as neutralizing soil pH as this will later have an impact on nutrient content, structure, texture, microbial activity, permeability, and aeration.

3.1.8.5. Water Sources

1. In the the North Area, there are two significant water sources, which are water from the hills and water from Sentarum Lake, utilized by the local community. Despite the availability of water sources, the community still purchases gallons of water from outside for drinking as the physical appearance and water quality indicate low pH levels, making it not drinkable .
2. Rainwater harvesting has also been practiced by the community, although it has not been maximally utilized. With unharvested rainwater runoff, the chances of stagnant floods are even greater, although the floods are less frequent than in the Central and South Areas.
3. Du e to the high rainfall in the three areas, a rainwater harvesting system is necessary for adaptation measures. Rainwater harvesting systems[16] can be multi-function fishponds, pools, ditches, etc. By designing the system for each household, it can fulfill water needs at the household level, especially during droughts, and could possibly reduce the risk of floods.[17]
4. There are several trees that function as erosion control in the North Area, such as *Sengkawang*, *Kayu Ulin*, and Ficus. The presence of vegetation can directly reduce erosion risk, with the existing trees acting as natural erosion controllers.

Photo: GIZ / IDEP Foundation

[16] Nani Heryani, Setyono Hari Adi, dan Budi Kartiwa, Kriteria Rancang Bangun Sistem Panen Hujan Dan Aliran Permukaan: StudiKasus Das Cisadane Hulu. Vol. 23, No.2, Riset Geologi dan Pertambangan. Desember 2013

[17] Rizky Franchitika, Meminimalisir Banjir dengan Sistem Pemanenan Air Hujan. SEMNASTEK UISU. 2019.

3.1.8.6. Carbon Sequestration/stock

1. The sample locations in the North Area have a higher variety of plant species than the Central and South Areas.
2. The total carbon sequestered/stored across the sample locations in the North Area is 448,369.92 tons/year. With 87,927 hectares of plant areas and peatlands, an estimated carbon sequestered from the sample location in the North Area is 5.099 tons/hectare/year.
3. The distribution average of carbon sequestered/stored in the North Area shows that peatlands store more carbon than the plants. As the dominant contributor to carbon sequestered/stock, peatlands contribute 94.95%, while plants contribute 5.04% of the total carbon sequestered/stored.
4. In terms of locations, Batang Lupar Sub-district sequestered/stored more carbon (80.8%) than Embaloh Hulu Sub-district (19.2%) of the total carbon sequestered/stored.
5. As the dominant contributor, peatlands have an estimated carbon stock of 384,767.27 tons/year (94.95%) of the total carbon sequestered. With 87,927 hectares of its area, an estimated carbon sequestered from peatlands in the sample locations in the North Area is 4.375 tons/hectare/year.
6. Rubber contributes 21,291.27 tons/year (4.74%) of the total carbon sequestered. With 800 hectares of rubber planted, the estimated carbon sequestered by rubber in the sample locations of the North Area is 26.61 tons/hectare/year.
7. Palm oil contributes a minor amount of carbon sequestration with estimated 174.95 tons/year (0,03%) of the total carbon sequestered, only from Labian (Batang Lupar Sub-district). With 15 hectares of palm oil planted, the estimated carbon sequestered by palm oil in the sample locations of the North Area is 11.66 tons/hectare/year.
8. Kratom makes a noteworthy contribution in both locations with 916.23 tons/year (0.20%) of the total carbon sequestered. With 45.5 hectares of kratom planted, the estimated carbon sequestered by kratom in the sample locations of the North Area is 20.136 tons/hectare/year.
9. Sacha Inchi contributes minimally to carbon sequestration, making up a very small percentage.


Photo: GIZ / IDEP Foundation

3.2. Central Area: Ecological Condition

In the Central Areas, we assessed 9 villages in two sub-districts as samples using the ecological parameters to collect data on vegetation, native plants, climate, soil, water sources, and carbon sequestration. The details for the locations are as follows:

1. Seven villages in Pengkadan sub-district, namely: Riam Panjang, Pinang Laka, Mawan, Kerangan Panjang, Hulu, Buak Limbang, and Permata.
2. Two villages in Mentebah, namely: Nanga Mentebah and Tanjung Intan.

3.2.1. Vegetation Conditions, Types, and Functions

The vegetation in the area is highly diverse and consists of five layers of vegetation that indicate the level of biodiversity. Regarding that, from a score of 1-5, the vegetation diversity score in the Central Area is 5. The following are the five layers of vegetation mentioned:

1. Emergent Trees (e.g., Ficus and local trees) usually function for ecological and sociocultural purposes. In total, the vegetation in this layer is estimated to be 5% of the total vegetation.
2. Canopy Trees (e.g., palm oil, rubber, *durian*) usually function for economic and sociocultural purposes. In total, the vegetation in this layer is estimated to be 70% of the total vegetation.
3. Trees (e.g., *asam kandis*, *rambutan*, *engkuis*) usually function for sociocultural and ecological purposes. In total, the vegetation in this layer is estimated to be 10% of the total vegetation.
4. Shrubs (e.g., *kratom*, banana, *sengkubak*, and other local plants) usually function for sociocultural and economic purposes. In total, the vegetation in this layer is estimated to be 10% of the total vegetation.
5. Ground Covers (e.g., *maram*/forest snake fruit, vegetables, rice, *taro*) usually function for sociocultural and ecological purposes. In total, the vegetation in this layer is estimated to be 5% of the total vegetation.

3.2.2. Native Plants Types

On native plants, we have observed, interviewed, and discussed with the community to identify as many as possible plants, followed by their functions, including sociocultural, economic, ecological, and health. Following are the results.

3.2.2.1. Plant Types

We have found 53 native plants in sample locations in the Central Area. Most of them are listed in their local language as we don't have information on their names in English. Further data collection with adequate sources of information is needed to comprehend these findings.

The native plants found are as follows:

1. Pulai Pipit (Ficus)
2. Rukam (similar to Kiranti)
3. Ringin
4. Asam Kandis
5. Kedadai
6. Simpur Air (60 species)
7. Local rice
8. Buah Kondang (Ficus Variegata Blume)
9. Daun Kondang
10. Sengkubak
11. Senggani (Melastoma)
12. Kratom (Mitrogyna speciosa)
13. Peronggang
14. Kangkang
15. Ficus Padana
16. Sengkuang
17. Smilax vegetables (Sarsaparilla)
18. Tengkawang (Shorea spp.)
19. Buah Entawa
20. Buah Koli (Nephelium H)
21. Engkuis
22. Local Matoa
23. Buah Rambai
24. Buah Kapul
25. Buah Keledang
26. Buah Terap
27. Buah Bemotong
28. Keranji or Keramu
29. Maritam/Durian Rimba/Lahung
30. Buah Kemantan
31. Sikup (Forest Rambutan, found in Puttusibau)
32. Buah Durian Merah
33. Rumbia (Metroxylon sagu)
34. Buah Kepayang
35. Kasturi
36. Asam Kelam (Local mango)
37. Buah Umbin (Local starfruit, found in Pengkadan)
38. Maram (Forest Snakefruit)
39. Buah Kemayau (black-colored)
40. Buah Kangkala
41. Buah Engkala
42. Sungkai
43. Buah Puak/Tampui/Enceriak
44. Jambu Tangkalak (American guava/Bellucia Terana)
45. Keranti
46. Sobang
47. Kedabang
48. Local Kecombrang
49. Daun Sinduk
50. Umbut Apin
51. Keranti
52. Kedabang
53. Daun Mali-mali

3.2.2.2. Plant Functions

On their functions, there are some plants that we have identified, while some have not due to the limited time and information we've collected from the community during the assessment process in the field. The identified functions are as follows.

3.2.2.3. Sociocultural

1. *Daun Kondang*: consumed to facilitate breastfeeding.
2. *Senggani/Kemunting*: its roots are used for tenderizing meat.
3. *Daun Mali-mali*: used in wedding ceremonies and postpartum rituals.

3.2.2.4. Economic

1. *Kedadai*: consumed as a vegetable.
2. *Senggani/Kemunting*: used for consumption. Its roots are used for tenderizing meat.
3. *Sengkubak*: used as a flavor enhancer.
4. *Peronggang*: can be used for brooms.
5. *Kangkang*: can be used as a vegetable.
6. *Sengkuang*: leaves can be used as a substitute for the souring agent (dracontomelon).
7. *Umbut Apin*: can be consumed as a vegetable.

3.2.2.5. Ecological

1. *Buah Kondang*: water retention, beneficial for soil, water, and biodiversity conservation.
2. *Engkuis*: primary food source for Hornbills and monkeys.
3. *Jambu Tangkalak* (American guava): erosion prevention, food for Frugivora.
4. *Pulai Pipit* (ficus): used for conservation purposes.
5. *Sobang*: ground cover (layer 5), biomass producer, carbon sequestration, and attracts pollinating insects.
6. *Umbut Apin*: used for conservation purposes.

