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LAND USE CHANGE AND LIVELIHOOD STRATEGIES

CASE STUDY IN EMPELANJAU ASAL, MALAYSIA

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Abstract

Livelihood diversification is a strategy used in rural communities to reduce vulnerability and risk by participating in many activities to expand their assets. The village of Empelanjau Asal in Sarawak, Malaysia was the focus of this case study and had experienced a major land use change from natural forest to oil palm plantation in the last ten years. Whilst the relationship between land use change and livelihoods has been studied in many locations, there is a lack of literature on how livelihood diversification impacts land use. This gap leads to the paper's research questions, which asked about how Empelanjau Asal diversified its livelihood, the reasons for it, and the effects of it. To accomplish this, an interdisciplinary research approach was utilised through a variety of social and natural science methods. The results were analysed through the lens of Ellis' (2000) sustainable livelihoods framework. This identified the main income sources within Empelanjau Asal as agriculture, rent from the joint venture company, wage work, and the collection of non-timber forest products. The main reasons for diversification were identified as global market trends, government shifting, individual perceptions of development, and the community's willingness to adapt. Negative environmental effects were experienced, specifically due to the land use change towards oil palm. Community effects were largely positive, but the sustainability of the current diversification strategy is still in question. Overall, this study showed the importance of livelihood diversification to the Empelanjau Asal community and how this diversification can influence land use change.

Acknowledgements

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Abbreviations

BMWP = Biological Monitoring Working Party

BR1M = Bantuan Rakyat 1 Malaysia

EA = Empelanjau Asal

EU = European Union

e.g. = exempli gratia

FCC = Fecal Coliform Count

i.e. = id est

JV = Joint Venture

KU = Københavns Universitet

LSLA = Large-scale land acquisition

LUC = Land use change

MFBI = Malaysian Family Biotic Index

NTFP = Non timber forest product

NTFPs = Non timber forest products

pH = potential of hydrogen

QRs = Questionnaire respondents

PRA = Participatory Rural Appraisal

RM = Malaysian ringgit (currency in Malaysia, 1 RM equals around 0.211 US $)

RQ = Research question

RQs = Research questions

TCC = Total Coliform Count

TR = Tuai Rumah (headman)

UNIMAS = Universiti Malaysia Sarawak

W-JV = Wintrip Joint Venture

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1 Introduction

Many papers identify land use change (LUC) as a key influencing factor of livelihood diversification (Lahai et al., 2022; Mertz et al., 2006). Predominantly stated negative impacts on the physical environment are a decline in water quality and increased erosion, which are a result of intensification (Mertz et al., 2006). Positive impacts, on the other hand, include improved infrastructure and increased income (Lahai et al., 2022). However, this paper takes the starting point of livelihood diversification and considers the role this strategy plays in LUC. While other authors investigate how land use changes affect livelihoods, Palacios et al. (2013) argue that changes in the environment, and actors are leading to a transformation of both livelihoods and land. Therefore, investigating this research gap, namely how livelihood diversification is affecting land use change, is especially useful when researching rural communities because, historically, they have had diversified income sources (Derebe & Alemu, 2023).

Livelihood and Diversification

Ellis (2000) defines livelihoods as the assets, activities, and access that determine the living gained by an individual or household. Livelihoods are important as they create opportunities, reduce poverty, and promote sustainable development. Not only can household incomes be enhanced, but access to social services like education, health, and water can increase, contributing to overall welfare (Wubayehu, 2020).

One prominent livelihood strategy found in rural households is diversification (Sanggin & Mersat, 2012). Ellis (2000) defines diversification as the process of rural households increasing their portfolio and assets to be more diverse, therefore improving their standards of living. To help understand household-level diversity, a framework is used for analysis (see *Figure 1*). It shows how assets (A) are modified by predetermined factors (B) and placed in a broader context (C) to produce livelihood strategies (D). These are composed of natural and non-natural resources (E) and in turn, have effects on livelihood security and environmental sustainability (F).

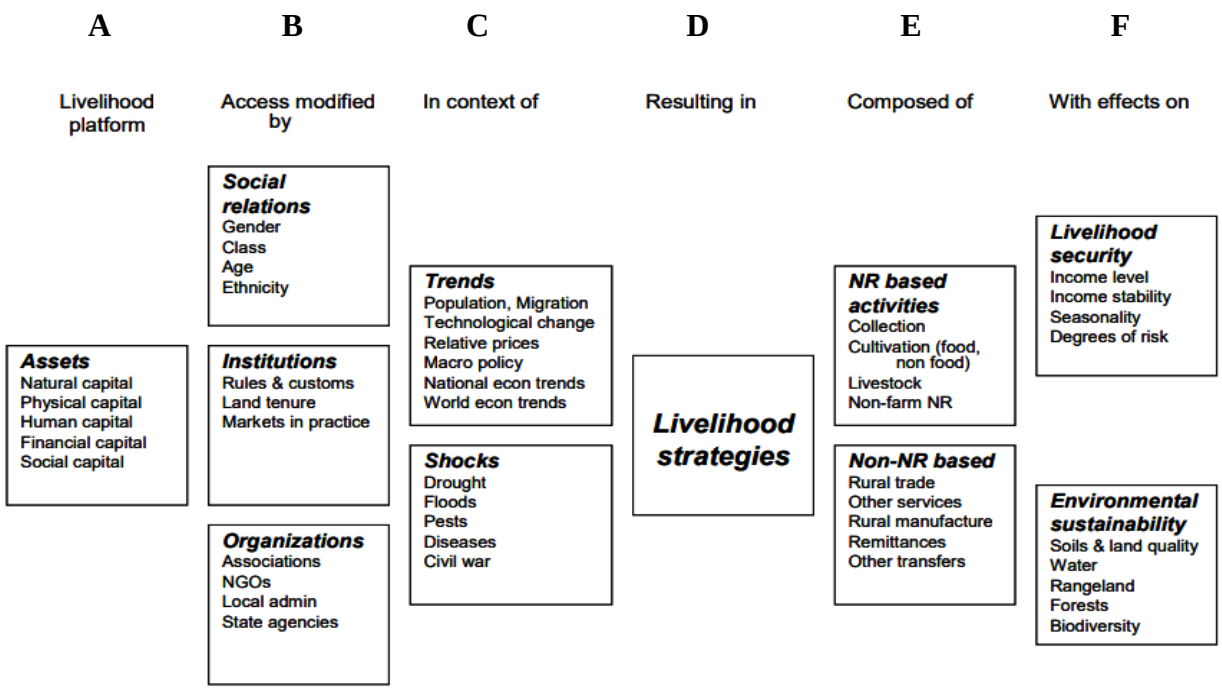

Figure 1: Sustainable Livelihoods Framework (Ellis, 2000)

Within this framework, livelihoods are defined by types of capital in the form of assets. Here, assets include five types of capital: natural, physical, human, financial, and social (Ellis, 2000). This study follows Ellis' (2000) definition of each capital. Natural capital is natural resource-based, referring to products humans use for their survival as well as soil, forest and generally the environment. Physical capital is assets obtained by economic production processes, like tools, machines, or land improvements. Human capital is the education level and health of individuals and populations. Financial capital is the access to stocks of cash. Finally, social capital refers to networks, status, or associations in which people partake in.

Ellis (2000) recognizes some income sources to include collection, cultivation, trade, remittances, and other services. Many of these are greatly dependent on the land, leaving households vulnerable. Vulnerability occurs when a household or individual faces risks or threats to their livelihoods, for example, shocks, trends, or seasonality (Ellis, 2000). These events can be uncontrollable and therefore can negatively impact livelihoods (Ibrahim et al., 2017). To reduce the risk, communities use diversification as a livelihood strategy that provides stability and protection.

Livelihood diversification can take the form of LUC. Additional income streams can be achieved through the transition of land for other purposes, impacting both communities and the environment. The causes of these changes have often centred around the increase in demand for land-based products, diet changes, and shifts in the consumption of energy (Müller et al., 2014) and are driven by human actions and natural environmental processes (Modin et al., 2023). He et al. (2022) recognise the Indo-Malaysian region as a hotspot of land cover and LUC since 1982 with the primary land transition being from forests to croplands. Resultantly, Malaysia is a key study site for the research of LUC.

Livelihoods in Malaysia

Rural communities in Malaysia rely on land, which can be used for agriculture, forestry, settlement, or pasture (Modin et al., 2023). The change in land usage or cover can impact a community socially, physically, and economically. Communities reliant on land usage for their livelihoods are more greatly impacted. For example, agriculture is a livelihood source in Sarawak (Modin et al., 2023) which affects land usage.

Diversification can be strongly influenced by external actors, including governments. The Malaysian government introduced initiatives aimed at improving the lives of rural communities such as the Rural Electricity Supply Program and Rural Water Supply Program as well as various transportation infrastructure projects (Leha et al., 2023). Legislation, often through targeted agricultural schemes, can influence land usage. In 1989-1990, the Department of Agriculture introduced the Oil Palm Subsidy Scheme providing oil palm seedlings to landholders. This crop has stayed profitable over the last 20 years and led to continued development (Cramb & Sujang, 2011).

A major type of oil palm plantations in Sarawak are Joint Venture (JV) companies (Kadir & Parveez, 2020). Joint Ventures are agreements between two parties where the company leases an area and determines the landowners' share in the venture. In 2006, the first large-scale JV oil palm scheme was proposed and later implemented (Cramb, 2013). In Sarawak, these companies contributed to the increase of oil palm plantations from 1.16 million hectares in 2013 to 1.62 million hectares in 2022 (Statista, 2023). Research on large-scale JV plantations highlights negative environmental impacts, with the establishment of plantations usually requiring deforestation, resulting in significant greenhouse gas emissions and global effects

(Purnomo et al., 2020). Contrastingly, local communities face ambivalent effects including compensation for rented land and local development (Purnomo et al., 2020).

Another income stream is the collection of non-timber forest products (NTFPs), which includes anything collected from the forest that is found naturally and not a timber product. Activities include gathering wild fruits and vegetables, fishing, and hunting for wild boar (Leha et al., 2023). This practice can be used for both consumption and trading. Establishing trade connections and networks is important for income (Leha et al., 2023). Wage work is another income source (Ellis, 2000) that can be more stable, as it is not reliant on supply and demand or trade to make income.

Iban Livelihoods

This case study focuses on an Iban village in Sarawak as an example of livelihood diversification. Ibans are the largest ethnic group in Borneo and have unique language, cultural habits, and spiritual connections (Simonson et al., 2011). JV oil palm is favourable for Iban people as it validates territorial claims for villages and leads to village development. It brings transport infrastructure and desirability to land that was once considered remote and unattractive (Cramb & Sujang, 2011). This allows easier access to markets, education, and healthcare for villages and increases their free time as the need to tend to land decreases with the JV managing the plantation (Cramb & Sujang, 2011). Although there are environmental and economic drawbacks to an unknown extend.

Study Site

The field study took place in Empelanjau Asal (EA), located approximately 150 km from Kuching in Sarawak, Malaysia. There are 33 longhouse apartments. EA has undergone a LUC from a natural forest to an oil palm plantation through the introduction of the Malaysian-based company Wintrip (W-JV) in 2018. The community has diverse income sources.

Initially, this case study focused solely on LUC, but after visiting the site and conducting research, it was found that the greatest topic of discussion was livelihoods in EA and not LUC. Because of this, the RQs were tailored to integrate topics of livelihood diversification through the lens of a JV LUC to fully utilise the methods conducted. Therefore, our overall research objective is ‘A study of livelihood diversification in Empelanjau Asal and its impacts on LUC (see *Figure 2*). The current RQs aim to provide a comprehensive overview of EA's livelihood

diversification efforts and their impacts. Firstly, to determine the extent of diversification and how it is being implemented. Secondly, to gain insights into the underlying reasons for diversification. Thirdly, to evaluate the environmental and social impacts to understand how the community is affected by diversification.

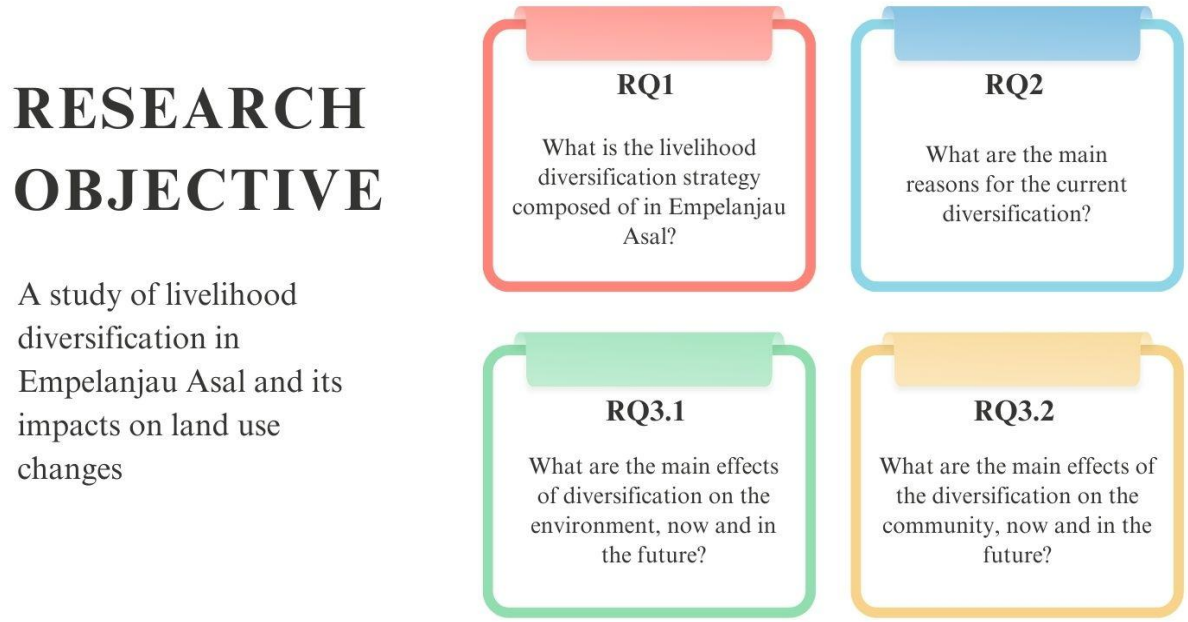

Figure 2: Overview of the research objective and research questions answered in this case study (Source: Own figure)

This report will answer the RQs stated above. Following the introduction is a methodology section, results and analysis, discussion, and conclusion. The methodology explains the approaches used to gather and analyse data as well as the limitations faced. The results and analysis section presents key findings and triangulates methods. The analysis is then discussed by RQ, where the results of the study are placed in a broader context.

2 Methodology

The study design is an interdisciplinary case study in which natural and social science methods were covered and qualitative and quantitative data were collected.

2.1 Biodiversity Assessment

A biodiversity assessment systematically evaluates the variety and abundance of living organisms within a specific ecosystem (Hill, 2022). Here, the focus was placed on forest flora. Three sites were selected, which included two sites in forested areas and one on TR Freddy's smallholder oil palm plantation. The first area was a secondary forest, the second a forest on the edge of the oil palm plantation, and the third within the oil palm plantation. Selection was based on determining the effect of current livelihood diversification on the environment, especially the fringe forest next to the oil palm will reveal the effect of expanding oil palm on existing forests. The other two sites, oil palm plantation and secondary forest, are used for comparison. Within each area, two 10x10m plots were analysed, conducting six biodiversity assessments in total. In each plot, two metrics were measured. First, tree species with a diameter greater than five cm were identified, with the help of local guides, and counted (see *Figure 3*). Second, non-timber forest products, excluding trees, were identified, and counted. Using the Shannon Index, which considers the quantity and proportion of species (Allen et al., 2009), a value indicating diversity was calculated for both tree species as well as NTFPs. Index values were compared to identify which area exhibited higher diversity levels and had a higher impact on livelihoods.

Figure 3: Assessment of biodiversity in a managed secondary forest. Help with identifying species was provided by our guides (Source: Own figure)

2.2 Focus Groups

Focus groups are group interviews where social structures and subjective opinions of participants are analysed in a natural setting (Brockington & Sullivan, 2003). This approach provides insights into how people justify their opinions and show emotions in a group discussion (Scott, 2011). This method was used to gain an overview of the community dynamics of the villagers and their perceptions of livelihood. All villagers were invited to participate in this method. Participants were divided into three groups: men (see *Figure 4*), women, and children with 13, 8, and 8 participants, respectively. A series of open-ended questions regarding their current perceptions and future aspirations of land usage and livelihood were asked (see *Appendix A)*. A moderator and translator facilitated the discussions. Notes were taken on participant answers and overall observations. Follow-up questions were asked for clarification. Analysis was made on general topics found within.

Figure 4: Men's focus group in the Empelanjau Asal longhouse (Source: Own figure)

2.3 Informal Interviews

Informal interviews are characterised by their lack of preset structure, allowing for conversational exchanges where interviewees are active participants. They are well-suited to establish a certain degree of trust within the interview (Atkinson, 2007; Brinkmann, 2020). Life story interviews are a subtype of informal interviews and aim to gain an understanding of the key events of a person's life.

Within this research, three life story interviews were conducted along with a multitude of informal interviews. All life story interview participants were above 75 years old and had different roles in the community i.e. former headman. They were carried out in natural settings, e.g., longhouses, forests, rice fields, or oil palm plantations. As interviews were carried out spontaneously during fieldwork, there was no single mode of questioning. However, questions were asked in a non-directive way to stimulate broad discussion, without interviewees feeling interrogated (Atkinson, 2007). Nonetheless, interviewers maintained a degree of control over questions because they were aligned with the overall research agenda. The sampling of participants prioritised eliciting information over achieving representativeness (Atkinson, 2007), which is why participants were selected based on their willingness to share desired knowledge or their role in the village.