3.2.2.6. Health Functions

1. *Senggani/Kemunting*: its leaves can be used for treating wounds.
2. *Sungkai*: used as a medicinal plant.
3. *Daun Kondang*: consumed to facilitate breastfeeding.
4. *Keranti*: consumed to increase breast milk production.
5. *Sobang*: its leaves and flowers can be used as medicine.

Apart from the plants, we found one type of native fish with their functions during our assessment:

1. *Jelawat*: Economic function for consumption.

3.2.3. Climate Condition

The climate condition, its changes, and impacts can be identified in the following table.

<table>
<tr><th>Exiting Climate</th><th>Pattern Changes</th><th>Impacts</th></tr>
<tr><td>Altitude: 50m</td><td>N/A</td><td rowspan="4">Pests:
There are wild boars, monkeys, snails, ants, beetles, leaf caterpillars, soil worms, whiteflies, and fruit flies identified as threats.

Diseases:
Plants in these areas experience decayed roots, decaying stems, and wilted leaves.

Yields:
The community is unable to harvest rubber during the rainy season.

Change in planting calendar:
Planting time shifted, delayed by half a month. It used to start in late August, but currently, it starts in September - October.

Change in crop types:
Transition to palm oil cultivation.

Natural disasters:
There are floods, tornadoes (2015-2016), and sometimes landslides.

Environment:
Rivers become broader and shallower (siltation).</td></tr>
<tr><td>Weather
30°C - 32°C</td><td>Weather
Irregular, no dry season last year, increasing temperatures</td></tr>
<tr><td>Rainfall
3,300mm/year
(generally in Kapuas Hulu)</td><td>Rainfall
5,000mm/year
(Averages in Kapuas Hulu)</td></tr>
<tr><td>Wind
West and South</td><td>Wind
Strong west winds occur from September to November, while outside those months, winds move from the South, East, and North</td></tr>
</table>

Table 6 Climate condition in Central Area

3.2.4. Soil Condition

Soil conditions in the Central Areas can be identified in the following table.

Soil Indicator	Findings
pH	4,5 - 5
Structure	Blocky
Main texture	Clay
Nutrient content	Low
Organic matter	0,7 % - 1,0 %
Microbial activity	Low
Permeability	Slow
Aeration	Moderate (50%/hour)

Table 7 Soil conditions in the Central Areas

3.2.5. Water Sources

Water sources in the Central Area can be identified in the following table.

Water Resources	Findings
Rainwater harvesting	Practiced but not maximized, mainly at the household level
Irrigation	Not available
Drainage	Not available
Erosion control	Not available
Types of water resources	1. PDAM (public water supply system) 2. Groundwater 3. Rainwater 4. River water 5. Pond water
Physical appearance of water quality	a. Color: Reddish brown b. Turbidity: Murky c. Aroma: Acidic

Table 8 Water sources in the Central Areas

3.2.6. Carbon Sequestration

Due to the limited time of assessment, we used focused-group discussion (FGD) to identify and then estimate carbon sequestration in the Central Area using seven villages as samples: Riam Panjang, Pinang Laka, Mawan, Kerangan Panjang, Permata representing Pengkadan while Nanga Mentebah and Tanjung Intan representing Mentebah sub-district. There is still a lack of data and information collected in some fields. Hence, further assessment is needed to complete the calculation.

However, as an initial overview of the potential carbon sequestration and stock in this area, we attempted to estimate it using allometric equations based on the available data from FGD results and assumptions developed based on references from existing literature. The unmeasured carbon pool, in this case, is presumed to be determined through the relationship between above-ground tree biomass and other carbon pools already established from prior research or studies in Kalimantan or other locations in Indonesia, along with additional information gathered from various sources. Below, we present the allometric equations and references we employed:

a. The Above Ground Biomass (AGB) was calculated using the allometric equation developed by Udayakumar et al. (2016) for the tropical dry forests:
   - AGBdry = exp (2.2014 x LN (DBH) - 1.0615)

   Where AGBdry = Above ground dry biomass of tree (kg); DBH = diameter at breast height (cm); 2.2014 and -1.0615 are constants.
b. Below Ground Biomass (BGB) was calculated using the following formula (MacDicken 1997, Hangarge et al. 2012):
   - BGB (Kg/tree) = AGB (Kg/tree) x 0.26
c. Total Biomass (TB) is the sum of the AGB and BGB (Sheikh et al. 2011):
   - TB = AGB + BGB (kg/tree)
d. Generally, 50% of the biomass of any plant species is considered carbon (Pearson et al. 2005). Therefore, the weight of carbon in the tree was estimated by multiplying the tree's biomass by 50% (Birdsey 1992).
   - Carbon Storage = Biomass x 50% or Biomass/2 (kg/tree).
e. To determine the weight of CO_2 sequestered in the tree, multiply the weight of carbon in the tree by 3.6663 (Vishnu and Patil 2016).
f. The weight of CO_2 sequestered in the tree per year was determined by dividing the weight of carbon dioxide sequestered in the tree by age.

Using the formula, a general overview of estimated carbon sequestration and stock from the plant is provided in the following table as preliminary data.

Tree Species per location	**Average Age**	**Average DBH** (cm)	**Above ground biomass** (kg/tree)	**Below ground biomass** (kg/tree)	**Total biomass** (kg/tree)	**Carbon** (kg/tree)	**CO2 sequestered** (kg/tree)	**Tree count**	**CO2 sequestered of all trees** (kg)	**CO2 sequestered/ year** (kg)	**CO2 sequestered/ year** (ton)
Riam Panjang (Pengkadan Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	200,000[18]	159,128,301.58	4,546,522.90	4,546.52
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	18,000	2,114,381.02	528,595.26	528.60
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	615[19]	25,380.22	25,380.22	25.38
									Sub-total	**5,100,498.37**	**5,100.50**
Pinang Laka (Pengkadan Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	4,600,000			104,570.03
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	0	0.00	0.00	0.00
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	0	0.00	0.00	0.00
									Sub-total		**104,570.03**
Mawan (Pengkadan Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	4,640,000[20]			105,479.33
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	0	0.00	0.00	0.00
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	0	0.00	0.00	0.00
									Sub-total		**105,479.33**
Kerangan Panjang (Pengkadan Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	800,000[21]	636,513,206.31	18,186,091.61	18,186.09
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	0	0.00	0.00	0.00
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	0	0	0.00	0.00
									Sub-total	**18,186,091.61**	**18,186.09**
Permata (Pengkadan Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	720,000[22]	572,861,885.68	16,367,482.45	16,367.48
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	0	0.00	0.00	0.00
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	0	0.00	0.00	0.00
									Sub-total	**16,367,482.45**	**16,367.48**
Tanjung Intan & Nanga Mentebah (Mentebah Sub-district)											
Rubber	35	23.019	344.468	89.562	434.030	217.015	795.642	800,000[23]	636,513,206.31	18,186,091.61	18,186.09
Kratom	4	9.650	50.856	13.223	64.079	32.039	117.466	600000	70,479,367.36	20,136,962.10	20,136.96
Palm Oil	1	6.000	17.867	4.645	22.512	11.256	41.269	0	0.00	0.00	0.00
									Sub-total	**38,323,053.71**	**38,323.05**
									Estimated Grand Total of Carbon Sequestered from Plants		**288,026.48**

Tabel 9 Estimated total of carbon sequestered from plants in the Central Area

18 Due to data limitations, we used the tree count per hectare data in Pinang Laka Village in the Central Area as a reference for other locations in the North, Central, and South areas. In Pinang Laka, the tree count per hectare ranges from 300 to 500. We used the mean value of 400 as the reference point.

19 Due to data limitations regarding palm oil, we used the tree count per hectare data in North Area as a reference for locations in the Central and South Areas. In the North Area, the tree count per hectare is 123.

20 Opcit.

21 Ibid.

22 Ibid.

23 Ibid.

As for peatlands, the estimation of carbon sequestration is calculated using the formula employed by Wahyunto and I Nyoman N. Suryadiputra (2008) in their research entitled *Peatland Distribution in Sumatra and Kalimantan - Explanation of its data sets including source of information, accuracy, data constraints and gaps*:

- **Below ground carbon store (KC) = B x A x D x C**

Where, KC = carbon store, in tons; B = Bulk density (BD) of peat soil in gr/cc or ton/m3; A = Area of peat soil, in m2; D = Peat thickness, in m; C = Carbon content (C-organic) as a percentage (%).

Peatland Locations	**Bulk Density (BD)** in ton/m³	**Area of Peat Soil (A)** in m²	**Peat Thickness (D)** in m	**Carbon Content (C)**	**Carbon Store (KC)** in ton
Bunut Hulu	0.23	69,548,400	4.52[24]	0.3624	26,202.43
Mentebah	0.23	133,939,000	4.69[25]	0.3624	52,359.55
Estimated Grand Total of Carbon Sequestered from Peatlands					**78,561.98**

Based on the information of the estimated carbon sequestered/stored contributed by plants and peatlands in the the Central Area, the following charts display how the carbon is distributed on average, either based on location or carbon pool.

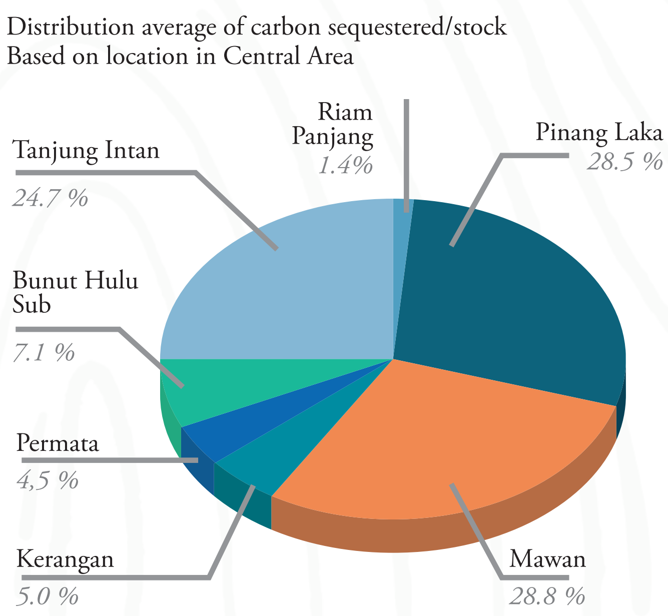

Figure 11 Distribution Average of Carbon Sequestered/ stored based on Location in the Central Area

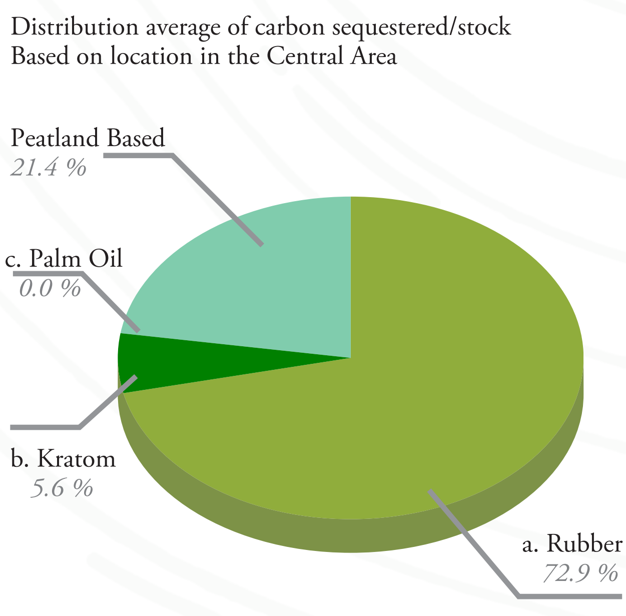

Figure 12 Distribution Average of Carbon Sequestered/ stored based on Carbon Pool in the Central Area

24 We use an average measured thickness of 452 cm (4.52 m) in peatlands around KHG Sungai Bunut - Sungai Kapuas, assuming it includes Bunut Hulu Sub-district, Central Areas, as reported in the "Kapuas Hulu peat remapping final report: Mapping peat extent and depth of 16 Peat Hydrological Units within the Kapuas Hulu Basin", p. 29 (Remote Sensing Solutions, 2019)

25 Ibid, p. 35

3.2.7. Other Findings in the Central Area

We also found other data related to socioeconomic conditions in the Central Area as follows:

1. On average, they have a land area of 2.1 hectares.
2. 74% of the land is privately owned.
3. 72% have a family burden of 1-3 individuals.
4. 62% of the community has an income of less than IDR 750,000, 28% amounting to IDR 750,000 - 2,500,000, and 10% amounting above IDR 2,500,000."
5. 70% of the population uses piped water supply (PDAM) daily.
6. 54% of the community uses piped water supply (PDAM) for drinking water.

3.2.8. Conclusion of Ecological Condition in the Central Area

Using the ecological parameters findings on vegetation, native plants, climate, soil, water sources, and carbon sequestration in the Central area, following are the conclusions.

3.2.8.1. Vegetation Condition, Type, and Function

1. Farmers in the Central Area have implemented a five-layer planting system, including palm oil as the main crop.
2. Conservation plants, including local species and food crops, are cultivated in the understory and ground cover layers.
3. The community has started seedling production for conservation and local plants, planting them on a small scale in their yards.
4. However, due to the limited availability of local and conservation plant seedlings, it is still challenging to find these plants for replanting purposes.

3.2.7.2. Native Plants

1. The presence of native plants is closely related to soil conditions. A higher number of native plants indicates better soil conditions in an area.
2. The greater the diversity of native plants, the richer the area's biodiversity.
3. Diverse native plant species support intercropping systems, creating more sustainable environmental impacts.
4. Increased diversity of native plants can serve as an indicator of the presence or absence of wildlife populations in a location.
5. The study area exhibits a significant number of native plant species.
6. In general, the mineral content and fertility in the sample areas in the Central Area are low. However, when compared to the South Area, its fertility is relatively higher.
7. The crops planted in this area demonstrate better resistance to pests and diseases due to the presence of native plants.
8. Compared to the Southern Area, the temperature in the Central Area is slightly cooler.
9. Natural disasters such as floods are less severe in the Central Area compared to the South Area due to the preserved diversity of native plants, resulting in faster water drainage.

3.2.7.3. Climate Condition

1. Climate indicators such as temperature, altitude, weather, rainfall, and wind play a crucial role in assessing climate changes in a specific area. Changes in temperature, weather patterns, rainfall, and wind can directly indicate the quality of the climate in an area.
2. The temperature in the Central Area have increased over the last 3 - 5 years. This is due to many trees, including rubber, *gopung*, and *tembawan*g being cut down and replaced with palm oil trees
3. Rainfall has also increased.
4. There has been an increase in plant pests and diseases, resulting in reduced crop yields.
5. The weather is difficult to predict.
6. Changes in temperature, rainfall, weather patterns, and other factors have a direct impact on the environment. These changes can be observed through the emergence of specific pests and diseases, which, in turn, affect crop yields, planting schedules, and the types of crops suitable for the area.
7. In the Central Area, there are significant pest problems, including wild boars, monkeys, snails, ants, bugs, leaf worms, soil worms, and fruit flies.
8. Many diseases have also been reported , including root rot, stem rot, and wilting. This also affects the crops and vegetables planted by farmers in their gardens, such as eggplant, chili, and local corn.
9. The impact of climate change extends beyond the ecological sphere and affects the economy and society.
10. Decreased crop yields significantly impact the economic aspect of the local community in the Central Area.
11. Cultivation practices and the types of crops grown are also influenced by the entry of companies into the area, resulting in socio-cultural impacts on farming methods and crop choices.
12. To mitigate the impacts of climate change, it is essential to identify plants capable of adapting to climate change, such as coconut, maize, local rice varieties, etc.

3.2.7.4. Soil Condition

1. The soil in sample locations in the Central Area is slightly acidic with clay texture and low nutrient content. This combination may require soil management practices to address nutrient deficiencies and improve soil structure. Additionally, the low microbial activity and slow permeability could impact the soil's ability to support healthy plant growth.
2. Assessing soil fertility involves considering various indicators, such as pH, organic matter, structure and texture, permeability, and aeration.
3. Soil with a pH below 6 is considered acidic, making it difficult for plants to absorb nutrients.
4. A minimum of 5% organic matter is required in soil for optimal fertility. Organic matter significantly affects soil structure and texture.
5. Higher organic matter content improves soil structure and texture.
6. Better soil structure and texture influence microbial activity, permeability, and aeration, all impacting soil nutrient availability.
7. If the soil has a high organic matter content but low microbial activity, the soil fertility will be low due to the lack of microorganisms that convert organic matter into nutrients.
8. Good soil aeration positively affects the growth of plants due to better air circulation.