2.4 Participatory Rural Appraisal (PRA)

Participatory Rural Appraisal (PRA) is a qualitative research method that takes a bottom-up approach through the active participation of the community in the research process (Narayanasamy, 2009). PRA emphasises community participation enabling local opinions and knowledge to be more accurately identified. This co-creation of knowledge assists the decolonisation of research through the reduction of researcher input and the promotion of grassroots development (Selener et al., 1999). PRA is typically accompanied by a semi-structured interview enabling researchers to learn from participants. Additionally, PRA empowers the marginalised, allowing the participants to discuss their situation (Narayanasamy, 2009).

Timeline

PRA timeline is an example of participatory diagramming (Mikkelson, 2005). Through purposive sampling four participants were selected, who were older and knew the history of EA better (see *Figure 5*). A question guide was used to initiate conversations and moderation and note-taking were split between the students. Questions regarding the key events that impacted the development of the village and how livelihoods changed over time were asked. This method took place on the first day of research to enable a greater understanding of the longhouse, the village, and the Iban culture. The timeline was visually analysed.

Figure 5: Preparation for the timeline interview with elderly people in the longhouse. Others, including kids, joined the circle and listened (Source: Own figure)

Resource Mapping (PRA)

Participatory mapping is a method used to gain an understanding of a limited physical space or, as for this study, a settlement (Mikkelson, 2005). Community members physically draw locations on a map which allows them to personally engage with the researchers (Anderson et al., 2017). Due to this, villagers can present their knowledge through a bottom-up approach, providing information that is often invisible to external actors (Hossen, 2016). Mapping is particularly useful for understanding the community and gaining knowledge with minimum bias. During this case study, the participants drew a map of their village highlighting the major physical landmarks. Next, the participants were asked to add key resources that exist within their space and label them. Convenience sampling was used and five participants joined. The final map was visually analysed.

Transect Walks

A transect walk is a visual cross-section of a specific environment that reveals the various microenvironments within the studied area (McArthur, 2005). Two transect walks were done and critical points of the transect were mapped via GPS location. First, a transect walk was completed through the W-JV oil palm plantation. The second walk was completed in a 20-year-old secondary forest where NTFPs are regularly sourced by the villagers (see *Figure 6*). Three local guides led the walk and explained the history, products and uses. A list of NTFPs was generated, and maps of the areas with important landmarks were created. Additionally, an insight into different land use and livelihood strategies was gained. The method aimed to provide details of NTFPs uses and their abundance within other contexts, allowing the results to feed into other methods.

Figure 6: Transect walk through the managed secondary forest jointly with the students from UNIMAS and KU (Source: Own figure)

2.5 Photovoice

Photovoice, introduced by Wang and Burris (1997), is a visual participatory research approach wherein participants collaborate as co-researchers to define the research aim and purpose while reducing power imbalances between them. The method utilises images taken by the participants to pinpoint significant community issues and analyse the social and political dynamics within (Wang & Burris, 1997). Participants have complete authority over the selection of photographs, highlighting their respective expertise through shared stories (Pearce et al., 2017).

The use of photovoice in EA provided an inclusive approach to gain insights into community dynamics and villagers' nuanced perspectives on future livelihoods, that students might have overlooked otherwise (see *Appendix B*). Based on random sampling, three individuals were empowered to take five photos that represented their aspirations and expectations for the future concerning their livelihoods. In subsequent interviews, the participants chose their two favourite photos and were then interviewed based on pre-prepared questions and follow-up questions if further clarification was needed. Subsequently, the images were visually analysed.

2.6 Questionnaire

In interdisciplinary research settings, questionnaires are essential tools for gathering structured data from a sample population (Young, 2015). Administered through various formats, these primarily aim to collect quantitative data. Through careful consideration of question phrasing, a series of unbiased and well-structured questions are used to analyse predetermined variables (Porst, 2014). The posed questions are simple and not double-barreled (Rea & Parker, 2005). When designing the questions, the answer scale is considered for later analysis (Mattisek et al., 2013).

For this study, printed questionnaires in Malay were used to gather information on the socio-demographics of the household, income, and expenditures, usage of land and forest resources, future perceptions regarding their lives and livelihoods, as well as personal opinions on the natural and human capital (see *Appendix C*). Minor changes regarding the draft were made to reduce the answer options and fit the case study setting. In a convenience sample, 29 out of 33 households agreed to answer the questionnaire. A translator was present to explain the questionnaire to the respondent (see *Figure 7*). Additionally, notes were taken on the stories and explanations people provided to answers. Most of the questions were closed-ended and answered using the Likert Scale for a straightforward analysis (Young, 2015). Descriptive statistics and correlation tests with predefined hypotheses were executed through Excel.

Figure 7: Explanation of the questionnaire questions provided by one of the translators if needed (Source: Own figure)

2.7 Ranking Exercise

Ranking is a tool used to assess the preferences of households on how they prioritise different resources, activities, and accessibilities (Mahesh et al., 2017). After the completion of the focus groups, the same participants were asked to join this exercise and answer as individuals. The objective was to gain an overview of the most frequently answered crops and NTFPs from the questionnaire and their importance for livelihoods. Two separate tables, one for crops and another for NTFPs, were created where six crops and ten NTFPs were ranked against criteria differing in each table based on suitability. For each criterion, participants were asked to select their top priority of crops and NTFPs in the respective categories by placing a marker on the table (see *Figure 8*). This was guided by a moderator and accompanied by a translator. Later, the information was visually analysed to find common trends in the importance of using crops and NTFPs.

Figure 8: Decisions made by women in regards to ranking the most frequently used NTFPs against relevant criteria (Source: Own figure)

2.8 Soil Sampling

Soil sampling takes a group of specimens to estimate measurements or parameters of the total population (Braidek et al., 2007). Measurements can be made for both the physical and chemical properties of the soil to determine soil health and/or fertility. In this study, the aim

was to look at soil health through a physical analysis to determine agricultural feasibility in the area. Two sampling sites were selected. One on the edge of a rice paddy field and one in an oil palm field. These sites were selected to compare soil quality within different livelihood strategies. Samples were taken from areas with no top vegetation, therefore there was direct access to the topsoil. Using a coring tool, sections of the topsoil were removed to make a soil core of about 1 m long, consisting of three horizons (see Figure 9). From those samples, a physical analysis was completed where the horizon depth and size, organic matter content, and texture of soil were determined. Physical analysis was used to determine the best land use for the soil type. This method aimed to provide a natural science perspective on the soil quality of different agricultural practices for triangulation with qualitative results.

Figure 9: Soil sampling at the rice field (Source: Own figure)

2.9 Water Sampling

Water quality measures physical, chemical, and biological parameters and thresholds to determine the quality in classes which limit the usage purposes i.e. safe drinking water or conventional treatment required (Camara et al., 2019). In addition to substituting road transport for the Iban communities in the rainforest, the water is needed for agricultural purposes and daily human use (Hanafiah et al., 2018). Because it is of relevance, adequate water quality is critical.

The water quality was measured at three sites along the river: at the dam where the gravity-fed drinking water pipeline, at a site where they used to fish, and at the JV oil palm plantation. In situ at the three locations, three measures with the YSI meter were used to create means on the physio-chemical parameters. Additionally, stream quality was measured through bio-indicators, where macroinvertebrates were identified (see *Figure 10*). Through this, the indices Biological Monitoring Working Party (BMWP) - Malaysia, Malaysian Family Biotic Index (MFBI) (Hui & Fikri, 2021) and Shannon-index were created (Allen et al., 2009). Furthermore, two water samples were taken from each location for subsequent biological and chemical analysis. The count of FCC and TCC bacteria colonies (Obafemi et al., 2018) was conducted in the longhouse as well as chemical analysis of reactive phosphate and nitrite levels in the water. Finally, from all recorded values the water quality was assessed through the national water quality standard of Malaysia.

Figure 10: Water sampling at the dam (location 1), while four students searched for macroinvertebrates, 2 students and resource persons helped to identify and noted the species found, which were collected in the yellow box (Source: Own figure)

2.10 Analysis

Through Ellis' (2000) Sustainable Livelihoods Framework, diversified livelihoods as well as their reasons and effects were analysed. To bridge the differences between methods, results are triangulated to enable a holistic understanding. All qualitative results were thematically analysed using NVivo.

Codes were formed based on the Sustainable Livelihood Framework according to Ellis (2000) and general themes identified from the RQs. The categories were thus formed deductively and inductively, a typical mixed form for qualitative content analysis (Kuckartz & Rädiker, 2022). Text passages that were not relevant to the RQs were not coded. Moreover, it should be noted that some text passages were assigned to several categories, which is unproblematic according to Kuckartz and Rädiker (2022).

2.11 Limitations

General and method-specific limitations occurred while conducting the methods. General limitations were found in group dynamics, local conditions, and academic execution.

Although the research proposals of the Malaysian and Danish groups were aligned, there were different research focuses. This resulted in varying interpretations of the methods' execution. Within the groups, there were many diverse backgrounds, which required patience and discussion on viewpoints to manage cultural differences.

Local conditions, like weather, prevented methods from being conducted timely. Therefore, flexibility in execution and adaptation in research focus was needed. Furthermore, the mourning of the community due to the death of the headman's mother influenced the study to an unknown extent, as the longhouse was calm and more desolate in the first days. Issues with reliable internet connection were experienced, creating difficulties in collaborative working and sourcing additional information.

Moreover, the execution of all ten methods was difficult in eleven days. With more time in advance and in the field, the methods could have been executed in greater detail. Therefore, it was crucial to prioritise the methods most pertinent to the research objectives. Methods were completed with the help of a translator. Misunderstandings between student groups, translators, and villagers occurred. To overcome communication issues, translators were briefed on each method and all involved were informed on the importance of asking follow-up or clarifying questions. Participant availability might have negatively influenced sampling, limiting the generalizability of the study. For example, younger community members could be underrepresented as many of them have relocated for work. Additionally, if a method was conducted in the longhouse, the number of participants fluctuated due to the social nature of

the setting. Many people joined or left throughout methods making it difficult to keep track of who participated and influencing the results. For better understanding, the specific limitations for each method are found in *Table 1*.

Table 1: Specific methodological limitations within this study (Source: Own table)

Method	**Limitations**	**Adaptations to limitations**
PRA	- Had to ask more directed questions, reducing the participatory nature of the method - Due to a lack of cooperation specifically as this was the first method completed and there was low rapport - Social dynamics within the group of participants may have meant some people's opinions were overlooked	- Encouraged participants to elaborate on answers and identify personal topics of discussion - Notes were made regarding social dynamics and incorporated within analysis
Informal Interviews	- Reliability: some participants were slightly forgetful due to their age and got some information mixed up - Interviews happened in the presence of other people which might have influenced interviewee's answers, social desirability also plays a role	- Asked follow-up questions to broaden or clarify answers - Listened to and recorded notes of sole interviewees' answers to avoid outside influence but noted the presence of others for potential bias
Focus groups	- Many of the same participants answered Social structures, unspoken hierarchy e.g., TR Freddy answered a lot for men's group	- Notes regarding social structures and which participants answered were made and incorporated within analysis

Photovoice	- Interviews should have taken place in a more secluded setting
	- Others watched, listened, teased, and prompted answers
	- Method required very abstract thinking therefore may not have been fully understood
	  - Some pictures were not showing future
	  - Turned into more of an interview asking about the future
	- Participant selected photos from the internet rather than taking them themselves
	- Not quite in the scope of the method but still provided interesting results
		- Adjusted interview guide on the spot to fit selected pictures
		- Asked follow-up questions to broaden or clarify answers
		- Listened to and recorded notes solely of interviewees' answers to avoid outside influence but noted the presence of others for potential bias

Question-naire	- One respondent per household
	  - Not always the head of house
	  - Based on availability
	- Interruptions, multiple people answering
	- Accuracy of the translations of questions (questions written in Malay)
	  - Translator being leading when questions were not understood
	  - Added bias if respondent was given answer examples
	- Close-ended questions and categories
	  - People needed to pick the closest to their opinion
	- Small sample size, but 87% of village households were surveyed
	- Lacks significance in correlation
		- QRs were made aware that they answered on behalf of the household
		- Conversations with translators were had to encourage an unbiased approach
		- Despite closed-ended questions there was always an 'other' category that could be selected

Ranking exercise	- Not understood at first, multiple stickers from one person in each row - Participants answered inconsistently - Each row does not have the same amount of stickers - People are influenced by others, followed first person to answer	- Invited participants to take part in smaller groups and encouraged them to answer for themselves

Biodiversity assessment	- Error in counting
	  - Plants were stepped on
	  - Ground litter covered species
	- Plot choice
	  - Very close to path and human interactions therefore may not be as representative of a forest
	- Lack of species knowledge
		- Local guides to provide knowledge

Soil sampling	- Only two samples taken - Not representative of area (rice paddy, smallholder oil palm plantation) - No repetitions preventing accuracy - Results were not relevant to the RQs and therefore excluded	
Water sampling	- Net and mesh sizes for biological macroinvertebrates were not identical - Location difficulties: entering the river middle because of depth, velocity and dangerous wildlife (crocodiles and snakes) - Heavy rainfall: biological parameters analysed only in 2 out of 3 locations - Assess water quality only through 2 indices (BMWP and MFBI) - Lab Work for biological and chemical parameters in the longhouse - Possible contamination - Disturbance by kids and pets (cats)	

3 Results and Analysis

Throughout the analysis, results were organised to help answer the research questions.

3.1 Results on the Composition of the Livelihood Diversification Strategy

RQ1: What is the livelihood diversification strategy composed of in Empelanjau Asal?

The community has a wide range of income sources involving farming activities, the collection of NTFPs, non-farming activities, and governmental support. Generally, it can be said that EA diversifies their livelihood as 76% of Questionnaire Respondents (QRs) indicated more than one income source.

Farming Activities

Farming activities predominantly revolve around smallholder cultivation of crops such as paddy, rubber, fruit trees, and oil palm as derived from the questionnaire. These crops serve both personal consumption and cash-earning purposes, except for palm oil, which was grown exclusively for sale. Additionally, informal interviews and focus groups showed that the community engages in backyard gardening for subsistence and practices swiftlet farming as a further source of income.

Collection of NTFPs

72% of QRs indicated that they use NTFPs as a livelihood strategy. Among them, 21% consume them daily, each 17% consume NTFPs 2-3 times a week or once a week, and 37% consume them less than once a week (see *Figure 11*).

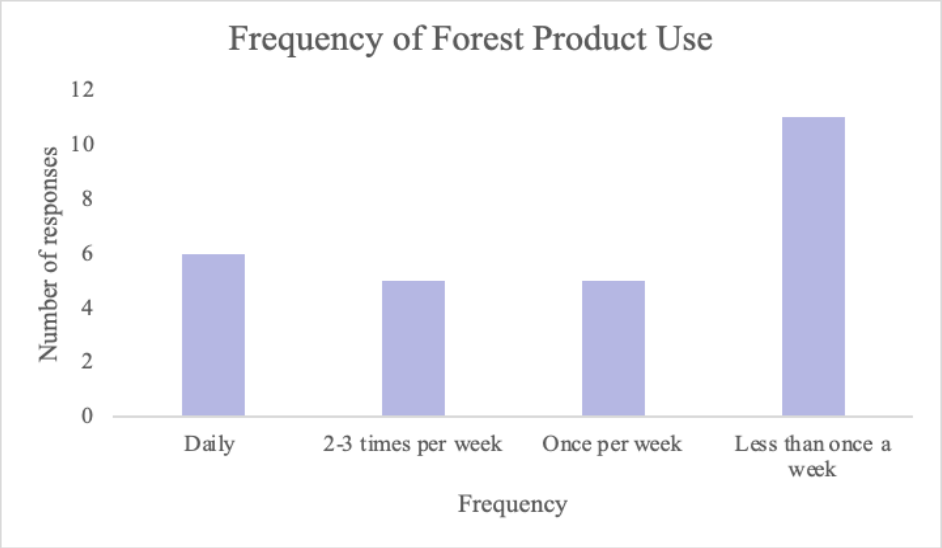

Figure 11: Frequency of the usage of NTFPs by the villagers of Empelanjau Asal from Questionnaire (Source: Own figure)

Indicating that the use of NTFPs varies among individuals, NTFPs still play a crucial role in generating income for villagers. It is interesting to note that there is no difference in the consumption of NTFPs between income groups. The results of a t-test have shown that there is no significant difference between villagers with an income below 1000 RM per month and those with a higher income. This highlights the significance of NTFPs in supporting livelihoods and fulfilling socioeconomic needs. According to both the questionnaire and the ranking exercise (see *Appendix D*), the same NTFPs were found to be commonly used in the village. Midin, for example, was the most frequently reported NTFP in the questionnaire (see *Figure 12*) and was also listed as the most frequently consumed and sold NTFP in the ranking. Through informal interviews and focus groups, it was found that NTFPs are used for personal consumption and are sold in local markets. Midin, for example, can be sold in bunches on the market for 2-3 RM or to a restaurant for 15-20 RM.

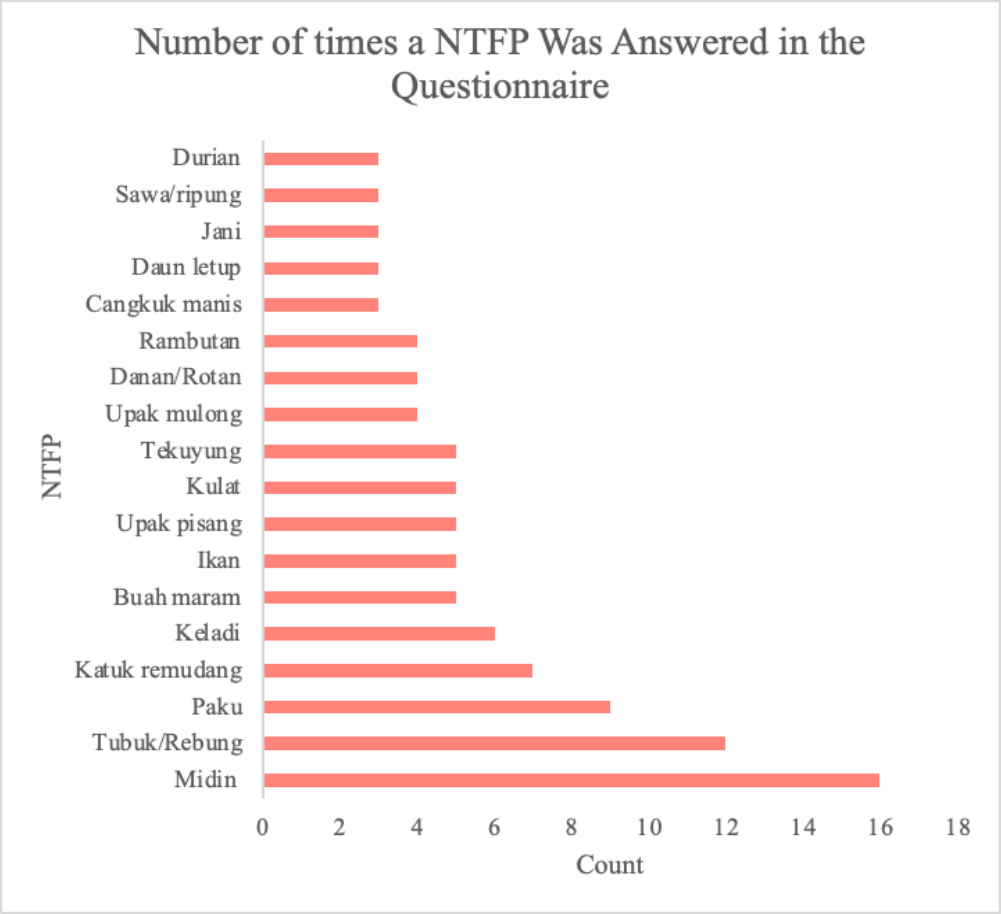

Figure 12: Overview of NTFPs questionnaire results (Source: Own figure)

Income Activities

The highest income sources, most frequently stated by QRs, were farming (64%), W-JV Rent (43%) and construction (21%). Non-farm activities in EA predominantly consist of wage jobs, such as construction, police work, or military service, as identified by the questionnaire. Additionally, informal interviews affirmed that younger generations prefer stable wage jobs that provide them with increased cash income, rather than relying on the labour-intensive and tiring process of collecting NTFPs or cultivating crops. Generally, photovoice and informal interviews revealed that villagers are highly willing to take on different wage jobs to increase their overall income and improve their standard of living, which may also lead to migration to cities. However, the majority of QRs were uncertain or strongly disagreed about migration from EA in the next decade, while only one-third of QRs strongly agreed or agreed with the likelihood of migration (see *Figure 13*).

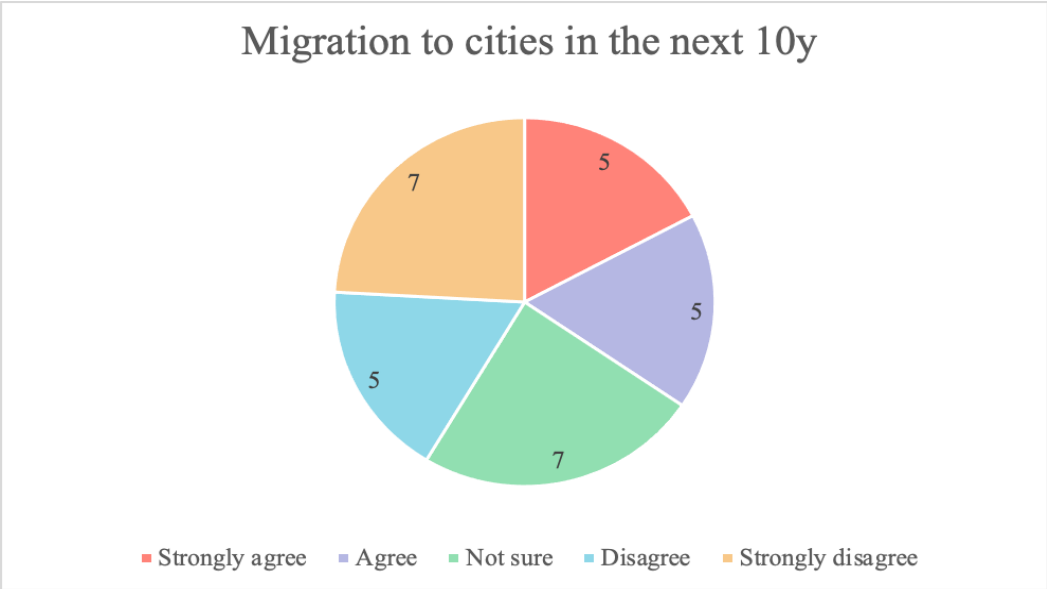

Figure 13: Likelihood of migration from Empelanjau Asal to the cities in the next decade from Questionnaire (Source: Own figure)

This divide in viewpoints can be explained through insights obtained within focus groups and photovoice. The strong ties that the villagers feel towards their land, heritage, and community network motivated them to stay in the village. Some villagers are also hopeful that W-JV will generate new job opportunities once the plantation is first harvested. Nonetheless, they aspired for their children to have access to higher education and good job opportunities, which could result in urban migration. Despite this, there remains uncertainty surrounding how migration could impact the future community composition and the preservation of Iban traditions.

Moreover, villagers generated additional revenue by leasing communal land to W-JV. According to the focus group discussions, each household in the village receives a monthly payment of 200 RM. This payment will increase to 300 RM per household once the oil palm plantation harvest begins. For some elderly villagers who are no longer able to work, W-JV rent is their only source of income, making them heavily reliant on it. Additionally, questionnaire results showed that intra-community trade as well as remittances contribute to income generation. A few villagers own small shops, in which they sell daily essentials like eggs, vegetables, rice, beverages, and gasoline. Remittances are usually received from relatives working in urban areas, such as Kuching, this often involves younger people who regularly send money to their families remaining in the village. Some families earn little additional money by collecting scrap metal which a dealer buys once a month.

Government Support

According to the questionnaire, 21% of QRs listed governmental support as one of their top three sources of income, indicating that depending on the government for income is a prevalent component of their livelihood. Further discussions held in focus groups reported that elderly individuals usually receive pensions, while younger villagers can apply for additional government support through Bantuan Rakyat 1 Malaysia (BR1M), which is a welfare system that provides cash benefits for low-income Malaysians.

3.2 Presentation of Reasons for Current Livelihood Diversification

RQ2: What are the main reasons for the current diversification?

Changing market trends

Informal interviews and the ranking exercise stated that smallholder rubber production decreased due to a lack of demand and profitability (see *Table 2*). However, villagers still partake in the scheme to receive a land title from the government, guaranteeing land security. This links to the idea that the Iban community has a strong connection to their land and prioritises securing it over more profitable livelihood strategies.

Table 2: Results from ranking exercise regarding crops (Source: Own table)

Criteria/Crops	Paddy	Rambutan	Durian	Rubber	Oil Palm
Consumed most	14		1		
Sold most (quantity)		9	4	1	2
Most cash income		10	6		3
Least labour requirements		1	1	10	

Through informal interviews it was revealed that the demand for palm oil had increased. Knowledge regarding the demand for palm oil was spread within the community, raising villagers' awareness of the benefits surrounding its profitability. This resulted in an increase in interest shown towards participating in oil palm cultivation, leading to the start of TR's smallholder oil palm plantation in 2011/12.

Ibans and their Land

The transect walk (see *Figure 14*) showed that commonly used NTFPs were easily accessible. On the walk, 18 NTFPs were identified by the Iban guide in the forest adjacent to the village.

This is crucial because 75% of QRs stated that NTFPs are either very important or important to their current livelihood.

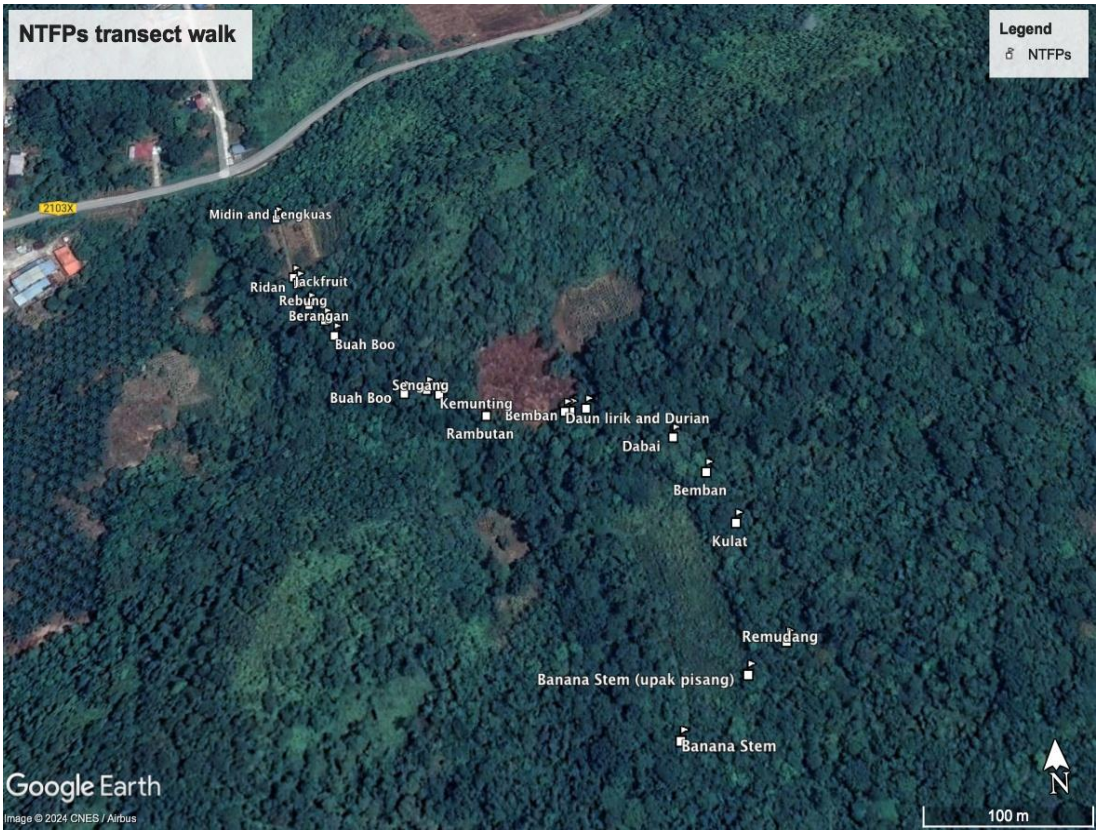

Figure 14: Map showing NTFP-guided transect walk (Source: Own figure)

A key cause of the LUC from community forest to the W-JV was the village's willingness to participate due to the development associated with large-scale oil palm cultivation. The PRA timeline (see *Appendix E*) uncovered that in 1972, the community converted to Christianity, resulting in a shift away from strict Iban traditions regarding land. Without the conversion to Christianity, the land may never have been rented to W-JV, demonstrating its role in driving the current livelihood strategy of oil palm production. Even with this conversion to Christianity, focus groups stated that a unanimous decision had to be reached amongst villagers to allow the acquisition of land by W-JV. Informal interviews explained the importance of Iban tradition in regard to land usages (see *Section 3.4*).

Governance

Government interventions acted as one of the main external reasons behind the livelihood diversification of the EA community. Therefore, results from questionnaires affirmed that government schemes were a major contributor to changing land usage in EA (see *Figure 15*). The schemes encouraged villagers to start smallholder rubber plantations by providing subsidies. This had historically taken place in EA, with the timeline revealing the initiation of rubber cultivation in the 1980s. Through informal interviews, it was found that subsidies included free saplings and fertilisers, as well as land-clearing services. Additionally, schemes helped to provide land security by giving land titles, which are still implemented.

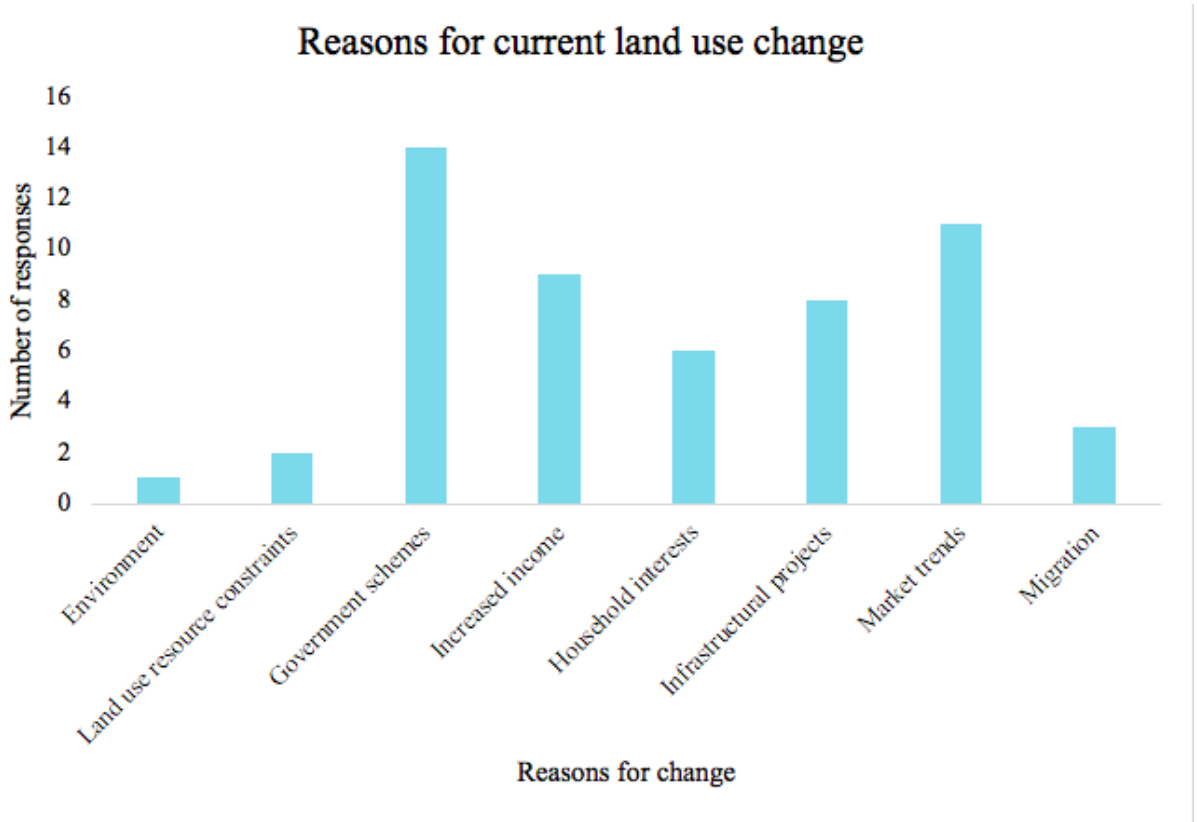

Figure 15: Reasons for current land use change in Empelanjau Asal from Questionnaire (Source: Own figure)

Perceptions of Oil Palm Cultivation

The growth of oil palm cultivation was highlighted in informal interviews, where interviewees discussed the rise in popularity of the crop. This notion was supported by the questionnaire, with 86% of QRs stating that oil palm cultivation was either very important or important to their current livelihoods (see *Figure 16*). Additionally, over one-third of QRs stated that it was very likely or likely that they would join an oil palm project in the future, indicating the positive

opinions surrounding the crop and its impact on decision-making regarding enhancing income sources.

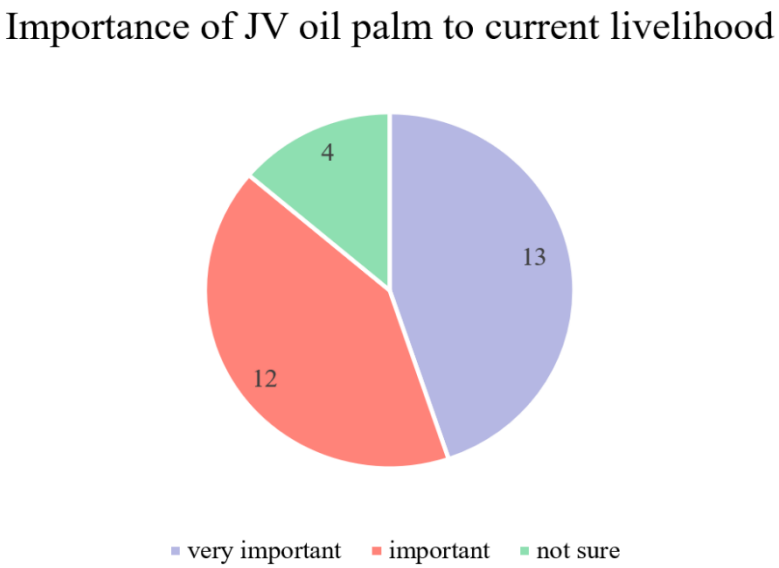

Figure 16: Importance of JV to current livelihood from Questionnaire (Source: Own figure)

Within informal interviews, respondents provided a positive outlook regarding the potential of W-JV oil palm plantation. In response to the contract, it was revealed that W-JV pledged villagers the opportunity to be employed when harvesting begins. Additionally, interviewees spoke highly of the associated road and infrastructure development that accompanied the presence of the W-JV.

A photovoice participant expressed a wish to start their own smallholder oil palm plantations. He hoped that this would support his children's education and provide better job opportunities for them without hard, physical labour. The notion of future career paths instead of rural farming practices is mirrored within the children's focus group where their envisioned occupations would require leaving EA.

3.3 Results on the Main Effects of Diversification on the Environment and the Community, Now and in the Future

RQ3.1 + 3.2: What are the main effects of diversification (on the environment and community) now and in the future?

Decline in Biodiversity

Villagers noted a decline in wildlife, particularly wild boar, and monkeys. Additionally, the W-JV contributes to river pollution, evident in the increased total number of bacteria colonies (see *Figure 17*).