3.2.7.5. Water Resources

1. Generally, when an area has at least two water sources, the community is secure regarding water needs, including consumption and agriculture.
2. From the available water sources, if water is used for agricultural and sanitation purposes, it is generally safe. However, if used for consumption, it is unsafe due to turbidity, odor, and low pH levels.
3. Technical erosion control measures such as building terraces and planting trees (vegetation) can be implemented. However, since the slopes in the three areas are relatively safe, terrace construction is not currently necessary.
4. Due to the high rainfall in the three areas, a rainwater harvesting system is necessary for adaptation measures. Rainwater harvesting systems [26] can be multi-function fish ponds, pools, ditches, etc. By designing the system for each household, it can fulfill water needs at the household level, especially during droughts, and could possibly reduce the risk of floods. [27]
5. Water resources serve as a crucial source for daily needs and agriculture.
6. In the Central Area, there are five water sources commonly used by the local community.
7. Having more than two water sources in a particular area indicates that the Central Area does not face water availability issues.
8. Rainwater harvesting is also practiced by the community in the Central Area, although not yet maximally utilized. This impacts the occurrence of floods in the Central Area, although not as frequent as in the North and Southern Areas.
9. The Central Area is at the bottom of the Kapuas basin, resulting in frequent flooding during periods of high rainfall that inundate the community's garden. The lack of drainage systems also makes the situation worse. Drainage is essential for adaptation measures in high-rainfall areas. As the heavy rainfall usually triggers floods, the water stays longer in the community's garden. Hence, with the drainage system, the water can be channeled out of the garden faster.
10. Several trees serve as erosion control measures in the Central Area, such as *Tengkawang*, *Kayu Ulin*, and Ficus.
11. This is closely related to the vegetation condition in an area. If the vegetation condition is still relatively good, the existing trees in the area can directly act as erosion controllers.
12. Although the Central Area has abundant water sources, most farmers still buy bottled water from outside to meet their drinking water needs. This is due to the low pH level, which makes the physical appearance of the water quality unsuitable for consumption.

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[26] Nani Heryani, Setyono Hari Adi, dan Budi Kartiwa, Kriteria Rancang Bangun Sistem Panen Hujan Dan Aliran Permukaan: StudiKasus Das Cisadane Hulu. Vol. 23, No.2, Riset Geologi dan Pertambangan. Desember 2013

[27] Rizky Franchitika, Meminimalisir Banjir dengan Sistem Pemanenan Air Hujan. SEMNASTEK UISU. 2019.

3.2.7.6. Carbon Sequestration

1. The total carbon sequestered/stored across the sample locations in the Central Areas is 366,588.47 tons/year.
2. The distribution average of carbon sequestered/stock in sample locations in the Central Area shows that plants have more carbon sequestered/stored than peatlands. Plants, particularly rubber, are the dominant contributor to carbon stock. Meanwhile, peatland is relatively small compared to plant-based sequestration. The plants contribute 78.56%, while peatlands contribute 21.43%.
3. In terms of locations, Mawan has more carbon sequestered/stored (28.8%) than other locations, only from rubber. Meanwhile, Riam Panjang contributes the least (1.4%). Both villages are in the Pengkadan Sub-district, with no peatland identified during the assessment.
4. As the peatlands are only found in Bunut Hulu and Mentebah sub-districts, the estimated carbon stock is 78,561.98 tons/year. With 20,348.74 hectares of peatlands, an estimated carbon sequestered from peatlands is 3.860 tons/hectare/year.
5. Rubber contributes significantly to carbon sequestration, comprising 267,335.55 tons/year (72.9%) of the total carbon sequestered. Pengkadan Sub-districts and Bunut Hulu Sub-district are the primary contributors. With 29,400 hectares of rubber planted, the carbon sequestered by rubber in the sample locations of the Central Area is 9.093 tons/hectare/year.
6. *Kratom* contributes 20,665.56 tons/year (5.63%) of the total carbon sequestered, mainly from Tanjung Intan and Nanga Mentebah (Mentebah Sub-district). With 530 hectares of kratom planted, the estimated carbon sequestered by *kratom* in the sample locations of the Central Area is 38.99 tons/hectare/year.
7. Palm oil contributes a minor amount of carbon sequestration at 25.38 tons/year (0,0069%) of the total carbon sequestered, only from Riam Panjang (Pengkadan Sub-district). With 5 hectares of palm oil planted, the estimated carbon sequestered by palm oil in the sample locations of the Central Area is 5.076 tons/hectare/year.


Photo: GIZ / IDEP Foundation

Photo: GIZ / IDEP Foundation

3.3. South Area

In the South Areas, we assessed three villages as samples, including Setunggul, Nanganuar, and Pangeran, in the Silat Hilir Sub-district. Using the ecological parameters to collect data on vegetation, native plants, climate, soil, water sources, and carbon sequestration, the following are the findings.

3.3.1. Ecological Conditions

The area´s vegetation tends to have low diversity and only consists of three layers of vegetation. Regarding that, from a score of 1-5, the vegetation diversity score in South Areas is 3. The following are the three layers of vegetation mentioned:

1. Emergent trees usually function for ecological and sociocultural purposes. In total, the vegetation in this layer is estimated to be 5% of the total vegetation.
2. Canopy trees (e.g., palm oil, rubber, *durian*) usually function for economic and sociocultural purposes. In total, the vegetation in this layer is estimated to be 90% of the total vegetation.
3. Trees (e.g., *asam kandis*) usually function for sociocultural and ecological purposes. In total, vegetation in this layer is estimated to be 5% of the total vegetation.

3.3.2. Native Plants

On native plants, we have observed, interviewed, and discussed with the community to identify as many as possible plants, followed by their functions, including socio-cultural, economic, ecological, and health. The following are the results..

3.3.2.1. Plant Types

During our observation in Nanga Nuar and Pangeran villages, we only found 5 native plants . Most of them are listed in their local language, as we do not have information on their name in English. Further data collection with adequate sources of information is needed to comprehend these findings.

1. *Senggani*
2. *Simpur Air*
3. *Kedabang*
4. *Sobang*

3.3.2. Plant Function

On their functions, there are some plants that we have identified, while some have not been identified due to the limited time. We have collected information from the community during the assessment process in the field. The identified functions are as follows.

3.3.2.3. Social-Cultural Functions

1. Senggani: used to tenderize meat.

3.3.2.4. Economic Functions

1. Sinduk leaves: consumed as a vegetable.
2. Senggani: the leaves can be consumed as a vegetable.

3.3.2.5. Ecological

1. Senggani: the flowers serve as pollinators.
2. Simpur Air: helps improve soil conditions.
3. Jambu Monyet: serves as food for wildlife.

3.3.2.6. Health Functions

1. Keranti: cooked to enhance breast milk production.
2. Senggani: leaves and fruits used for stomach ailments.

3.3.3 Climate Condition

The climate condition, its changes, and impacts can be identified in the following table.

Existing Climate	Pattern Changes	Impacts
Altitude 30-50m	**N/A**	**Pests and diseases** Weevils, caterpillars, grasshoppers, fruit flies. **Yields** Palm oil harvest decreases during the rainy season, and other crops can only be planted during the dry season when no floods occur. **Change in planting calendar** Planting time has shifted, delayed by 1/2 month, usually in late August but now in September-October. **Change in crops grown** Shift towards planting palm oil. **Natural disaster** Flooding
Weather 33°C - 34°C	**Weather** 33°C - 35.9°C (rainy and dry seasons are unpredictable)	
Rainfall 3,300mm/year (generally in Kapuas Hulu)	**Rainfall** 5,000mm/year (generally in Kapuas Hulu)	
Wind West and South	**Wind** West from September to November (strongest), outside of that, wind moves from South, East, North.	

Table 11 Climate condition in the Southl Area

3.3.4 Soil Condition

Soil conditions in the South area can be identified in the following table.

Soil Indicator	Findings
pH	4,5 and 5
Structure	Blocky
Main texture	Clay
Nutrient content	Low
Organic matter	1 % - 5 %
Microbial activity	Low
Permeability	Moderate
Aeration	Moderate (50%/hour)

Table 12 Soil condition in the South Area

3.3.5. Water Resources

Water Resources in the South Area can be identified in the following table.

Water Resources	Findings
Rainwater harvesting	Currently implemented at the household level but not fully maximized in scale
Irrigation	Not available
Drainage	Not available
Erosion control	Not available
Types of water resources	1. Wells 2. Rainwater (for drinking) 3. Bottled water (for drinking) 4. River
Physical appearance of water quality	1. Color: Reddish brown 2. Turbidity: Cloudy 3. Aroma: Acidic

Table 13 Water resources in the South Area

3.3.6. Carbon Sequestration

Due to the limited time of assessment, we used focused-group discussion (FGD) to identify and then estimate carbon sequestration in the South Area using three villages as samples, Setunggul, Nanga Nuar, and Pangeran Village representing Silat Hilir sub-district. There is still a lack of data and information collected in some fields hence, further assessment is needed to complete the calculation.

However, as an initial overview of the potential carbon sequestration and stock in this area, we attempted to estimate it using allometric equations based on the available data from FGD results and assumptions developed based on references from existing literature. The unmeasured carbon pool, in this case, is presumed to be determined through the relationship between above-ground tree biomass and other carbon pools already established from prior research or studies in Kalimantan or other locations in Indonesia, along with additional information gathered from various sources.