	(1) Water dam	(2) Before W-JV	(3) In W-JV
pH	6.266	6.176	6.706
FCC	150	125	125
TCC	2585	7425	20910
BMWP - My	57 (moderately good)	29 (fair)	#
MFBI	5.41 (good)	4.5 (good)	#
Shannon Index*	1.12	0.96	#

* Shannon Index is calculated by family not by species for aquatic insects and fish
# due to weather conditions and dangerous wildlife no measurement of bio-indicators was possible

Figure 17: Comparison of most important water quality assessment results of three locations alongside the river: the water dam (1), before the W-JV (2) and in the W-JV (3) (Source: Own figure)

While measuring water quality downstream, indicators showed a deterioration in water quality except potential of hydrogen (pH) and FCC (see *Appendix F*). Villagers said they were forced

to abandon fishing spots (see *Figure 17, location 2*) due to contaminated fish with a diesel-like taste. Consequently, they had higher expenses purchasing seafood from the nearest market, Lachau.

Informal interviews revealed a lack of concern regarding the decline in biodiversity, specifically regarding wildlife. This was apparent through comments on monkeys viewed as pests towards the crops, even to the extent that monkeys were hunted. Additionally, only half of QRs agreed that there is a need for the conservation of wildlife and biodiversity in the area and none of the QRs strongly agreed. However, 72% of QRs were aware that the local biodiversity was decreased by the oil palm plantations.

Decline in NTFPs

NTFPs play a significant role in the livelihood strategies of EA. *Section 3.1* demonstrated the high frequency of forest product usage. Resultantly, any variations in the availability of NTFPs can have significant impacts on the livelihoods of EA.

Compared to the past, interviewees mentioned that the consumption of forest products has declined. Overall, the availability of NTFPs is decreasing, as stated in informal interviews and focus groups. Still, 55% of QRs used NTFPs at least once a week and because these are regularly sourced, villagers have a higher reliance on them for their livelihoods. For example, certain fruits used to be abundant in the forest and women would sell them on the market. Today, they are extinct in the local forest and the price has increased on the market, making them unavailable to the villagers.

The decline in NTFPs was also apparent in the biodiversity assessment results. The forested area next to the oil palm plantation had lower biodiversity than the secondary forest which can be seen in the Shannon Index values of 0.47 and 0.69 respectively for NTFPs (see *Figure 18*). The oil palm plantation had a value of 0, meaning there is no NTFP diversity there. The secondary forest had been untouched for about 20 years, whereas the oil palm plantation and forested area next to it had been intact for at most 10 years. This showed the effect that LUC had on the environment and the availability of NTFPs. The strong spiritual connections this Iban community has to their land has led to an increased severity of impacts, as revealed through informal interviews.

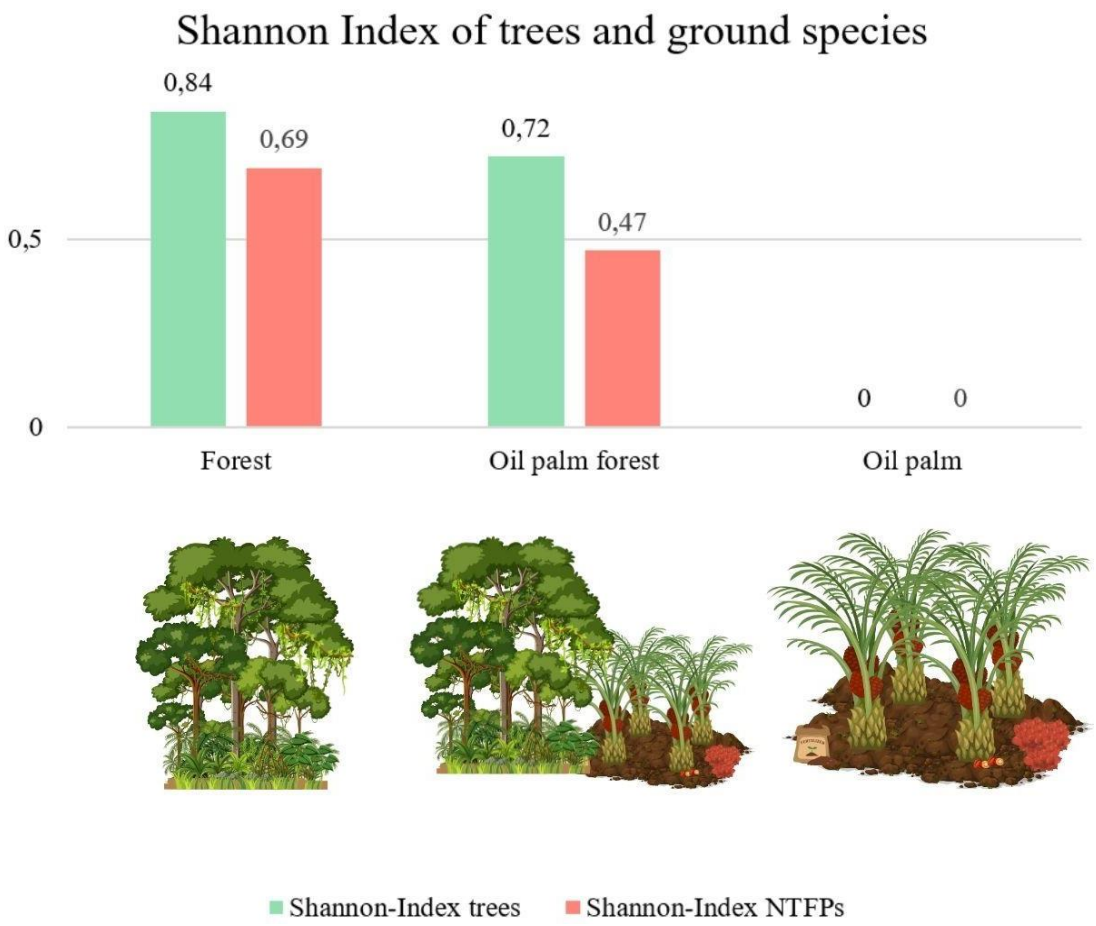

Figure 18: Calculated Shannon-Index for trees and ground species at three different locations: secondary village forest (1), secondary forest bordering with oil palm plantation (2), and within a smallholder oil palm plantation (3) (Source: Own figure)

Increased Income

Beyond environmental impacts, communal aspects emerge. Firstly, the community identified the W-JV as part of their village by including it in the village resource map (see *Appendix G*). 93% of QRs agreed that oil palm cultivation will (continue to) positively impact village development. Secondly, the W-JV serves as an income source, with their monthly rent of 200 RM seen as one of the top three income sources by 46% of respondents. Subsequent interviews revealed additional positive effects of the W-JV like the security of land titles through the 60-year contract. Generally, 51% of the villagers earned less than 1000 RM last month, showing that the 200 RM rent has a significant share in their income. Respondents across methods wished to further develop oil palm as smallholder businesses, offering stable income and job opportunities while fostering village development. Despite some interviewees referring to the above-mentioned impacts such as reduced forested land and limited access to NTFPs negatively, most villagers, emphasise the primary benefits of increased income and village

development from the W-JV. Oil palm plantations are seen by 93% of the respondents to help the community to develop in the next 10 years.

Moving the focus from impacts on the villagers and their livelihoods, the W-JV has a 60-year contract on 263 hectares. While the global demand remains stable, the monthly harvest cycles are expected to yield high profits. In 2028, when the palms are mature and ready for harvest, villagers will receive an additional 100 RM for their rent. However, until now, W-JV covered rental payments without an income from this plantation.

Envisioned Future

Aligning findings from focus groups and photovoice, participants mentioned that the W-JV rent would provide them more time for wage labour. They prefer a stable and higher income associated with wage labour to crop cultivation and the search for forest products. However, this contradicts the photovoice results, in which all three participants depicted agricultural activities. Two participants expressed a desire for a smallholder oil palm plantation, while another aspired for a jackfruit plantation, with plans to export internationally (see *Figure 19*).

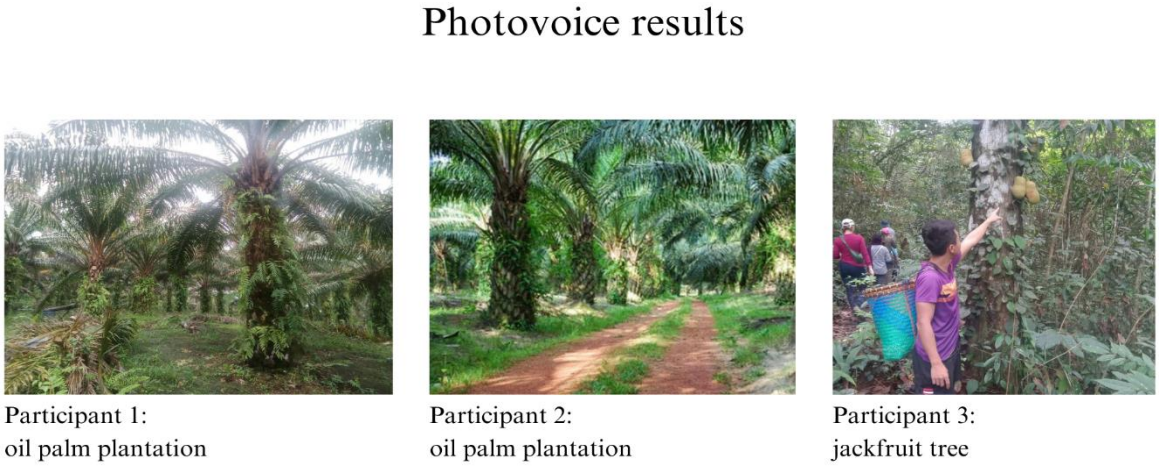

Figure 19: Photos from photovoice showing the wish for own smallholder plantations, especially for oil palm (Source: Own figure)

It is noticeable here that participants wished for monoculture plantations and wanted to sell fruits on a large scale. Alongside the economic benefits, an additional reason for this development was the preference of a clean and managed look of nature within their community.

Moreover, the informal interviews showed that villagers saw another opportunity in eco-tourism to diversify their future income sources as a means of fostering economic development in the village without exploiting nature. The majority of QRs strongly agreed or agreed with the possibility of starting eco-tourism within the next ten years (see *Figure 20*), a sentiment supported by informal interviews. However, interviewees expressed concerns about promoting EA as a tourist destination and obtaining unanimous village-wide consent.

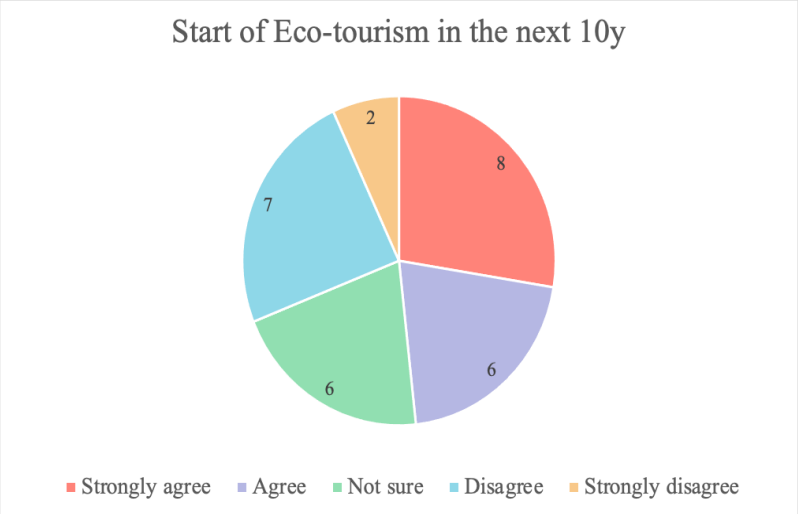

Figure 20: Start of eco-tourism as a future livelihood strategy from Questionnaire (Source: Own figure)

3.4 Application of Sustainable Livelihood Framework

As 76% of respondents indicated more than one income source, and villagers spoke about diverse incomes, diversification was their primary livelihood strategy. Therefore, they drew from a variety of assets to sustain their survival and well-being. The five types of capital (Ellis, 2000) were initially analysed by households and then shifted to the village level.

Villagers in EA utilise **Natural Capital** in various ways. They use their land to cultivate crops and rent it to W-JV for oil palm cultivation. The river is the primary source of overall water consumption. Additionally, villagers collect products from the forest, hunt, and fish (Ellis, 2000). Furthermore, **Physical Capital** plays a crucial role in the livelihood of EA's residents. Infrastructural assets, such as roads, electricity, and water supplies, are particularly significant. The government and W-JV's expansion of the road network in the last ten years has vastly improved the residents' access to their lands. Transporting harvested products, resources like fertilisers and machinery used in cultivated land have become more efficient, saving time and money. Additionally, commuting to nearby towns such as Lachau for employment

opportunities or taking children to school got easier. Roads have also fostered markets for villagers to sell their products and purchase consumption goods. Due to the migration of younger generations to urban areas, villagers' **Human Capital** is deprived due to a shortage of labour. 72% of respondents have received primary or secondary education and 45% of respondents work as farmers. They are aware that more education and skills lead to a higher potential to make a decent living. Therefore, parents encourage their children to pursue higher education to gain access to better job opportunities. **Social Capital** is of high relevance for the community as they rely on a strongly interconnected network within the village. Generally, there is a high degree of trust among community members and people reciprocally support each other. This cuts across all areas of life, including working together, sharing resources, raising children, or socialising. Finally, the community is equipped with **Financial Capital**. W-JV provides a monthly income of 200 RM for every household in the village. Some households have additional stable income from wage jobs, while others earn money by selling their crops and NTFPs.

The conversion of assets into livelihood strategies is influenced by the prevailing social, economic, and political circumstances, which are called conditioning factors (Ellis, 2000). One conditioning factor is observed in the community's affiliation with the Iban ethnicity. Iban traditions have decreased in influence in recent times, especially due to the community's conversion to Christianity in 1972. Through the timeline and informal interviews, a shift from traditionality towards a more open interpretation of the Iban culture was presented. The traditional Iban belief in the spirits is still prevalent, particularly amongst the older generation. A suitable example is the deforestation of large parts of the community forest in 2018/2019 to make way for W-JV where the community conducted a ritual to gain the approval of the spirits and appease them. According to Iban's beliefs, they perform "*Miring*" which seeks permission from the spirits through offerings before a tree can be cut down by a human. Furthermore, some community members continue to grow rice, as a means of preserving their tradition, even though they could easily buy rice from the market. This indicates that Iban traditions still have an impact on people, are an integral part of the community's identity and influence their decisions regarding the use of their land and, thus the use of their assets.

Another conditioning factor influencing the community in the conversion of assets into livelihood strategies is the state of Sarawak. EA does not have official titles for its community land, which has resulted in land conflicts with the state but also neighbouring communities.

Therefore, a main reason for entering the contract with W-JV, besides financial benefits, was the assurance of community ownership of this land for the next 60 years. Market trends also impact EA's livelihood strategies and are exogenous to local circumstances (Ellis, 2000). According to Ellis, the "international economy is of direct importance to small farm producers of export crops" (Ellis, 2000) which applies to smallholder oil palm owners in EA.

4 Discussion

In this section, each RQ is elaborated on, according to the relevant results found. Therefore, after talking about general livelihood diversification in EA, reasons for the diversification will be mentioned as well as the effects of a more specific example of income diversification on the environment and the community.

4.1 Livelihood Diversification in Empelanjau Asal

RQ1: What is the livelihood diversification strategy composed of in Empelanjau Asal?

As previously mentioned (see *Section 3.1*), the villagers of EA are implementing a livelihood diversification strategy, as 76% of the QRs had at least two or more income sources during the last 12 months. However, a limitation arises from the interpretation by QRs of 'income' solely in financial terms, possibly excluding activities such as the collecting of NTFPs. Moreover, this does not capture variations in income levels within these 12 months.

Researchers studying Iban communities in Sarawak have also identified the strategy of income diversification. According to research by Cramb and Sujang (2011) on a community in the Ungai Bok lands, the Iban people have developed a diversified livelihood system that has enabled them to adapt to rapidly changing economic conditions. In the past, they relied on subsistence agriculture through shifting cultivation, but have now transitioned to grow perennial cash crops. Currently, they are in the process of shifting from smallholders to shareholders, referring back to their shares in oil palm plantations. In addition to the rent received from leasing land to a JV oil palm company, the Ungai Bok land community also cultivated rice, pepper, and own smallholder oil palm plantations. However, there is an overall trend where other farming activities besides palm oil are declining, which is reinforced by the outmigration of younger people to cities for off-farm job opportunities. This has caused a shortage of labour for labour-intensive agricultural activities (Cramb & Sujang, 2011). Urban migration and a lack of labour were also observed in EA through the questionnaire. Additionally, as explained through informal interviews and focus groups, the primary reason for the community to join the W-JV was to establish legal ownership of their ancestral lands besides financial benefits, thus keeping the land as an asset that can be transferred into current and future livelihood strategies. This aligns with findings from the study by Cramb and Sujang (2011).

Conclusions on EA income sources were predominantly derived from questionnaire results, which were sampled based on convenience and did not consider aspects such as gender and wealth disparities within households. From the answers of one household representative, generalised claims for the entire household were made. Therefore, these results might not be representative of the entire household, and one should be aware of this limitation and remain critical of the conclusions drawn. The notion of disparities within households should be investigated by future research to obtain a more nuanced understanding. Moreover, this case study is a cross-sectional study and does not capture temporal fluctuations of different incomes in diversified livelihoods, specifically not the income derived from palm oil.

Another study by Tan et al. (2020) also found that people in Sarawak are diversifying their livelihoods. They investigated how the assets available to ethnically diverse riverine communities in Samarahan, Sarawak contributed to sustaining their livelihoods. The research revealed that the communities also employed a variety of income strategies by efficiently utilising the assets at their disposal. Moreover, communities that possessed a broader asset base demonstrated increased resilience and adaptability (Tan et al., 2020).