Below, we present the allometric equations and references we employed:

a. The Above Ground Biomass (AGB) was calculated using the allometric equation developed by Udayakumar et al. (2016) for the tropical dry forests:
   - AGBdry = exp (2.2014 x LN (DBH) - 1.0615)

   Where AGBdry = Above ground dry biomass of tree (kg); DBH = diameter at breast height (cm); 2.2014 and - 1.0615 are constants.
b. Below Ground Biomass (BGB) was calculated using the following formula (MacDicken 1997, Hangarge et al. 2012):
   - BGB (Kg/tree) = AGB (Kg/tree) x 0.26
c. Total Biomass (TB) is the sum of the AGB and BGB (Sheikh et al. 2011):
   - TB = AGB + BGB (kg/tree)
d. Generally, 50% of the biomass of any plant species is considered carbon (Pearson et al. 2005). Therefore, the weight of carbon in the tree was estimated by multiplying the tree's biomass by 50% (Birdsey 1992).
   - Carbon Storage = Biomass x 50% or Biomass/2 (kg/tree).
e. To determine the weight of CO_2 sequestered in the tree, multiply the weight of carbon in the tree by 3.6663 (Vishnu and Patil 2016).
f. The weight of CO_2 sequestered in the tree per year was determined by dividing the weight of carbon dioxide sequestered in the tree by age.

Using the formula, a general overview of estimated carbon sequestration and stock from plants is provided in the following table as preliminary data.

Tree Species	Average Age	Average DBH (cm)	Above ground biomass (kg/tree)	Below ground biomass (kg/tree)	Total biomass (kg/tree)	Carbon (kg/tree)	CO2 sequestered (kg/tree)	Tree Count	CO2 sequestered of all trees (kg)	CO2 sequestered/ year (kg)	CO2
Silat Hilir Sub-district											
Rubber	13	19.477	238.411	61.987	300.398	150.199	550.674	290,000[28]	159,695,557.75	12,775,644.62	12,775.64
Palm Oil	6	36.000	922.419	239.829	1,162.248	581.124	2,130.575	178,350[29]	379,988,018	63,331,336	63,331.34
Pepper	1	5.000[30]	11.962	3.110	15.071	7.536	27.628	3,200	88,410.57	88,410.57	88.41
Estimated Grand Total of Carbon Sequestered from Plants											**76,195.39**

Tabel 14 Estimated total of carbon sequestered from plants in South Areas

As for peatlands, the estimation of carbon sequestration is calculated using the formula employed by Wahyunto and I Nyoman N. Suryadiputra (2008) in their research entitled *Peatland Distribution in Sumatra and Kalimantan - Explanation of its data sets including source of information, accuracy, data constraints and gaps*:

- **Below ground carbon store (KC) = B x A x D x C**

Where KC = carbon store, in tons; B = Bulk density (BD) of peat soil in gr/cc or ton/m3; A = Area of peat soil, in m2; D = Peat thickness, in m; C = Carbon content (C-organic) as a percentage (%).

28 Due to data limitations, we used the tree count per hectare data in Pinang Laka village in Central Areas as a reference for other locations in the North, Central, and South areas. In Pinang Laka, the tree count per hectare ranges from 300 to 500. We used the mean value of 400 as the reference point.

29 Due to data limitations regarding palm oil, we used the tree count per hectare data in North Areas as a reference for locations in the South. In the North, the tree count per hectare is 123.

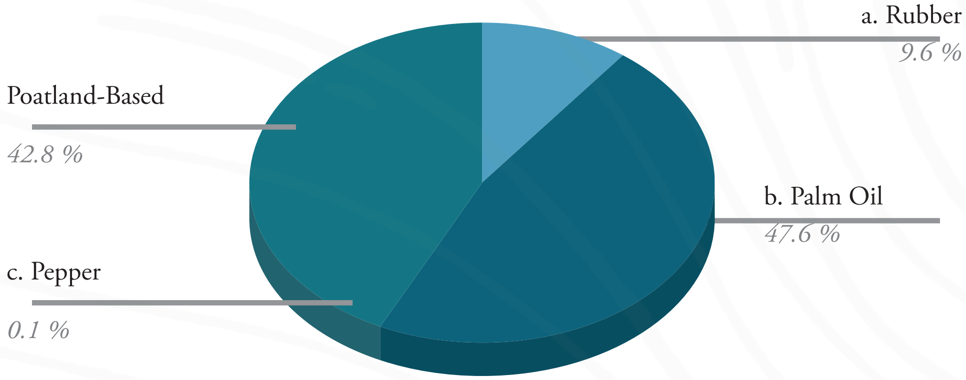
30 The pepper plant exhibits elongated cylindrical stems with prominent nodes. Young stems are green, while mature ones become woody, with diameters reaching between 4-6 cm (Yudiyanto, Plant-Based Pepper in Autoecological Perspective, 2016). We use its meaning as reference.

Peatland Locations	Bulk Density (BD) in ton/m³	Area of Peat Soil (A) in m²	Peat Thickness (D) in m	Carbon Content (C)	Carbon Store (KC) in ton
Silat Hilir Sub-district	0.23	149,548,600.00	4.57[31]	0.3624	56,965.85
Estimated Grand Total of Carbon Sequestered/stock from Peatlands					**56,965.85**

Tabel 15 Estimated total of carbon sequestered from peatlands in the South Area

Based on the information of the estimated carbon sequestered/stock contributed by plants and peatlands in South Areas, the following charts display how the carbon is distributed on average, either based on location or carbon pool.

Distribution average of carbon sequestered/stock based on Carbon Pool in South Areas



31 We use an average measured thickness of 457 cm (4.57 m) in peatlands around KHG Sungai Embau - Sungai Kapuas, assuming it includes Silat Hilir Sub-district, South Areas, as reported in the "Kapuas Hulu peat remapping final report: Mapping peat extent and depth of 16 Peat Hydrological Units within the Kapuas Hulu Basin", p. 47 (Remote Sensing Solutions, 2019)

3.3.7. Other Findings in the South Area

We also found others data that related to social-economic condition in the South area as follows:

1. On average, individuals possess a land area of 1.7 hectares.
2. 80% of the land is owned individually.
3. 60% of the population has 1-3 dependents.
4. 40% of the community has an income of less than 750,000, 30% between 750,000 and 2,500,000, and 30% earns above 2,500,000.
5. 70% of the population utilizes well water for daily needs.
6. 50% of the community uses rainwater for drinking purposes.

3.3.8. Conclusion of Ecological Conditions in the South Area

Using the ecological parameter findings on vegetation, native plants, climate, soil, water sources, and carbon sequestration in South areas, the following are the conclusions.

3.3.8.1. Vegetation Conditions, Types, and Functions

1. In the South Area, there are only three layers of vegetation, with many farmers cultivating a single type of crop (palm oil).
2. It is necessary to introduce conservation plants for the emergent layer and food crops for the shrub layer and ground cover.
3. The vegetation condition is inadequate and requires additional vegetation, especially in the emergent layer, to have environmental and socio-cultural impacts and ground cover to have social impacts, particularly regarding food.

3.3.8.2. Native Plants

1. In general, native plants are a good indicator of the soil conditions. The higher the presence of native plants, the better the soil condition in an area.
2. Increased diversity of native plants contributes to greater biodiversity in an area.
3. Diverse native plant availability supports intercropping systems, creating more sustainable environmental impacts.
4. The diversity of native plants can also serve as an indicator of the presence or absence of wildlife populations in a location.
5. The area has low biodiversity due to the limited presence of native plants, resulting in less fertile soil.
6. Consequently, the cultivated plants are more susceptible to pests and diseases.
7. The South Area experience the highest temperatures compared to the Central and Northern Areas, given that the southwestern corner of Kapuas Hulu district has most of the large palm oil concessions.
8. The reduced presence of native plants affects soil conservation.
9. Natural disasters like floods are more severe in the South Area due to the minimal presence of native plants.
10. This directly impacts high water levels and longer recovery periods after floods.

3.3.8.3. Climate Condition

1. Generally, temperature, elevation, weather, rainfall, and wind are important indicators of climate change in an area, as temperature, weather, rainfall, and wind directly reflect the overall climate conditions.
2. Temperature and rainfall have increased in the South Area.
3. The weather has become unpredictable.
4. There is an increase in pests and plant diseases, leading to decreased crop yields.
5. Changes in temperature, rainfall, weather, and other factors directly impact the environment. This can be observed through the appearance of specific pests and diseases in an area, affecting harvests, planting calendars, and crop selection.
6. In the South Area, various pests such as caterpillars, grasshoppers, fruit flies, and fruit worms have become prevalent.
7. The environmental impact extends to economic and social aspects. Decreased crop yields significantly affect the local economy in South Areas.
8. Socially and culturally, local crops that were once abundant in the southern area are now only planted during the dry season due to increased rainfall frequency.
9. The presence of company palm oil plantations in an area also influences the crops cultivated by farmers, resulting in social and cultural impacts on farming methods and crop selection.
10. To mitigate the impacts of climate change, it is necessary to identify plants that can adapt to these changes, such as cultivating coconut, maize, local rice, etc.