4.2 Reasons for Livelihood Diversification

RQ2: What are the main reasons for the current diversification?

In this section, the main reasons for livelihood diversification in EA are discussed as external and internal factors. From informal interviews, focus groups, and questionnaires, it became prominent that global demand, governance, and conversion to Christianity acted as external factors that influenced their livelihood diversification, whilst the willingness of the community to diversify played a role as an internal factor.

<u>Global Demand</u>

Focus groups revealed that constantly changing market trends due to global demand influenced livelihood strategies of EA through the introduction of cash crops like the government-funded rubber schemes. Cramb and Sujang (2016) support these findings, stating the introduction of government-funded rubber schemes in the 1960s, and the introduction of oil palm subsidy schemes during the 1990s. This demonstrates how the community adapted their agricultural practices within their livelihood strategies to the evolving growth in the global market.

However, global markets can become unprofitable, and informal interview results specifically mention rubber. The result is supported by studies which showed that the market price for rubber (Khin et al., 2008) decreased. Contrary to that, an increasing global demand for palm oil led to the increase in oil palm schemes in Sarawak (Tang & Al Qahtani, 2020). Interviewees explained that they already started, or plan to start practising smallholder oil palm plantations as a profitable source of income in their livelihood strategy.

Conversion to Christianity

Land possesses a very significant value in Iban culture (Ngidang, 2003). Traditionally in Iban culture, the forest has always been a part of livelihood strategies through the collection of NTFPs as seen in transect walks and spiritually through special locations within the forest. Because of the conversion to Christianity in 1972, assessed through the timeline, Iban traditions and spiritual beliefs became more flexible. This resulted in the allowance of large-scale land clearing in combination with the *miring* ritual resulting in the establishment of the oil palm plantation, as stated in informal interviews and focus groups. Literature confirms how the introduction of Christianity to rural Sarawak during the 1960s-1970s influenced the livelihood of the Bidayuh which is an Iban community of Sarawak (Chua, 2012). When the Bidayuh converted to Christianity, they began to abandon their old rituals related to rice cultivation and harvesting to join state-led development programs as young generations moved to cities for more profitable and stable income sources (Chua, 2012). As an external factor, this is influencing the individual and the community's perception of land within their livelihood diversification.

Governance

50% of QRs noted the presence of the government as another main reason for the types of land usage. Governmental influence is experienced in EA through agricultural programs intending to help villages to develop. Through timeline results the different cash-crops recommended by the government changed due to market demand. This is exemplified by the infeasibility of the rubber market, declining their abundance (Nicod et al., 2020). Ultimately, the decision of implementation lies with the community and the individuals. Communities have the freedom of choice, although their decisions are still influenced by customary land laws (Ngidang, 2003). Focus groups revealed that in order to clear the land for the W-JV, a unanimous decision across the village was needed, showing how the power is in the community's hands. Even though governance is recognized as a major external influence, the degree to how much they influence

can differ. A study by Hoe et al. (2018), shows the agency of Iban people by stating the degree to which the government's influence can differ based on community willingness to cooperate with government administrations. Therefore, limitations to this study are a lack of knowledge on village agency. Questions about decision-making and participation in government schemes as well as the level of government influence were not investigated. To improve the understanding of governmental importance in EA, future studies could involve interviews with government officials as well as a temporal analysis of the relationship between the government and the villagers.

Willingness of the Community to Diversify

Through globalisation and increased exposure to new income options, people are willing to diversify. Interviewees described that they were quick to adjust their livelihood strategies to follow new trends and respond to any changes other villagers may have made. This desire to diversify is common amongst rural communities (Ellis, 2000), highlighting how the diversification of EA is aligned with literature. For example, in EA this willingness to diversify has resulted in the shift towards the currently most market-favourable crop oil palm.

Focus group results stated that the W-JV might provide future employment opportunities for villagers. However, this is yet to occur and within literature, there is speculation regarding the truthfulness of such claims (Sanggin & Mersat, 2013). Additionally, informal interview results showed the improved road infrastructure developed by W-JV, enabled the community to access nearby markets and cities more easily. The want of this development by the community and their perception that W-JV will achieve this drives the reasoning behind this income stream within their livelihood diversification strategy.

Moreover, from the results of photovoice and informal interviews, it became clear that the community had a high willingness to diversify their incomes to provide a better future for their children. Diversification is viewed as a method to increase their income, with one photovoice participant stating they wished to start a smallholder oil palm plantation in the future as they believed it would support their child's future education. This aligns with the children's focus group interview where most children wished to pursue a career that would require leaving EA. Cramb et al. (2009) support these findings by highlighting the wish to provide children with a better future and higher education as major reasons for rural communities in Southeast Asia to diversify their incomes through cash crops and non-farm wage jobs.

Ellis (2000) and Derebe and Alemu (2023) argued that having multiple income streams and being flexible to respond to changes is vital to achieving resilience within livelihoods. However, this case study did not investigate the role of risk reduction as an influencing factor for the community's chosen livelihood strategies. This limitation is present due to the change in research focus within this study after the formulation of the methods, meaning the methods were not planned to have a focus on livelihoods. Therefore, an interesting line of future research would be to consider the presence of risk reduction within causes of livelihood diversification.

4.3 Main Effects of the Current Diversification of Livelihoods

RQ3.1 + 3.2: What are the main effects of diversification (on the environment and community) now and in the future?

4.3.1 Effects on the Environment

Historical Iban livelihoods, such as shifting cultivation and NTFP collection, have strong connections to land and a small-scale disturbance on the environment (Ichikawa, 2007). Whilst Ellis (2000) expresses difficulties with predicting the interrelations between livelihood diversification and environmental sustainability, Wilms-Posen et al. (2014) have reported that the shift has been accompanied by increased environmental degradation. This notion of diversification negatively impacting the environment is reflected in the results of EA.

<u>Negative Environmental Effects of Oil Palm</u>

The introduction of oil palm plantations, both JV and smallholder, is widely associated with negative environmental impacts (Wilms-Posen et al., 2014).

A key environmental effect of oil palm plantations is soil degradation, with studies showing that plantations degrade soil significantly more than alternative land uses (Wilms-Posen et al., 2014; Hamdan et al., 2000). The long-term negative impacts of oil palm on soil quality reduce future land use options of the plot, decreasing available natural capital (Cramb, 2013). Whilst only physical soil analysis was completed within this study, this was not enough to determine how soil quality was impacted by oil palm and the results did not help to answer the research questions. Although literature identifies negative impacts, Tanaka et al. (2009) argue that soil quality in plantations can be maintained over time through management practices such as low soil disturbance and organic fertiliser usage. This consideration could be vital for the future of diversified livelihoods in EA, allowing the community to continue experiencing the benefits of oil palm but increase its environmental sustainability.

Another environmental effect of oil palm plantations is water pollution. EA experienced an increase in TCC in the river at the plantation compared with further upstream. Due to safety reasons, fertiliser inputs were not tested for at the plantation site. However, studies in a similar environment in peninsular Malaysia found raised levels of nitrate and sulphate in oil palm plantation water samples because of fertiliser usage (Itoh et al., 2023). Furthermore, the results from the water assessment method could have benefited from improved site selection which considered the relief of the land and patterns of surface run-off.

Decline of NTFPs

The usage of NTFPs is environmentally sustainable (Parnwell & Bryant, 1997) because of the sporadic collection of non-renewable resources, allowing them to regenerate over time. As stated by Wilms-Posen et al. (2014), the loss of biodiversity is a key environmental impact of livelihood diversification, specifically through the growth of oil palm plantations. This loss can take the form of declining NTFPs (Parnwell & Bryant, 1997), aligning with the comparison of Shannon Indices from the biodiversity assessment within this study. The low asset requirements of the collection of NTFPs encourages EA's frequent usage (Parnwell & Bryant, 1997), as shown through questionnaire results. Resultantly, their reduced availability will have significant impacts on EA's livelihoods and limit their ability to pursue diversification.

The focus of these results is on the local environmental impacts; however, literature highlights many additional widespread environmental effects (Purnomo et al., 2020). Whilst it is understandable for the local community to only present effects they have experienced, it is important to note the varying spatial scales which the diversification of livelihoods impacts.

Disconnect Between Effects and the Community's Perceptions of Environmental Effects

Within the results of this study, there is a disconnect between the researched environmental effects of livelihood diversification and EA's perceptions and opinions of these effects. Natural science methods, including biodiversity assessments and water sampling, demonstrated the environmental degradation as a result of oil palm plantations, whilst social science methods such as questionnaires and interviews highlighted a lack of concern regarding the impacts. Many QRs were aware of the decrease in biodiversity but no action is being taken to combat the issue. The reason for this disparity could be an interesting focus for future research, specifically utilising a longitudinal study that could consider temporal changes in the village.

This became apparent from the discussion of monkeys who were considered as a pest to crop production by villagers. Additionally, a photovoice participant stated their preference for the clean and managed appearance of oil palm rather than natural forests but expressed no concerns regarding the environmental impacts. These examples bring forth controversies within development regarding the local context of EA and priorities within the community that do not align with environmental sustainability. In the context of Malaysia, these communities are relatively poor and priorities development. Many now-wealthy communities followed a similar path of intense land usage and environmental exploitation to achieve development (Adams, 2019). Therefore, why should EA and other rural communities in Sarawak not follow the same trajectory? This becomes interesting when considering the foreign investment required for JV plantations and the role of both foreign and domestic governments in driving this environmental degradation. Resultantly, this line is important for researchers to consider and would be an interesting focus for future research.

4.3.2 Effects on the Community

While diversifying their income, villagers adapt to changing environmental conditions. For example, the nearby river cannot be used for fishing anymore, due to the pollution. Therefore, these protein sources are bought at expensive prices at the market.

The additional income of JV rent is crucial, especially in the state of Sarawak, which has one of the highest poverty rates of rural population in Malaysia (Sanggin & Mersat, 2013). QRs mentioned increased and stable income as benefits of the W-JV, which is supported by infrastructural development and future job opportunities on the plantation. Over half of QRs earned less than 1000 RM last month, including the 200 RM rent. The World Bank (2023) reports the national poverty line of Malaysia being 2208 RM per month. In this study, over 50% of QRs fall below that line. The limitation in results is the choice of these income categories, as the poverty line was not accounted for. Because of this, further research is needed to understand how the community is impacted by poverty. Although a livelihood consists of more than purely income (Ellis, 2000), this study did not consider the social effects of diversification.

4.3.3 Expected Sustainability in the Future

Adding onto Ellis (2000) definition of livelihoods, a sustainable livelihood can cope with and mitigate shocks towards the different forms of capital (Scoones, 2015). This ensures that livelihoods are secured or enhanced in the future. A deprivation in natural capital is found with large-scale land acquisition (LSLA) and deforestation. This exposes households to vulnerability, which is explained by the 'enclosure of livelihood assets' by Oberlack et al. (2016). In this archetype, factors and processes in LSLA are analysed, leading to an enclosure of livelihood assets. The main facilitating factors in EA, identified through focus groups and photovoice, are government support for JV oil palms, villagers' visions for progressive development, and global demand for palm oil.

Simultaneously, compensation in the form of rent increases their financial capital and adds a stable income source for the next 60 years. Whether the fixed amount of income is enough now and also in the future remains unknown. Villagers envisioned their future with smallholder plantations (oil palm), developing tourism and educating their children, where further assets are required. As the W-JV affected people's livelihoods, the question is raised, how sustainable livelihoods dependent on oil palm are (see *Section 4.3.1*). Economically, although palm oil is yielding around 4100 RM/ton (Malaysian Palm Oil Council, 2024), villagers only receive a fraction. Socially, oil palm plantations can provide job opportunities, as experienced on TR's plantation. If the W-JV will provide job opportunities, as stated in the contract, remains unknown until this date. The socioeconomic costs of oil palm, including potential community conflicts, increased food insecurity, and exploitation by the companies (Sibhatu, 2023) are not yet visible in this community due to the recent start of the W-JV in 2021. In regards to oil palm, there are many negative environmental effects, mentioned in *Section 4.3.1*. Concludingly, the sustainability of their livelihoods is threatened, as the dependency on oil palm increases. Linking this to the fact that oil palms are promoted by the Malaysian government in smallholder and JV schemes and already cover 26% of Sarawak (Tang & Al Qahtani, 2020), the livelihood sustainability of communities in Sarawak is at risk.

4.4 How Land Use Change Affects Livelihood Diversification in Empelanjau Asal

To better understand the causes and impacts of livelihood diversification, this part zooms in on a strategy of livelihood diversification, the land use transition towards JV oil palm. *Figure 21* presents a causal chain, derived from the results (see *Section 3*), that characterises the land development specifically from community forest to JV oil palm. The colours in the figure represent important factors from each research question. Special focus is put on the main external influence of the government, as a lack of information about W-JV prohibited further examination.

This discussion provides an in-depth assessment of one of the newest and commonly used income streams in EA which fosters diversification. Land use transitions play a major role in livelihood diversification (Lahai et al., 2022). Therefore, this assessment enables a holistic understanding of livelihood diversification in EA. Policy decisions in Malaysia and worldwide led to the expansion of oil palm plantations. Global markets have greatly increased due to the United States's and European Union's (EU) renewable energy policies (Rulli et al., 2019). Whilst this study aimed to separate causes and effects, analysis, and discussion of results presented them as intertwined. This is demonstrated within *Figure 21* where many causal loops were identified. Initial chains showed many connections, but for ease of viewing only the most important linkages remain. Additional connections exist both within causes and effects as well as between them, stating once more the circularity within both this land use transition and the subsequent livelihood diversification. Furthermore, the interconnection between the causes and effects is dynamic, adding a further layer of complexity to this case study. Livelihood diversification is presented to cause LUC, which in return has an effect on land and livelihoods. Resultantly, strategies of livelihood diversification can be influenced by LUC, demonstrating the circularity between the two topics.

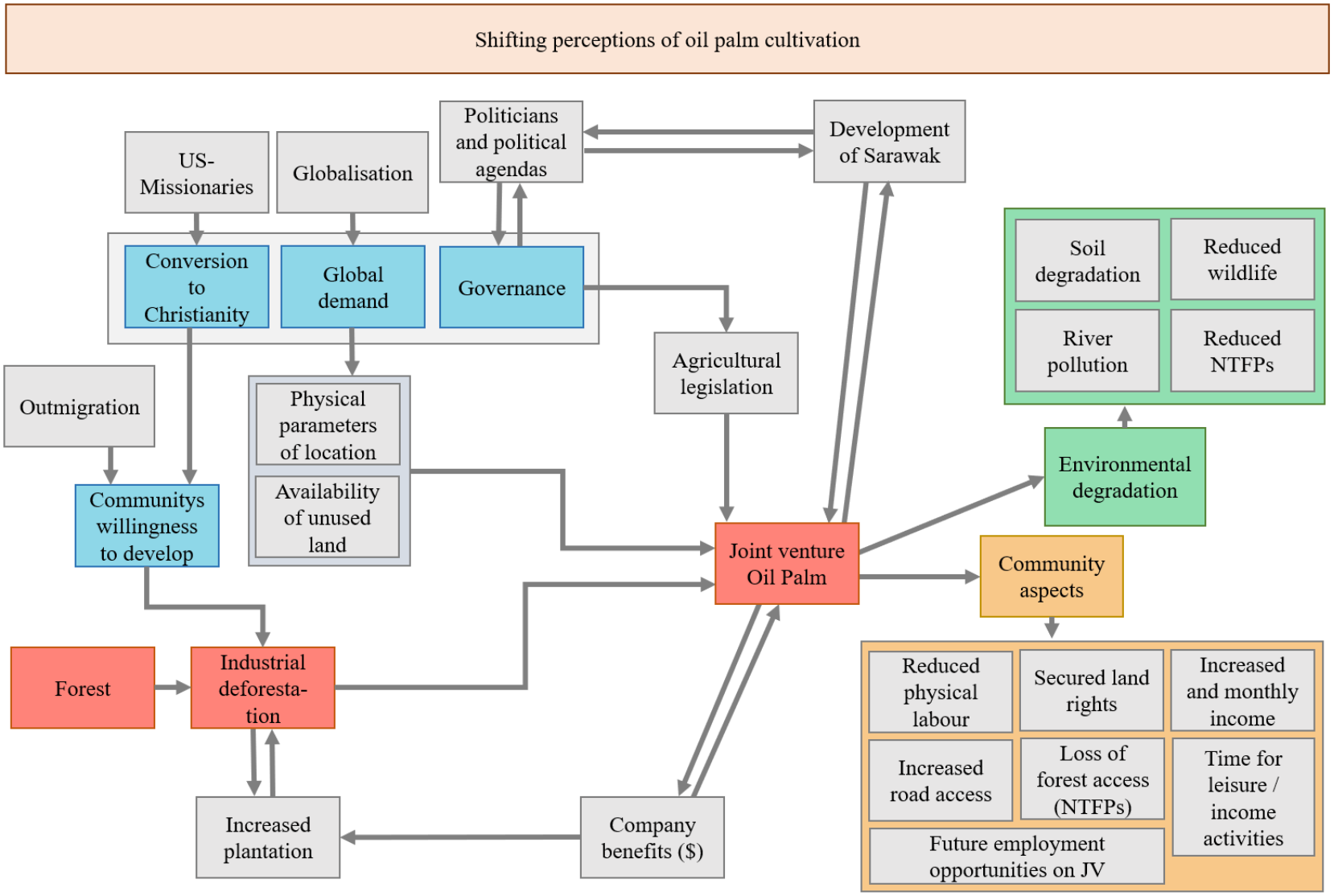

Figure 21: Presentation of the causal chain for the land use change in Empelanjau Asal from community forest to JV oil palm plantation, while red represents the main additional income to the diversification strategy (RQ1, red), the main reasons for livelihood diversification (RQ2, blue), and effects on the environment (RQ3.1, green) and on the community (RQ3.2) (Source: Own figure)

Decisions in Sarawak were made regarding the development of infrastructure and modernising agriculture. This led to the provision of land for commercial plantations, especially for oil palm (Cramb & Sujang, 2016). The authors mention that oil palms are planted on 70% of Sarawak's agricultural area and 80% of these plantations are leased to companies by contracts, a so-called LSLA. Additionally, the construction of mills, establishment of electrical infrastructure for mills, clearing of land, and planting of seedlings are supported (Schaffartzik & Kastner, 2019). The Malaysian corporate and governmental interest was to increase the world market share of palm oil export and therefore revenue generation (Yacob, 2018). These internal factors led to a significant increase in exports, starting in the late 1990s (Yacob, 2018). While exporting palm oil to the demanding markets, an income flow is generated. In 2019, the biggest purchasers of Malaysian palm oil products were India (23,9%), China (13,5%), and the EU (11,3%) (Kadir & Parveez, 2020). Although the EU is banning biodiesel containing palm oil from 2030, Indonesian exports will only decrease by 1% (Purnomo et al., 2020). Malaysia's exports may not be affected unless India or China adopts the same policy, as Malaysia and Indonesia share similar markets.

5 Conclusion

This study showed that the community in EA is diversifying their incomes. Important income sources captured in this study include W-JV rent, NTFPs, wage jobs, and smallholder agriculture. Both external and internal factors influence the diversification of livelihoods. The government and global demand are highlighted as the predominant external reasons for diversification and the conversion to Christianity. These externalities play a role in the promotion of the internal factors of the community's perceptions of land use and their willingness to diversify to increase incomes and develop to provide their children with a better future. The diversification of livelihoods has affected the environment and community in varying ways. The main LUC within livelihood diversification is the introduction of oil palm plantations, especially with the establishment of W-JV, which has caused significant environmental degradation. The community is positively impacted by the increase in income from the W-JV, but their reliance on palm oil is undetermined. The focus on JV oil palm helped to identify the causes and effects of development, presented through a causal chain (see *Figure 21*). However, the intertwined nature of the causes and effects demonstrates the complexity of this development and the requirement for a more holistic approach to understanding the process of livelihood diversification.

The case study of EA demonstrates that land use changes towards oil palm plantations seem to only favour economic benefits, without thinking further about environmental and socioeconomic effects. The villagers of EA are sacrificing a natural forest to participate in the global supply chain, further diversifying their income and earning an insignificant share of the exported product's value. While this study explored many effects of livelihood diversification through LUC e.g., economic security and multidimensional environmental degradation, additional socioeconomic and environmental effects may have been overlooked or are yet to occur. Therefore, it remains unknown how sustainable this transition is for EA and how changes in the global demand might affect their vulnerable, yet diversified, livelihoods.

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7 Appendix

- A. Focus Group Guide

Aim: local perceptions of change and RQ 1 “What caused the change to occur?”

Brief introduction (name, age, gender, primary occupation)

- What do you like about living in Empelanjau?
- What are your opinions on the land use change in Empelanjau?
- What kind of role do your Iban traditions play in the communities’ current land use?

- How has your life been impacted by the change? (source of income, occupation, health, education etc.)
- What aspects motivated the change? (ecological, political, cultural)
- Do you like the changes that have occurred?
- How do you envision your future?
- How do you think Empelanjau can increase their income in the future?
- What do you like about traditional crops?
- Do you feel like you are supported by the government? (corporate/authority)

Kids:

- What do you like about living in Empelajau Asal?
- Do you like living in Empelanjau or city?
- What do you want to be when you grow up?
- Do you want to have the same job as your parents?
- Do you like oil palm?

Appendix

- B. Photovoice Guide

Follow-up questions in semi-structured interview:

- First of all, can you please describe what can be seen in the picture?
- How do you feel about this picture?
- What elements of this image resonate with your vision of an ideal future?
- Do you think this representation of your ideal future can be translated into tangible aspects of your future livelihood? Is it realistic?
- What challenges/obstacles do you expect encountering in realizing this vision?
- In what ways do you believe your aspirations align with the aspirations of others in your community? Or the local government?
- What steps/actions do you believe are necessary to move closer to realizing your envisioned future?
- How do you see your community/the environment being impacted by the realization of your envisioned future?

Appendix

- C. Questionnaire

Study on Shifting in land use for oil palm plantation in Empelanjau Asal, Pantu, Sarawak	
Introduction: Greetings, residents of Empelanjau Asal, Pantu, Sarawak. We are a collaborative team of students from Universiti Malaysia, Sarawak, and the University of Copenhagen, Denmark. Our joint research project aims to study the shift in land use for oil palm plantations in your community. Your valuable insights will help us better understand the local dynamics and contribute to sustainable development. **Purpose:** We are conducting this study to explore the environmental, social, and economic impacts of the transition to oil palm cultivation. By participating, you contribute to the broader knowledge about land use changes and their implications on local communities. Thank you for your consideration, and we look forward to your valuable contributions to our research.	
Date:	Time:
Respondent Name:	Household:

SECTION A: DEMOGRAPHIC							
A1: Age:			A2: Gender:				
A3: Primary occupation:							
A4: Highest level of formal education:							
1. No education		2. Primary education		3. Secondary education		4. Tertiary education	
A5: Did you grow up in Empelanjau Asal? (YES / NO) If NO, how many years have you lived here:							
A6: How many people permanently live in your door?							
A7: Have any family members moved out of the village to live somewhere else within the last 20 years? (YES / NO) If YES, how many:							
A8: Are you a member of a joint venture company/smallholder? (YES / NO) If YES, Name of company venture/smallholder: How much land are you participating with (%):							

SECTION B: LAND USE (RESEARCH OBJECTIVE 1)			
B1: Are you using the land? (YES / NO) If YES, for what primary purpose?			
1. Agriculture		3. Housing	
2. Joint Venture/smallholder		4. Other, please specify:	
B2: If AGRICULTURE, what crops? (Multiple answers possible)			
1. Swamp rice		5. Pepper	
2. Hill rice		6. Oil palm	

1

3. Rubber		7. Rambutan	
4. Fruits orchard		8. Other, please specify:	

B3: If you commercialize, where do you primarily sell it?

1. Individually on market		3. Merchants come into the longhouse	
2. Through 3rd party/Headman		4. Other, please specify	

B4: Has your land usage changed compared to 20 years ago? (YES / NO)
If YES, How? (Select one answer)

1. Increased smallholder agriculture		5. Increased housing	
2. Decreased smallholder agriculture		6. Decreased housing	
3. Increased joint venture		7. Increased backyard garden	
4. Decreased joint venture		8. Decreased backyard garden	
9. Other, please specify:			

B5: What were the reasons for the change? (Multiple answers possible)

1. Environment		5. Household interest	
2. Land use/Resource constraints		6. Infrastructural projects	
3. Government schemes		7. Market trends	
4. Increased income		8. Migration	
9. Other, please specify:			

	1. Positive	2. Neutral	3. Negative
B6: If agriculture: How do you perceive your yield has changed over the last 20 years?			
B7: How do you perceive changes to soil conditions over the last 20 years?			

B8: What are the top 3 challenges you face with the land change? Please rank them from 1,2, 3.

1. Pests		4. Labour Input	
2. Commuting		5. Time Input (to grow, to harvest, etc.)	
3. Inputs (costs, transportation, etc.)		6. Other, please specify:	

B9: What are the top 3 benefits you experience from the land change? Please rank them from 1,2,3.

1. Increased Income		5. Social gain		
2. Stable employment		6. More free time		

3. Improved health		7. Infrastructure development		
4. Better education		8. Stable income		
9. Other, please specify:				

SECTION C: INCOME AND EXPENDITURE (RESEARCH OBJECTIVE 2)

C1: Last month income:

1. Below RM1000		2. RM1001 to RM3000		3. RM3001 to RM5000		4. RM5001 and above	

C2: Out of these categories, which three have been your highest sources of income in the past 12 months? Please rank them from the highest to the 3rd highest and put in numbers 1,2,3.

1. Farming crops/livestock (Bertanam/bertupik)		5. Construction (Kerja pembinaan/Pan Borneo)	
2. Forestry (perhutanan)		6. Households (Suri Rumah, cleaning, cooking, etc)	
3. Education services (e.g. teaching/mengaja)		7. Retired (Pesara Perintah/Kerajaan)	
4. Public service (e.g. firefighter, policeman)		8. Public administration (kerja perintah)	
9. Other, please specify:			

C3: Follow up for each categories above:

Income source (Write below)	Usage			Time	Compared to 20 years ago		
	For own use	Selling	Both own use & selling	Monthly or seasonal	Income increased	Decreased income	Stable
1.							
2.							
3.							

C4: Have you experienced a crisis or unforeseen events in regards to your income and if so, which? (Multiple answers possible)

1. Droughts		4. Death	
2. Floods		5. Migration	
3. Political reasons		6. Other, please specify:	

C5: Out of these categories, which three have been your highest expenditure now and 20 years ago? Please rank them from the highest to the 3rd highest.

	Now	20 y/o ago		Now	20 y/o ago
1. Food			6. Luxury items (Mobile phones/gadgets)		
2. Clothes			7. Household items/repairs		

3. Medicine/Health			8. Rents		
4. Education			9. Agriculture inputs		
5. Utility bills			10. Petrol (Vehicle)		
11. Other, please specify:					

SECTION D: FOREST RESOURCES (RESEARCH QUESTION 3)

D1: Do you use non-timber forest products (lauk kampung, buah, sayur ari babas/hutan)? (YES/NO)
If yes, state what type of food: fruit, vegetables, meat and fish:

D2: How important are the forest resources for your livelihood?

1.Very important		2. Important		3. Neutral		4. Less important		5. Not important at all	

D3: How often do you use the resources of the forest?

1. Daily		3. Once a week	
2. 2-3 times a week		4. Less than once a week	

SECTION E: FUTURE PERCEPTIONS (RESEARCH OBJECTIVE 4)

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
E1: My household will have enough food to eat in the next 10 years.					
E2: Oil palm plantations will help my community to develop in the next 10 years.					
E3: In the next 10 years, more people will leave Empelanjau Asal to move to cities.					
E4: The new airport (Bebuling airport) will improve livelihoods.					
E5: In the next 10 years, I will increase agricultural production.					
E6: In the next 10 years, I will start eco-tourism to support my livelihood.					

SECTION F: PERSONAL OPINIONS

F1: How important do you think oil palm plantations are for your current livelihood?

1.Very important		2. Important		3. Neutral		4. Less important		5. Not important at all	

F2: If you do not take part in the oil palm plantation, how likely is it that you will join in the future?

1. Extremely likely		2. Likely		3. Neutral		4. Unlikely		5. Extremely unlikely	

Statements	1. Strongly Agree	2. Agree	3. Neutral	4. Disagree	5. Strongly disagree

F3: The joint venture/palm oil plantation should cultivate more land in our area.					
F4: There is a need for conservation of wildlife and forest in our area.					
F5: I have sufficient access to education.					
F6: I have sufficient access to wage work opportunities.					
F7: I have sufficient access to infrastructure.					
F8: I have sufficient access to water resources.					
F9: I am satisfied with the quality of water in our village.					

F10: The operations of the palm oil companies have _____ the biodiversity in our area.

1. Increased		2. Decreased		3. No effect on	

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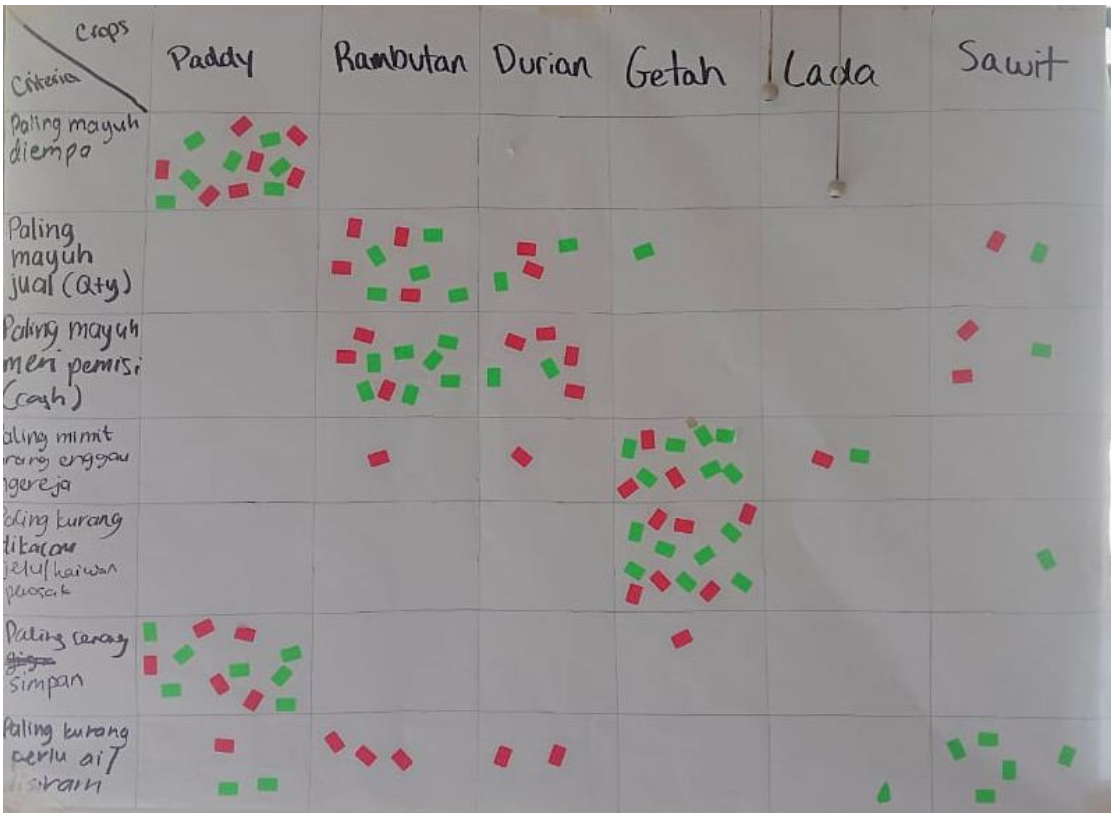
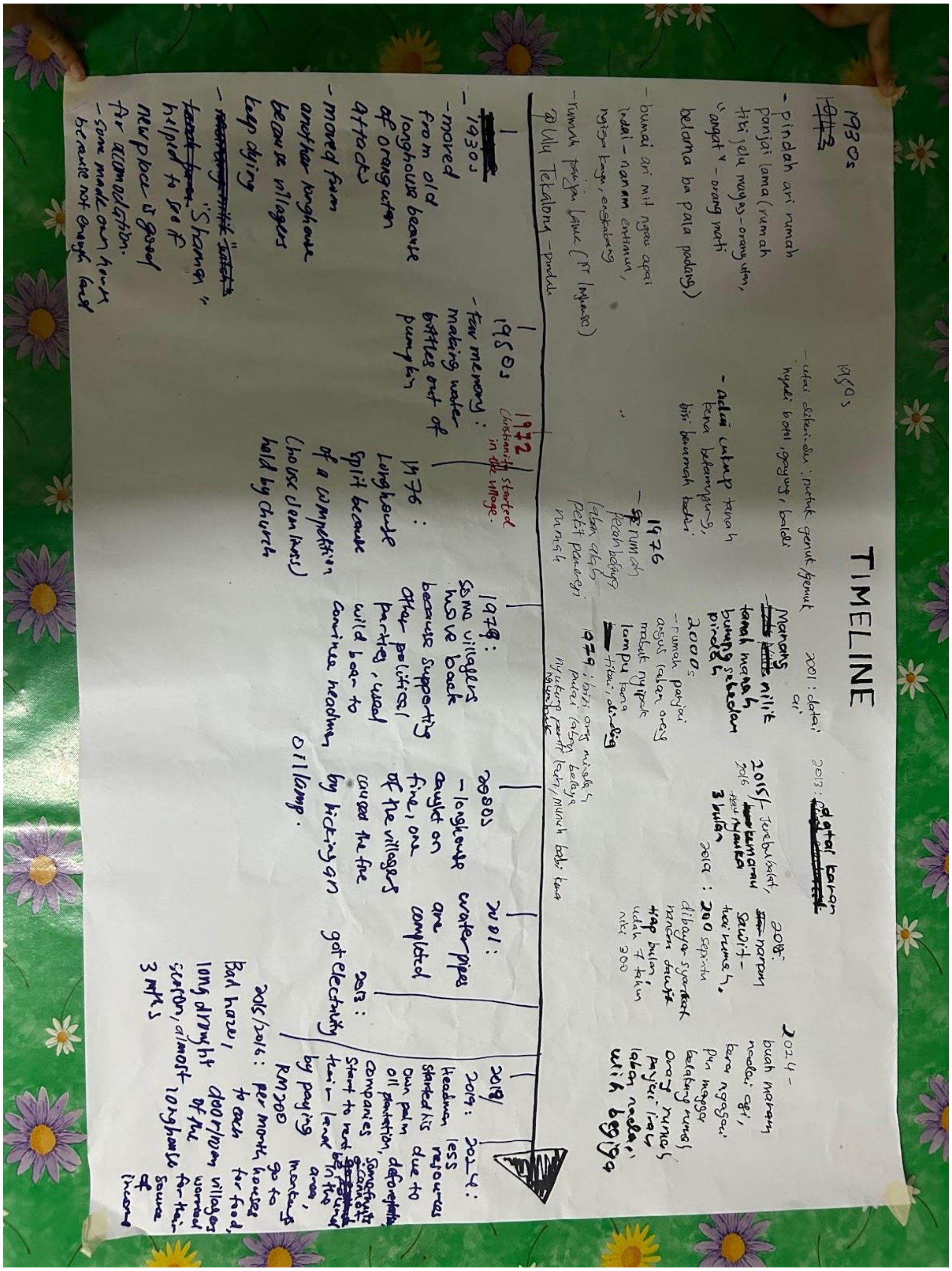
Appendix