3.3.8.4 Soil Condition

1. Overall, to assess soil fertility, various indicators should be considered.
2. If the soil pH is below 6 (acidic), the nutrients in the soil cannot be adequately absorbed by plants.
3. The minimum organic matter content in soil should be 5%. Organic matter influences soil structure and texture.
4. Higher organic matter content improves soil structure and texture.
5. Soil texture and structure affect microbial activity, permeability, and aeration, impacting nutrient availability.
6. If the soil has high organic matter but low microbial activity, soil fertility will be reduced due to the lack of microorganisms that convert organic matter into nutrients.
7. Good soil aeration positively affects the growth of plants due to better air circulation.
8. Moderate soil permeability indicates good nutrient retention, while slow permeability results in poor nutrient retention.
9. In the South Area, the soil pH ranges from 4.5 to 5, indicating acidic soil conditions.

3.3.8.5. Water Resources

1. Generally, the presence of at least two water sources in an area ensures the water needs of the community, including consumption and agriculture, are generally secure.
2. In the South Area, there are four water sources which serve as a significant source for daily needs and agricultural activities. Hence, there are no significant water scarcity issues in this area.
3. When used for agricultural and sanitation purposes, the water sourced from available water sources in the South Area is generally safe. However, for consumption, it is deemed unsafe due to turbidity, odor, and low pH levels. Hence, most of the population still purchases bottled water from external sources for drinking purposes.
4. During periods of high rainfall in the South Area, frequent flooding inundates the community's garden. The lack of drainage systems also makes the situation worse. Drainage is essential for adaptation measures in high-rainfall areas. As the heavy rainfall usually triggers floods, the water stays longer in the community's garden. Hence, with the drainage system, the water can be channeled out of the garden faster.
5. Besides the drainage system, rainwater harvesting is also necessary as one of alternatives to mitigate floods. Based on our assessment, the communities also have practiced the rainwater harvesting although not its full potential.
6. Based on the vegetation condition in the South Area, which only consists of three layers, erosion control measures are necessary. Therefore, tree planting, particularly in the watershed areas, is essential to mitigate floods.
7. Although it is technically feasible to implement erosion control measures such as building embankments and planting vegetation, the relatively safe slope conditions in the three areas including the South Area suggest that embankment construction is not currently necessary.

3.3.8.6. Carbon Sequestration/stock

1. The total carbon sequestered/stored from the sample locations in Silat Hilir of the South Areas is 133,161.24 tons/year.
2. The distribution average of carbon sequestered/stock in Silat Hilir shows that plants have more carbon sequestered/stored than peatlands. Plants, particularly palm oil, is the primary contributor, sequestering 63,331.34 tons/year (47.55%) of the total carbon sequestered, likely due to its larger tree size and extensive cultivation in the area. With 1,450 hectares of its plant area, an estimated carbon sequestered from palm oil in Silat Hilir is 43.67 tons/hectare/year.
3. Meanwhile, peatlands in Silat Hilir also contribute an estimated carbon stock of 56,965.85 tons/year (42.77%). With 14,954.86 hectares of peatlands, an estimated carbon stock in Silat Hilir is 3.809 tons/hectare/year.
4. Rubber contributes to 12,775.64 tons/year (9.59%) of the total carbon sequestered in Silat Hilir. With 725 hectares of its plant area, an estimated carbon sequestered from rubber in Silat Hilir is 17.62 tons/hectare/year.
5. Pepper is the least contributor in Silat Hilir, only sequestering 88.41 tons/per year. With an estimated 3,200 plants spread over 2 hectares, an estimated carbon sequestered from pepper is 44.20 tons/hectare/year.


Photo: GIZ / IDEP Foundation
Nama
Kayu Ara
Nama Latin
Ficus crassiramea
Manfaat :
Pakan Enggang, Pakan Bekantan Dll
Nama : Anggrek Tebu
Nama Latin : Grammatophyllum speciosum
Manfaat : Sebagai Tanaman Hias
Resort Sepandan, 2020

4. Problem Identification

Problem Identification	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
Vegetation	- In terms of vegetation, there are quite a lot of native plant species, but the community has not yet made nurseries and planted local plants in their yards. - Particularly, food crops have not been optimally planted so that most of the food is purchased from outside the village.	- Vegetation consists of a large number of native plants, but these are not conserved or produced locally in nurseries, so these plants are still difficult to find for replanting. - Particularly, food crops have not been optimally planted so that most of the food is purchased from outside the village.	- There are only 3 layers on their land, even in many farmers' fields they only plant one type of crop (palm oil). - The condition of the vegetation is still lacking so that it requires additional vegetation, especially in the emergent layer to have environmental and socio-cultural impacts and ground cover to have a social impact, especially for food, because most of the food is imported from outside the area. - This is also an area with quite low biodiversity because it has few native plants. - So that the condition of the soil becomes less fertile because there are no ground cover plants.

Problem Identification	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
Climatic	- Temperature in the North Area has increased , rainfall has increased, plant pests have increased, and yields have decreased. - Erratic weather has a direct impact on the environment. This can be seen from the emergence of certain pests and diseases in an area, to the impact on crop yields, planting calendars, and types of plants planted in an area. - For example, pests such as monkeys and bugs appear. Diseases also appear caused by viruses, fungi and bacteria. Climate change has also caused economic and social impacts.	- Temperature in the Central Area is increasing, rainfall is increasing, plant pests are increasing and yields are decreasing, the weather is erratic, and this has a very direct impact on the environment. - This can be seen from the emergence of certain pests and diseases in an area, to the impact on crop yields, planting calendars, and types of plants planted in an area. - In the Central Area, for example, there are quite a lot of pests such as: wild boar, monkeys, snails, ants, stink bugs, leaf caterpillars, caterpillars, and fruit flies. - The number of diseases is also rising, including root rot, stem rot, and shoot wilt. This not only impacts the environment, but also carries economic and social impacts. - Declining crop yields greatly impact the economic aspects of the people in the Central Area. - Socio-culturally, there were quite a lot of local plants in the Central Area, but because it now rains more frequently in the rainy season, planting of other crops is only done during the dry season. - The existence of companies, especially palm oil companies, in an area also greatly influences what crops will be planted by farmer groups in that area, so that socio-culturally this can have an impact on farming methods and types of crops planted.	- Temperature in the South Area is increasing, rainfall is increasing, plant pests are increasing and yields are decreasing, weather is erratic which has a direct impact on the environment. - This can be seen from the emergence of certain pests and diseases in an area, to the impact on crop yields, planting calendars, types of plants planted in an area. - In the South Area, for example, there are quite a lot of pests such as weaver, caterpillars, fruit locusts and fruit caterpillars. - Not only has an impact on the environment, economically and socially also has an impact. - Declining crop yields greatly impacted the economic aspects of the people in the South Area. - Socio-culturally, there were quite a lot of local plants in the South Area, but because it now rains more frequently in the rainy season, planting of other plants is only done during the dry season. - The existence of companies, especially palm oil companies, in an area also greatly influences what crops will be planted by farmer groups in that area, so that socio-culturally this can have an impact on farming methods and types of crops planted.

Problem Identification	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
Land and Soil Condition	- In the North Areas the soil pH is between 4.5 - 5. - This indicates that the soils in the area are quite acidic. - So that the nutrients in the soil cannot be absorbed optimally by plants, which can cause inhibition of the growth and development of plants in the area. - Nutrient content and microbial activity in the North Area are low, so even though the soil has a high organic matter content, its fertility is still low due to lack of microorganisms that convert all the organic matter in the soil into nutrients. - Soil permeability in the North Area is at a low level, this indicates that the soil cannot store nutrients properly. - Soil aeration in North Area, is moderate which indicates good air circulation in the soil.	- In the Central Area, the soil pH is between 4.5 - 5. - This indicates that the soils in the area are quite acidic. So that the nutrients in the soil cannot be absorbed optimally by plants, which can cause inhibition of the growth and development of plants in the area. - Nutrient content and microbial activity in the Central Area are at low levels, so even though the soil has a fairly high organic matter content, its fertility is still low due to lack of microorganisms that convert all the organic matter in the soil into nutrients. - The permeability of the soil in the Central Area is at a low level, which indicates that the soil cannot store nutrients properly.	- In the South Area, the soil pH is between 4.5 - 5. - This indicates that the soils in the area are quite acidic. - So that the nutrients in the soil cannot be absorbed optimally by plants, which can cause inhibition of the growth and development of plants in the area. - Organic matter in the South Area is the lowest compared to the Central and North Areas. - The percentage is from 1% - 5% which indicates poor organic content. This also affects the structure and texture of the soil in the South Area which is blocky and clay. - The level of nutrient content and microbial activity in the South Area is low, so soil fertility is also low due to a lack of organic matter and microorganisms which convert all the organic matter in the soil into nutrients.

Problem Identification	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
Water Source	Water source issues are the same in all areas. The communities have started a rainwater harvesting system but it has not been fully optimized. As a result, these areas continue to face issues with flooding during periods of heavy rainfall that inundates the community's gardens. Additionally, none of the areas have proper drainage systems in place, exacerbating the risk of flooding during high precipitation. Although the North, Central, and South areas possess multiple water sources to meet their drinking water needs, the communities predominantly rely on purchasing bottled water or gallon water from external sources. This is due to the subpar quality of the available water, characterized by low pH levels that render it unsuitable for consumption. In the South Area, apart from the rainwater harvesting system being underutilized, the area also lacks vegetation that can act as erosion control. This exacerbates the flooding issue, as the water discharge and receding times are prolonged. To mitigate the frequency and intensity of floods, it is crucial to undertake tree plantation initiatives, particularly around the watershed areas in the South Area.		
Community Capacities Capacities	- We measured the KAP of the participants by distributing questionnaires during the FGD. - The total of the participants in the North Area is 20 participants, with following results: **Knowledge** - 20% of the respondents have a low knowledge of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 70% of the respondents have a knowledge but not practicing of the concept of maintaining biodiversity and sustainability as part of the environmental, sociocultural, and economic aspects. - 5% of the respondents have a knowledge of the concept and partially have practice of maintaining biodiversity and sustainability as part of the environmental, sociocultural, and economic aspects. - 5% of the respondents have an adequate capacity and practice of maintaining biodiversity and sustainability as part of the environmental, sociocultural, and economic aspects.	- We measured the KAP of the participants by distributing questionnaires during the FGD. - The total of the participants in the North Area is 50 participants, with following results: **Knowledge** - 8% of the respondents have a very low knowledge of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 68% of the respondents have a low knowledge of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 20% of the respondents have the knowledge but not practicing of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 2% of the respondents have a knowledge of the concept and partially have practice of maintaining biodiversity and sustainability as part of the environmental, sociocultural, and economic aspects. - 2% of the respondents have an adequate capacity and practice of maintaining biodiversity and sustainability as part of the environmental, sociocultural, and economic aspects.	- We measured the KAP of the participants by distributing questionnaires during the FGD. - The total of the participants in the North Area is 10 participants, with following results: **Knowledge** - 40% of the respondents have a very low knowledge of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 60% of the respondents have low knowledge of the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects.

Problem	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
	- **Attitude** - 65% of the respondents have the knowledge, but it does not reflect in their attitude toward maintaining biodiversity and sustainability between the environment, social culture, and economy - 35% of the respondents have the knowledge and it does reflect in their attitude toward maintaining biodiversity and sustainability between the environment, social culture, and economy. However, the respondents have not put it into practice yet **Practice** - 5% of the respondents do not have the knowledge and not practicing of maintaining biodiversity and sustainability between the environment, social culture, and economy. - 45% of the respondents have the knowledge that reflects in their attitude toward the importance of maintaining biodiversity and sustainability between the environment, social culture, and economy. However, they have not put it into practice yet. - 40% of the respondents have the knowledge that reflects in their attitude and have practiced in a few areas the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 10% of the respondents are aware and actively practice the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects.	**Attitude** - 18% of the respondents have the knowledge, but it does not reflect in their attitude toward maintaining biodiversity and sustainability between the environment, social culture, and economy - 70% of the respondents have the knowledge and it does reflect in their attitude toward maintaining biodiversity and sustainability between the environment, social culture, and economy - 12% of the respondents have the knowledge, and it is reflect in their attitude, and practice as well toward maintaining biodiversity and sustainability between the environment, social culture, and economy **Practice** - 14% of the respondents are not aware and not practicing of maintaining biodiversity and sustainability between the environment, social culture, and economy. They have not also put it into practice yet. - 48% of the respondents have the knowledge and reflect in their attitude, but have not practiced the importance of maintaining biodiversity and sustainability between the environment, social culture, and economy. - 28% of the respondents have the knowledge that reflects in their attitude and have practiced in a few areas the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects. - 10% of the respondents are aware and actively practice the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects.	**Attitude** - 40% of the respondents have the knowledge, but it does not reflect in their attitude toward maintaining biodiversity and sustainability between the environment, social culture, and economy - 30% of the respondents have the knowledge and it reflect **in** their attitude, but have not practiced toward maintaining biodiversity and sustainability between the environment, social culture, and economy - 30% of the respondents have the knowledge, and it is reflect in their attitude, and practice as well toward maintaining biodiversity and sustainability between the environment, social culture, and economy **Practice** - 14% of the respondents do not have the knowledge of maintaining biodiversity and sustainability between the environment, social culture, and economy. They have not also put it into practice yet. - 80% of the respondents have the knowledge and reflect in their attitude, but have not practiced the importance of maintaining biodiversity and sustainability between the environment, social culture, and economy. - 10% of the respondents have the knowledge that reflects in their attitude and have practiced in a few areas the concept of maintaining biodiversity sustainability as part of the environmental, sociocultural, and economic aspects.

Problem Identification	North Area, Kapuas Hulu	Central Area, Kapuas Hulu	South Area, Kapuas Hulu
Access to resources	- The North Area is located near Badau (bordering the country between Indonesia and Malaysia) where transportation is good enough in general, although there are still many challenging access points. - Access to knowledge is relatively easy, but the majority of institutions are poorly organized. They primarily focus on advocacy for biodiversity conservation, with limited practical implementation.	- The Central Area is located near the town of Putussibau, transportation is good, although some access remains challenging. - Access to knowledge is relatively easy, but most institutions providing information on biodiversity mainly focus on conservation advocacy, with limited practical application.	- The South Area is located near the city of Sintang, access to transportation is good. - However, there is a lack of knowledge regarding biodiversity conservation and sustainable agriculture/plantations. - This is due to the significant presence of palm oil companies in the South Area and the majority of the population working as company staff.
Other Social and Economic challenges	- The North Area is an area where the majority of the population is Dayak, with a small portion being Malay. - The farming and consumption patterns in the North Area have started to change slightly with the consumption of instant food. - However, the community, especially the Dayak people, still maintain the cultivation and consumption of local food, and the cultural practice of gathering resources from the forest is still preserved.	- The Central Area is an area where the majority of the population is Malay, with a small portion of Dayak and Javanese ethnic groups. - Both the farming and consumption patterns of the community in the Central Area have undergone significant changes. - A small portion of the population still cultivates local fruits and food crops, but not on a large scale. - The availability of food crops and traditional medicines in this area is very limited.	- The South Area is an area where the majority of the population consists of Javanese ethnic groups, with some Malay and very few indigenous Dayak people who are marginalized. - Culturally, many local customs, including consumption patterns (food), have significantly changed, and the majority of food is imported from outside the area.

Table 16 Problem Identification in 3 Areas

5. Recommendations

Based on the result of ecological assessment which conducted in 6 sub-districts in Kapuas Hulu, then we provide a recommendations based on Permaculture zones as follows:

5.1. General Recommendation

As stated above, all areas (North, Central, and South) would require interventions on zoning as below:

- **Zone 1**
    1. Identification of climate change-adaptive plant species, including coconut, maize, local rice, and other crops.
    2. Promotion of home gardens with locally adaptable food crops in various areas, such as Sengkubak, Kondang, Sawi Pahit, Simpur, coconut, local rice, and local maize.
    3. Encouragement of integrated livestock systems within households to produce compost for soil fertility support and ensure the growth of planted vegetation.
    4. Implementation of training programs on home garden management based on Permaculture principles, with a focus on native plant species.
    5. Training on post-harvest processing using local plant materials, such as Jambu Monyet, to generate economic benefits and motivate farmers to diversify and maintain vegetation.
    6. Soil pH neutralization through the addition of organic materials like banana stems and livestock manure, to promote the growth of soil microorganisms.
    7. Enhancement of soil permeability and pH neutralization through the addition of dolomite and sea salt.
    8. Implementation of intercropping systems utilizing banana plants.
    9. Provision of regenerative agriculture training based on Permaculture principles to improve soil conditions.
    10. Creation of rainwater or river water storage with natural filtration systems, including gravel, stones, charcoal, and sand.
    11. Construction of simple irrigation systems for household and home gardens
    12. Training on water filtration techniques based on Permaculture principles.
    13. Development of home gardens using regenerative agriculture practices.
    14. Conducting training sessions on regenerative agriculture for home gardens.
    15. Monitoring and providing assistance to farmers in implementing the recommended practices.