- D. Ranking Exercise results



Appendix

- E. Timeline



Appendix

- F. Water sampling data

Physical parameters that were measured

- Temperature
- Pressure
- Dissolved oxygen (in %)
- Dissolved oxygen in mg/L
- Specific conductance
- Conductivity
- TDS
- Salinity
- pH value

Water Sample | Water Dam				
Parameter	**Measurement 1**	**Measurement 2**	**Measurement 3**	**Average**
Temperature (°C)	25.1	25.1	25.1	25.1
Pressure (mmHg)	767.7	767.7	767.8	767.73
Dissolved oxygen (in %)	71.7	65.2	68.4	68.43
Dissolved oxygen in mg/L	5.91	5.38	5.64	5.643
Specific conductance (uS/-cm)	92.4	93.6	94.1	93.366
Conductivity (uS/-cm)	0.093	0.094	0.094	0.0936
TDS (mg/L)	59.80	61.10	61.10	60.66
Salinity (ppt)	0.04	0.04	0.04	0.04
pH value	6.11	6.30	6.39	6.266

Water Sample | Before Oil Palm Plantation				
Parameter	**Measurement 1**	**Measurement 2**	**Measurement 3**	**Average**
Temperature (°C)	25.7	25.5	25.7	2563
Pressure (mmHg)	768.1	768.2	768.2	768.16
Dissolved oxygen (in %)	36.4	34.8	32.8	34.66
Dissolved oxygen in mg/L	2.97	2.84	2.68	2.83
Specific conductance (uS/-cm)	89.5	89.3	89.1	89.3
Conductivity (uS/-cm)	0.091	0.090	0.090	0.0903
TDS (mg/L)	57.85	57.85	57.85	57.85
Salinity (ppt)	0.04	0.04	0.04	0.04
pH value	5.95	6.20	6.38	6.176

Water Sample | After Oil Palm Plantation				
Parameter	**Measurement 1**	**Measurement 2**	**Measurement 3**	**Average**
Temperature (°C)	25.7	25.7	25.7	25.7
Pressure (mmHg)	767.9	768.0	767.9	767.93
Dissolved oxygen (in %)	37.1	34.2	32.3	34.53

Dissolved oxygen in mg/L	3.03	2.79	2.63	2.816
Specific conductance (uS/-cm)	95.8	95.2	91.0	94
Conductivity (uS/-cm)	0.097	0.096	0.092	0.095
TDS (mg/L)	62.40	61.75	59.15	61.1
Salinity (ppt)	0.04	0.04	0.04	0.04
pH value	6.67	6.70	6.75	6.706

Biological parameters

In situ measurements

- we counted the macroinvertebrates as bio-indicators which allowed us to access the stream quality, only identified by family name
- 3-5 students used nets to catch macroinvertebrates for 30 min
- Macroinvertebrates were identified with the help of a sheet "Assessment of Stream Quality Using Macroinvertebrates As Bio-indicators" that also scored their tolerance to pollution (ranging from 1 = tolerating poor water quality to 10 = tolerating to only high quality water)
- Limitations:
    - We were not trained/experienced with this activity, so we required more time to catch and identify the macroinvertebrates
    - The nets were not identic (different overall size and mesh size)
    - At sample location "before the oil palm", we could not enter the river because of the depth, crocodiles, snakes and there was high velocity
    - At sample location "after the oil palm", we could not enter the river because of the depth, crocodiles, snakes, high velocity and heavy rain
- The assessment allowed us to calculate the Biological Monitoring Working Party (BMWP) and the Malaysian Family Biotic Index (MFBI), both indexes indicate water quality
-

Calculation for BMWP – My

- Sum of tolerance score of different families identified

Calculation for MFBI

- (Sum of tolerance score x individuals found) / total no. of all individuals

Location	**Dam**	**Before palm oil plantation**
BMWP - My	57 (moderately good)	29 (fair)
MFBI	5.41 (good)	4.5 (good)
Shannon Index per family *	1.12	0.96

* Shannon Index also includes the fish families found, they are excluded for BMWP and MFBI

Interpretation:

- Usually both indexes show the same result (same category), however we were not that experienced so this explains why they differ (see other limitations)
- At the dam we found four level 6 species and one level 7 species (sensitivity)
- At the "before oil palm plantation" we found one level 7 species

Measurement of FCC (Fecal coliforms, blue e-coli bacteria colonies) and TCC (total coliforms, all bacteria colonies, also purple)

Procedure:

- 2 samples for each sampling location
- 2 pump bursts (1ml per burst) into the middle of the vacuum pump
- Vacuum pump presses water through filter, bacteria left on the filter
- Filter is put into a petri dish with agar agar, left in a dark place at room temperature and after 24 h FCC and TCC bacteria colonies can be counted
- Visual assessments colonies within the circle are counted, we take the average for the two samples
- Limitation: we tried to keep the study sterile however we sat on the floor in the longhouse with humans and cats around

Calculation for FCC:

FCC/100 ml = (No. of colonies/volume of sample) x 100

FCC/100 ml = (No. of colonies/2) x 100

Calculation for TCC:

TCC/100 ml = (No. of all colonies/volume of sample) x 100

TCC/100 ml = (No. of all colonies/2) x 100

Location	**Dam**	**Before palm oil plantation**	**After palm oil plantation**
FCC Sample 1 count	2	2	2
FCC Sample 2 “	4	3	3
TCC Sample 1 “	63	124	418,2
TCC Sample 2 “	40,4	173	(3)*

Location	**Dam**	**Before palm oil plantation**	**After palm oil plantation**
FCC value	150	125	125
FCC class in MWQI	Class II	Class II	Class II
TCC value	2585	7425	20910
TCC class in MWQI	Class II	Class III	Class III

* due to inconsistent and obviously faulty result, we cannot include it in the TCC value calculation

Chemical parameters

Reactive Phosphate and Nitrite testing

Procedure:

- Device: portable UV-vis spectrometer
- 10 ml per test tube, add with the reactant (solid), check for a change in colour
- Homogenize the solution and put it in the portable UV-vis spectrometer, the device has different modes for measuring different compounds
- Reaction time for phosphate is 2 min and for nitrite is 20 min
- Put the samples in and wait for the values

Phosphate and Nitrate values at the 3 different sampling locations in mg/L				
Location	**Control P**	**Actual P**	**Control N**	**Actual N**
Dam	0	0.34	0	0.008
Before palm oil plantation	0	0.21	0	0.000*

After palm oil plantation	0	0.11	0	0.001

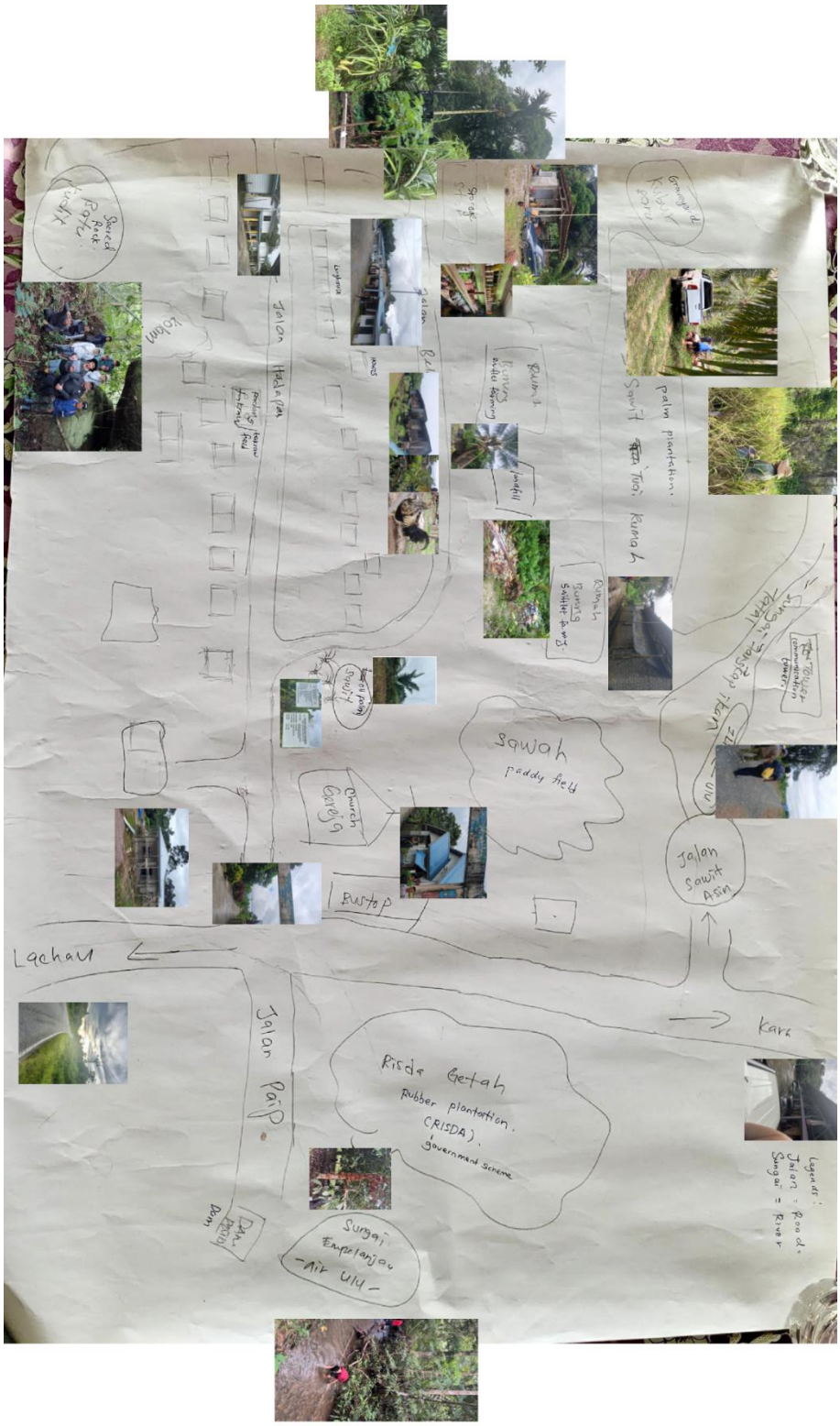
*value is very low because high velocity

National Water Quality Standard of Malaysia

- Can be calculated with the biological, chemical and physical water parameters
- Classes from 1-5 (1 is the best, 5 is the worst class)
- Limitation: we can only calculate the standard through the parameters that we measured, the ones we have are:
    - DO
    - pH
    - color
    - electrical conductivity
    - salinity (%)
    - TDS
    - Temperature
    - FCC
    - TCC

Appendix

- G. Resource Map



- H. Synopsis

Land Use Changes in Empelanjau Asal, Sarawak

Case study (4th-15th March 2024)

Course 5480-B3-3F24: Practising Interdisciplinary Field Research on the Environment

University of Copenhagen

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1 Introduction

Land systems are the terrestrial component of earth systems and encompass the activities and processes of human use of land additional to the socioecological impacts of land use (Müller et al., 2014). They are susceptible to change, with previous land system changes being among the most important drivers of global environmental change (Müller et al., 2014). The causes of these changes have often centred around the increase in demand for land-based products, diet changes, and shifts in the consumption of energy (Müller et al., 2014). He et al. (2022) recognise the Indo-Malaysian region as a hotspot of land cover and land use change since 1982 with the primary land transition being from forests to croplands. In Sarawak, a large proportion of this cropland is oil palm plantations, with the plantations increasing from 1.16 million hectares in 2013 to 1.62 million hectares in 2022 (Statista, 2023). Resultantly, Malaysia is a key study site for the research of land use change.

Oberlack et al. (2016) identify adverse livelihood outcomes that most commonly arise as the result of large-scale land acquisitions in the global south which cause significant land use changes. Ellis (2000) defines livelihoods as the assets, activities, and access that determine the living gained by an individual or household. This definition of livelihood is reflected within the three predominant outcomes of land acquisition-induced change which are identified as elite capture, selective marginalisation, and the polarisation of development discourses (Oberlack et al., 2016). These impacts highlight how land use changes resulting from land acquisitions can negatively impact local livelihoods. Therefore, it is crucial to understand the potential livelihood outcomes of land use changes in additional contexts. This is most effectively achieved through a causal analysis of land use change within a specific case study (Meyfroidt, 2016).

The field study will take place in Empelanjau Asal (Fig. 1), located approximately 60 km from Sri Aman town in Sarawak, Malaysia. There are 33 longhouse apartments. The majority of the inhabitants used to do rice cultivation but this practice is declining.

Figure 1. Empelanjau Asal longhouse settlement picture collected from Google Earth, 2024. N 1.138140° E 111.205817°

Appendix

Land use change has occurred in Sarawak, such as logging practices in the 1960s and oil palm plantations in the early 2000s (Ichikawa, 2007). The causes of change can vary greatly, stemming from social, economic, or political reasons. Socially, young populations are moving to urban areas, creating a lack of labour for crop cultivation (Field course information, N.d.), therefore causing a decline in agricultural land use. Economically, deforestation provides a profitable timber industry and clears land for other purposes, such as oil palm plantations. Politically, the government sponsors programs that commercialise the land by leasing to joint venture palm oil companies, which can cause a land use shift from local practices (Ngidang, 2003).

Indigenous communities, similar to Empelanjau Asal, are largely dependent on the land for their livelihoods, but it is not the sole source of income. Many individuals receive wages from jobs in oil palm plantations, logging companies, government sectors, or construction sites as their primary source of income (Modin et al., 2023). Households rely on the collection and sale of non-timber forest products and handicrafts to supplement agricultural practices or employment wages for their livelihoods (Modin et al., 2023). In Empelanjau Asal, rice cultivation was a major cash crop, but today there are no more than a handful of houses cultivating rice (Field course information, N.d.). This decline means a decrease in income from rice, which must be supplemented by another source.

Indigenous communities depend heavily on forest products (Modin et al., 2023). Collected products include, but are not limited to, resin, medicinal plants, rattan, honey, wild fruits and vegetables, wild animals, and timber (Sakai et al., 2016), indicating a wide biodiversity available in forested areas. A change in land use, especially a decline in forested areas, leads to a change in forest product availability and dependability.

The trend in land use change in Empelanjau Asal might be similar to other Iban communities in Sarawak (Ngidang, 2003; Mertz et al., 2013). However, the community's perceptions of the land use changes impacts on their livelihoods and the local environment may vary due to the uncertainty of the long-term effects. For example, land use changes from local practices to oil palm plantations had negative impacts on communities in Borneo by reducing land availability for farming/forest resources use (Mertz et al., 2008). Additionally, individual farmers were often left with little choice other than joining because of internal pressure in communities (Mertz et al., 2008). The local community might be sceptical about the shift in land use to start (Sanggin & Mersat, 2013), but saw improved livelihood and socioeconomic conditions (Modin et al., 2023).

Therefore, to determine the impacts on the livelihood of the Empelanjau Asal community and their perceived future, our overall objective and research question to answer is: How is the Emplanjau Asal community affected by the shift in land use from local practices to oil palm plantations?

First, the cause of land use change and its effects on the community need to be identified. Furthermore, local multi-facetted perceptions of this change will be determined. Our study

focuses on the Iban's economic and social situation as well as their food security, including the usage of available forest resources. In this project, aligning with Ellis' (2000) Sustainable Livelihoods Framework, livelihoods are understood as the assets, activities, and access that determine the living gained by an individual or household. Additionally, their perceptions of the future about the change in the area will be captured. Therefore, our research questions, while considering the potential limitations of our study (Appendix 7), are:

- What caused the land use change to occur? (RQ 1)
- How has land use change impacted the livelihoods of households, culturally and economically? (RQ 2)
- How has the land use change impacted the local usage of non-timber forest products? (RQ 3)
- How does the community envision its future livelihoods due to the current land use change? (RQ 4)

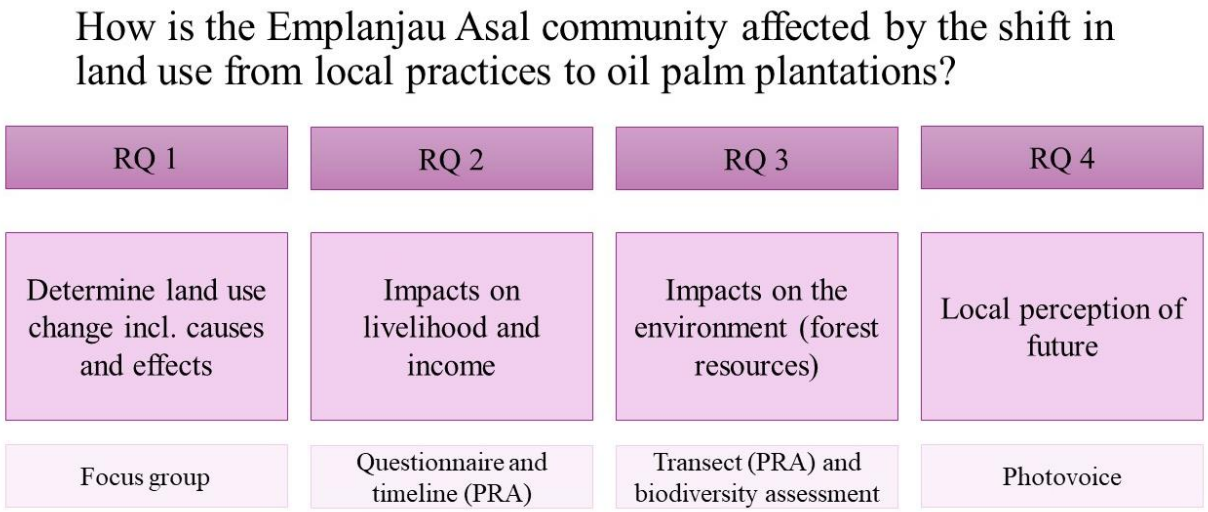

Figure 1. Overview of research goal and research questions with primary methods (own figure)

2 Methodology

The study design is an interdisciplinary case study. We aim to cover natural and social science methods to collect qualitative and quantitative data. This mixed methods approach will be useful in answering our research questions as the problem at hand is inherently interdisciplinary. Mirroring Oberlack et al. 's (2016) use of Ellis' (2000) Sustainable Livelihoods Framework to identify the diverse impacts on livelihoods caused by land use changes, we plan to integrate the same framework within our analysis. The planned primary methods for each research question are summarised in a research matrix (Appendix 1). To

bridge the differences between methods, results will be triangulated to enable a holistic understanding. The structure of the intended fieldwork can be found in Appendix 8.