Zone 2

1. Promote collaboration with village governments (BUMDEs) to facilitate the collection and marketing of local food products (Layer 4 and 5 plants), expanding market access and providing economic benefits.
2. Provide training on seed and seedling production, integrated farming systems, and climate-resilient agricultural practices based on Permaculture principles.
3. Conduct soil analysis and provide recommendations for soil improvement techniques, such as composting, mulching, and cover cropping.
4. Promote organic farming practices to enhance soil fertility and reduce degradation.
5. Implement water harvesting techniques and promote efficient irrigation methods.
6. Encourage the adoption of agroforestry practices to increase carbon sequestration.
7. Monitoring and providing assistance to farmers in implementing the recommended practices.

Zone 3

1. Establish community-based nurseries to propagate and distribute local and native plant species suitable for the zone.
2. Promote agro-biodiversity by encouraging farmers to cultivate a variety of crops, including traditional and indigenous species.
3. Provide training on sustainable farming practices, crop diversification, and native plant cultivation.
4. Support marketing and value-added processing of local and native agricultural products.
5. Provide climate information and advisory services to farmers, including weather forecasts and climate-smart farming techniques.
6. Promote the adoption of climate-resilient crops, farming practices, and land management techniques suitable for the zone's climate conditions.
7. Conduct soil testing and analysis to determine soil health, nutrient deficiencies, and provide tailored soil management recommendations.
8. Promote organic farming practices and encourage the use of compost, green manure, and biofertilizers.
9. Develop water management strategies, including water storage, irrigation systems, and water-efficient practices.
10. Promote agroforestry practices, the planting of trees with high carbon sequestration potential, and sustainable land management practices.
11. Monitoring and providing assistance to farmers in implementing the recommended practices.

Zone 4

1. Promote the cultivation of drought-tolerant crops and resilient plant varieties suited for arid and semi-arid conditions.
2. Establish community-based seed banks to preserve and distribute locally adapted seeds.
3. Provide training on water-efficient farming techniques and sustainable land management practices.
4. Create awareness about the importance of conserving and restoring native plant species in arid and semi-arid ecosystems.
5. Promote agroforestry practices with native trees and shrubs for ecosystem restoration and soil conservation.
6. Provide farmers with climate information and forecasts to help them make informed decisions.
7. Promote climate-smart agricultural practices such as water-saving techniques, soil moisture conservation, and crop diversification.
8. Conduct capacity-building programs on climate change adaptation and mitigation strategies.
9. Support the installation of weather stations for localized climate monitoring.
10. Encourage the use of drought-tolerant cover crops and green manure to enhance soil fertility and moisture retention.
11. Provide training on soil conservation practices and sustainable land management.
12. Implement water harvesting techniques, such as rainwater collection and storage systems, for irrigation during dry periods.
13. Promote efficient irrigation methods like drip irrigation and micro-sprinklers to minimize water usage.
14. Provide training on water management strategies and water-saving practices.
15. Support the development of community-based water resource management initiatives.
16. Monitoring and providing assistance to farmers in implementing the recommended practices.

Zone 5

1. Conduct soil assessments to determine nutrient content and soil structure.
2. Promote sustainable land management practices, including erosion control and nutrient cycling.
3. Support the conservation and restoration of native plant species.
4. Provide climate information and localized weather forecasts to farmers.
5. Promote the use of climate-resilient crop varieties and climate-smart farming techniques.
6. Conduct capacity-building programs on climate change adaptation and risk management.
7. Provide training on sustainable land management practices.
8. Collaborate with the Danau Sentarum National Park to obtain seeds and seedlings of local plants that do not exist in customary and production forest areas.
9. Monitoring and providing assistance to farmers in implementing the recommended practices.

5.2. Specific Recommendations

As there are different findings, problems, and needs for each of the three areas, specific recommendations are provided, based on areas and zoning as follows:

Zone 1

Central Area

1. Develop home gardens with locally adapted food crops suitable for wet environments, considering the high flood risk in the Central Area.
2. Build irrigation systems to address frequent flooding caused by high rainfall.
3. Introduce integrated livestock systems (chicken and ducks) in households to provide compost materials for soil fertility support and ensure the fertility of planted vegetation.

South Area

1. Develop a vertical garden system and maximize the cultivation of water-submerged food crops.
2. Introduce integrated livestock systems (chicken and ducks) in households to provide compost materials for soil fertility support and ensure the fertility of planted vegetation.

Zone 2

North Area

1. Develop the Batang Lupar Demo Plot (Mensiau) into a seed and seedling center for local plants, build additional Demo Plots, and implement integrated livestock systems as a central compost model.
2. Strengthen collaboration with village governments (BUMDEs) to market local food products and provide training on native plant cultivation.
3. Establish a climate-smart agriculture center, provide climate-resilient crop selection training, and implement weather monitoring systems.

Central Area

1. Establish Demo plots in each sub-district for learning access and develop local food crop nurseries.
2. Implement integrated livestock systems and collaborate with village governments (BUMDEs) to collect and market local food products.
3. Provide training on seedling and nursery techniques, climate-resilient agriculture practices, and soil management.
4. Promote water harvesting techniques, efficient irrigation methods, and agroforestry practices.

South Area

1. Build a demo plot in the Silat Hilir area and establish a local food and seedling center.
2. Develop integrated livestock systems and collaborate with village governments (BUMDEs) to market local food products.
3. Provide training on seedlings, seed propagation, integrated farming systems, climate-smart agriculture practices, and soil conservation.

Zone 3

North Area

1. Establish community-based nurseries to propagate and distribute native plant species.
2. Promote the conservation and cultivation of native plants through awareness campaigns and incentives.
3. Provide training on native plant cultivation and sustainable farming practices.

Central Area

1. Establish demonstration farms and training centers to showcase sustainable agricultural practices suitable for the Central Area.
2. Promote the cultivation of drought-tolerant crops adapted to drought season that is longer than before. Usually, the community does not plant in drought season. They only plant in rainfall. Given that the drought is longer than before, the cultivation of drought-tolerant crops potentially benefit for the community.
3. Collaborate with local communities and indigenous groups to identify and preserve native plant species.
4. Establish seed banks and nurseries to propagate and distribute native plant species for ecological restoration and sustainable use.

South Area

1. Establish community-based nurseries for propagating native plants and fruit trees.
2. Encourage the cultivation of fruit trees to provide food security and economic opportunities for farmers.
3. Promote mixed cropping systems and agroecology practices to increase vegetation diversity and enhance ecosystem resilience.
4. Conduct climate vulnerability assessments to identify specific challenges and adaptation strategies for the area.

Zone 4

North Area

1. Support the development of value chains for drought-resistant crops.
2. Establish nurseries for native plant propagation and provide seedlings to farmers.

Central Area

1. Encourage the adoption of terrace farming techniques to maximize land use and prevent soil erosion.
2. Collaborate with local indigenous communities and environmental organizations to identify and preserve native plant species in the area.

South Area

1. Promote permaculture principles to maximize vegetation diversity and ecosystem resilience.
2. Establish seed banks and botanical gardens for native plant conservation.

Zone 5

North Area

1. Support the cultivation of crops and plant varieties adapted to high-altitude and cold-climate conditions.
2. Establish community-based nurseries for cold-tolerant plant species.
3. Promote the conservation and restoration of native plant species in high-altitude ecosystems.
4. Provide training on cold-climate farming techniques.
5. Support the development of eco-tourism initiatives centered around native plant conservation.
6. Conduct soil assessments in high-altitude areas.
7. Promote water-saving techniques and efficient drainage methods.
8. Support the establishment of weather monitoring stations in high-altitude areas
9. Promote agroforestry practices to enhance biodiversity and soil carbon storage.

Central Area

1. Collaborate with local communities and conservation organizations to identify and preserve native plant species
2. Promote the use of organic matter and compost to improve soil fertility.
3. Encourage the adoption of agroforestry systems

South Area

1. Identify and promote native plant species adapted to Zone 5 conditions.
2. Promote sustainable land management practices to reduce soil erosion.
3. Conduct surveys and assessments to conserve endangered and endemic native plant species
4. Conduct climate vulnerability assessments specific to Zone 5.
5. Promote the use of drought-tolerant crop varieties and water-efficient irrigation methods
6. Encourage the adoption of agroforestry systems.
7. Promote water harvesting techniques and efficient irrigation methods.
8. Encourage the restoration of degraded lands through reforestation and ecosystem restoration projects.

Documentation

Documentation 1: Socialization and ecological assessment in the South Area (Photo: GIZ)

Documentation 2: FGD and ecological assessment in the South Area
(Photo: GIZ)

Documentation 3: FGD and ecological assessment in the Central Area.
(Photo: GIZ)

Documentation 5: Socialization and ecological assessment in the North Area.
(Photo: GIZ)

Documentation 6: Ecological assessment in the North Area
(Photo: GIZ)

Documentation 7: Ecological assessment in the North Area
(Photo: GIZ)

Documentation 8: Interview and conduct ecological assessment in the North Area (Photo: GIZ)

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DEUTSCHE ZUSAMMENARBEIT

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