2.1 Qualitative research

2.1.1 Focus Groups

Focus groups are an approach for multidisciplinary studies, which can help identify key factors in land use (Scott, 2011). Focus groups are group interviews where individuals' statements are analysed as well as the dynamic between participants. Seeing how people justify their opinions shows emotion and provides complementary and comparative data to triangulate with the collected empirical data and theoretical knowledge (Scott, 2011). In this qualitative approach, social structures and subjective beliefs are analysed in a natural setting (Brockington & Sullivan, 2003). Besides the participants, a moderator poses the questions and opens the discussion (Brockington & Sullivan, 2003).

In this study, small focus groups are used to analyse the history of local land use change (Appendix 1). Through the discussion, the different drivers and causes, and the effects on people's livelihoods, will be identified. Furthermore, when assessing the amount of discussion over certain aspects and the number of people agreeing on one factor, the dimension and certainty of each factor will be determined. Minor and more uncertain factors (drivers) will become visible. Asking open-ended questions (Appendix 2) will provide data that also answers other research questions. By conducting two separate focus groups, the different results can be triangulated and support the arguments made.

2.1.2 Participatory Rural Appraisal (PRA)

Participatory Rural Appraisal (PRA) is a qualitative research method that takes a bottom-up approach through the active participation of the community in the research process (Narayanasamy, 2009). PRA emphasises community participation enabling local opinions and knowledge to be more accurately identified. This co-creation of knowledge assists the decolonisation of research through the reduction of researcher input and the promotion of grassroots development (Selener et al., 1999). Within our study, this is particularly relevant due to our privileged, Western backgrounds as researchers. PRA is typically accompanied by a semi-structured interview to allow the researcher to learn from the participants (Narayanasamy, 2009). Additionally, PRA empowers the marginalised by allowing the participants to discuss and analyse their situation (Narayanasamy, 2009).

a) **Timeline**
   Our research will use PRA through the creation of timelines (Appendix 1); an example of participatory diagramming (Mikkelson, 2005). The visuality of a timeline allows community members to participate more effectively (Selener et al., 1999). Through purposive sampling, ten participants will be selected based on their lived experiences within the local community. The timeline aims to gather a life history of the participants'

livelihoods and their experiences because of land use changes over the past twenty years (Appendix 3). This research method aims to gain a greater understanding of the causal effects, as well as local perceptions, of the land use change.

b) Transect Walk

A transect walk can be understood as a visual cross-section of a specific environment that reveals the various microenvironments within the studied area (McArthur, 2006). In our research we aim to complete transect walks across various land use types, visually mapping the transect through GPS points. Community members will guide the walk and explain the history, uses, and products of respective sections (Appendix 1). Additionally, guides will be asked about the importance of these products for their livelihoods with the aid of a Likert scale, a rating scale to measure opinions (Kallus, 2016), which will in this case range from very unimportant to very important (Appendix 4). The aim of these transect walks is twofold. Firstly, to gain further insights into how land use transition has impacted community members and secondly, to identify two suitable sampling sites for conducting a biodiversity assessment.

2.1.3 Photovoice

Photovoice, introduced by Wang and Burris (1997), is a visual participatory research approach wherein participants collaborate as co-researchers to define the research aim and purpose while reducing power imbalances between them. The method utilises images taken by the participants to pinpoint significant community issues and analyse the social and political dynamics within (Wang and Burris, 1997). Participants have complete authority over the selection of photographs, highlighting their respective expertise through shared stories (Pearce et al., 2017).

Using photovoice in the Empelnanjau Asal community offers an inclusive approach to gaining insights into community dynamics and the nuanced perspectives of members on land use transition that we as students from Denmark, might overlook (Appendix 1). More specifically, six individuals, based on convenience sampling, are empowered to share their wishes and expectations for the future about their livelihoods and express their feelings about it (Appendix 5). This will allow for a richer understanding of the community's collective experiences with land use change.

2.1.4 Participatory Observation

Participant observation is a valuable method to gain a deeper understanding of a community and its livelihoods (DeWalt & DeWalt, 2011). This ethnographic method will enable informal and more personal interactions to be documented through the constant writing of field notes. While other methods have a more specific research focus, participant observation can help to fill any gaps and can provide a background understanding of the subject area (DeWalt & DeWalt, 2011). Participant observation will be particularly useful for our study as we will be fully immersed in the Empelanjau Asal community and therefore will be constantly surrounded by the environment we are researching.

2.2 Quantitative Research

2.2.1 Quantitative Survey

In interdisciplinary research settings, questionnaires are essential tools for gathering structured data from a large(r) participant pool. Administered through online platforms or traditional paper formats, this primarily aims to collect quantitative data. Consequently, the formulation of questionnaire aspects necessitates careful consideration. A series of unbiased and well-structured questions are used to analyse predetermined variables and factors (Porst, 2014). An effective questionnaire is clear and understandable, gives a holistic view of the topic, and is acceptable to answer, considering privacy and ethical issues. The posed questions are simple, straightforward, unbiased, neutral, and not double-barreled (Rea & Parker, 2005). When designing the questions, the scale for the answers is considered for later analysis (Mattisek et al., 2013).

For this study, digital questionnaires are used to define the income streams of households and their diversification to determine livelihoods (Appendix 6). For the subsequent quantitative analysis through Excel and PSPP, a significant difference may be found between answers among different age groups or genders. As the preliminary research village has only 33 households, this study aims for a convenience sample, trying to reach as many households as possible. Additionally, questions about causes and drivers (RQ1), usage of local forest products (RQ3), and their future aspirations (RQ4) will be asked. The obtained quantitative data will be triangulated with the more qualitative data from each research question (Appendix 1).

2.2.2 Biodiversity Assessment

On the transect walk, two suitable sampling sites for a biodiversity assessment will be identified. A biodiversity assessment systematically evaluates the variety and abundance of living organisms within a specific ecosystem (Hill et al., 2022). We will conduct two separate biodiversity assessments at the predefined sampling sites. This will allow us to evaluate how changes in land use influence the availability and abundance of forest species in Empelnanjau Asal. Specifically, the Shannon Index for tree species will be calculated, considering both species richness and species evenness. Calculating the Shannon Index for both sampling sites allows for a comparison of index values and enables us to identify which area exhibits higher diversity levels and might consequently be a better source of forest-derived products (Appendix 1). Furthermore, this assessment would provide critical insights into how land use transition influences the availability of forest products and the role they play in local livelihoods (Hill et al., 2022).

2.3 Planned Collaboration with the Malaysian Counterparts

We have initiated first contact with our Malaysian counterparts through an email and are excited to discuss our projects further. When in Empelanjau Asal, we hope to have daily morning meetings with the group to plan the day and address any queries. We also hope to

have short de-briefs at the end of each day to keep everyone up to date. We plan to share all notes and results to ensure an open relationship with the group so we can all get the most out of the experience as possible.

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4. Appendix

1. Research Matrix

Overall Research Question: How is the Emplanjau Asal community affected by the shift in land use from local practices to oil palm plantations?							
Hypothesis	Method	Tools/materials	Input Data/Data requi	Sampling Strategy	Outputs/Variables	Analysis	Assumptions
	Key informant interview (informal) with resource mapping (non-timber forest products)	Paper and pen (Map), individual notebook		Headman Freddy	Gain a baseline understanding of the community, their main interests and the main resources used	Initial information that informs our methods	
	Participant Observation	Individual notebooks and pens			Any additional interesting or useful information we gather whilst staying in Empelanjau	Results triangulated with other main methods	
Research Q1: What caused the land use change to occur?							
	Focus group	Prepared questions, recording device, pens, paper	Data on reasons for the land use change	Simple random sampling with adults, sample size: 5 participants per group, two groups divided by gender		Qualitative content analysis using Nvivo - thematic analysis	Participant's willingness to take part in the focus group; Participants answer truthfully and accurately; Interactions between participants is helpful
Land use change is caused by globalization (telecoupling), foreign investment, lack of labour/youth moving to urban areas.	Literature review of the last 20 years	Scholarly articles	Data on reasons for the land use change	Purposive sampling of relevant papers	Causal chain (visualisation format)	Qualitative content analysis; Triangulation of results with focus groups	Availability of relevant literature
Research Q2: How has the land use change impacted the livelihoods and income streams of households?							
	Surveys	Prepared questions, tablets	Overview of current households income sources	Convenience sampling: as many participants as possible (one per hh, can they be seperated?)	Contributing to causal chain with causes, effects, and future perceptions; information on income streams	Quantitative analysis (Simpson's Diversity Index, Gini Coefficient); descriptive statistics	Peoples willingness to participate in the survey; All answers are truthful
Livelihoods have become more diversified since the shift from traditional practices to palm oil plantations; Percentage of wage work from total income increased since the shift	PRA (Timeline)	Prepared instructions, recording device, pens, paper	Life history of livelihoods and changes over time (within the agreed upon timeframe - last 20 years)	Purposive: Elderly people who have experienced the shift from small-scale agriculture to large-scale agriculture and palm oil plantations, sample size 10	Causal effects and perceptions of the land use change by the local community; Timeline for PRA	Qualitative content analysis using Nvivo - thematic analysis; Across-method trianguation of results with surveys	Individuals willingness to particpant; individuals will provide truthful information
Research Q3: How has the land use change impacted the local usage of forest products?							
The land use change decreased local usage of forest products.	PRA (Transect walks)	Prepared instructions, GPS device, prepared questions, local expert	Information on how land is used/has been used in the past 20 years and what products are derived from it	4 transect walks - forest rim - close/ in oil palm plantation - fallow land - fruit orchard	List of non-timber and timber forest products, an understanding of how the land use transition has changed available products	Qualitative content analysis; using descriptive statistics for Likert scale of importance	Participants are truthful with their answers and dependent on forest products to some degree
There is a significant difference in biodiversity when comaring primary forest with a fallow area.	Forest biodiversity assessment	Measuring tapes, laser for measuring tree heights, pens, paper	Tree data for diameter, height, and species	Two areas of X size, one an older, intact forest and one a fallow area	Biodiversity index of tree species	Shannon-Index	There is access to an intact primary forest and a fallow land
Research Q4: How does the community perceive its future livelihoods due to the current land use change?							
The community believes that land use change will bring more infrastructure and development to the region.	Photovoice	Cameras, instructions, prepared questions	Information about wishes for the future and expectations for the future in regard to their livelihoods	Convenience Sampling, sample size: 6 (5 pictures per person)	An understanding of perception through photographs	Visual analysis of pictures; Qualitative content analysis of interviews using Nvivo - thematic analysis	Individuals willingness to participate

2. Focus Group Guide

Aim: Local perceptions of change and RQ 1 “What caused the land use change to occur?”

Introduction (to us and method specific) - who we are and why we want to do this

- Brief introduction from participants (name, age, gender, primary occupation)
- How do you use the land in your community? For what reasons do you use that land this way?
- How did you use the land 20 years ago?
- Follow up why?
  → Why has there been a change in land use? (what happened)
  → How were you involved in the change? Who else was involved? (external actors)
- How has your life been impacted by the change?
- Have there been changes in your sources of income/your occupation(s), if so which? What aspects motivated that change? → ecologic, political, cultural,...
- Do you like the changes that have occurred? (please give a reason)
- How do you envision your future?

3. PRA (timeline) Guide

Aim: Important events + RQ 2 “How has the land use change impacted the livelihoods and income streams of households?”

- Instructions including who we are and why we want to do this
- Impacts (every participant does her/his own timeline, we don't have a fixed starting point)
Introduction (to us and method specific)

- What is your earliest childhood memory in the community?
- Since when are you living in the village?
- What is your favourite memory of using the land?
- Which has been the best year in terms of yield?
- Which has been the worst year in terms of yield?
- How do you perceive the relationship between historical events and changes in livelihoods?
- Can you share any anecdotes or stories from your family or community about how livelihoods were pursued in the past?
- What role have environmental (political, financial, materialistic, etc.) factors played in shaping the historical development of livelihoods in your region?
- Can you give us information on the development of infrastructure in the village (we want to add this to the timeline: road, 1st car, 1st motorcycle, 1st smartphone, 1st TV, wifi, washing machine, electricity)
- Based on your understanding, what were the most significant challenges or obstacles faced by individuals or communities concerning LUC?

[more informal conversation, for each identified timestamp: why they chose this and how it affected them i.e. positive or negative]

4. Transect Walk

Aim: RQ 3 “How has the land use change impacted the local usage of forest products?”

Participatory method, see local use of products (Qualitative information)

- Go with local people, who explain the different species, that they are using
- Should be predominantly led by participants (participatory method)
- How is the surrounding land being used? Has this changed from previous uses? Why? What is the significance of certain aspects of the land? (specific plants, animals, paths, areas, etc)
- Follow-up in a kind of **questionnaire** (name of species, picture, Lickert scale of importance, For what purpose are you using each forest resource? [construction, handicraft, commercial (selling), food, medicine]
- How do you use…, did it increase/decrease?
- Collect quantitative information on that

5. Photovoice Guide

Aim: RQ 4 “How does the community perceive its future livelihoods due to the current land use change?”

Beforehand:

- Selection of participants
- Instructions about the procedure and taking pictures; what is the purpose and what should they take pictures of

Participants are asked to take five pictures symbolising their ideal future livelihoods, participants can express their hopes and dreams for the future, portraying their desired lifestyle

Follow-up questions in a semi-structured interview:

- First of all, can you please describe what can be seen in the picture?
- How do you feel about this picture?
- How does it show your future?
- How will you achieve this future?
- DO you think others in Empelanjau share this wish?
- How do you see your community/the environment being impacted in your future?

6. Questionnaire

Aim: overall quantitative information about each research question, in particular aiming to answer RQ 2 “How has the land use change impacted the livelihoods and income streams of households?”, Variables: Income sources (RQ 2), Expenditures (RQ 2), Use of land (RQ 1-2), Advantages and disadvantages of current land use (RQ 1-2), Forest products (RQ 3), Opinions of oil palm plantations in their area (RQ 1, 2, 4), Future perceptions on livelihoods (RQ 2, 4)

- **Introduction** about who we are and why we want to do this

Demographics:

- How old are you?
- What is your gender? [male, female, prefer not to answer]
- What is your primary occupation? [work for palm oil plantation, agriculture, non-agriculture, other]
- What is your highest level of formal education? [options tbc]
- Did you grow up in Empelanjau Asal? [y/n]
- Have any family members migrated within the last 20 years? [y/n how many]

Land USE (RQ1)

- Are you taking part in activities that use the environment (e.g., the ground/soil, trees) [y/n]
    - If yes: What activities [MULTIPLE agriculture for own use, agriculture to sell, working or external oil palm companies, housing, other]
    - If agriculture: What crops? [MULTIPLE: swamp rice, hill rice, rubber, pepper, fruits, oil palm, other]
    - If agriculture: Has the quantity of agricultural products changed over the last 20 years? [likert scale increase-decrease]
    - If agriculture: Has the quality of agricultural products changed over the last 20 years? [likert scale increase-decrease]
    - If you sell products to a market, where do you sell them?:[MULTIPLE: individual traveling to market to sell, headman, and people coming into the longhouse to buy products]
- Is your current or previous land being used by an oil palm plantation company? [MULTIPLE: Yes leasing, yes sold, no]
- Have your activities that use the environment changed compared to 20 years ago? [y/n]
    - How? [MULTIPLE increased agriculture for own use, decreased agriculture for own use, increased/decreased oil palm production by an external company, increased/decreased housing, other: please specify, backyard garden]
- What were the reasons for the change? [MULTIPLE: Environment, lack of resources (e.g., water, food, timber), Government laws/programs, Increased income, Household wants, projects with roads and buildings, etc, market trends, migration, …]

- How do you perceive changes to soil qualities over the last 20 years in the community? [Likert scale (positive to negative)]
- How do you perceive the availability and amount of plant and animal species in the natural/primary forest over the last 20 years? [lickert scale (increase to decrease)]
- What are the top 3 challenges you face with current activities on your land? [Pests, oil palm plantation presence, dangerous working conditions, getting to and from the field, inputs (costs of fertilizers, transportation, etc.), lack of workers, lack of time (to grow, to harvest, etc.), not enough income, migration]
- What are the top 3 benefits you experience with current activities on your land? [increased income, stable employment, improved health, better education, social benefits, food source]

FOREST RESOURCES (aim for RQ3) - finalize answers when there, are 10 most common species for example

- Do you use forest products (lauk kampung ari babas)? [y/n]
- If yes: type of fruits and vegetables (tbc.): daun salbung, Bamboo Shoot, Kemiding, Paku ikan / paku keru (fern), Buah Binjai, other:
- What types of trees are you using? [MULTIPLE: Nyelutung, Keruntum, Geruggang, Merebung, Engkabang, Rotan (Rattan), Others]
- How important are the forest resources for your life? [lickert scale of importance]
- How often do you use the resources of the forest? [MULTIPLE: daily, 2-3 times a week, once a week, less than once a week]

Income (RQ 2):
In the following, could you please tell us about your income in the last month?

- How much did you make in the following income sources (past month, for own use, selling or both) → the amount/category of income is still to be determined
    - Crops/livestock (Bertanam/bertupik)
    - Forestry (perhutanan)
    - Education services (e.g. teaching/mengaja)
    - Government jobs (e.g. firefighter, policeman)
    - Public administration (kerja perintah)
    - Construction (Kerja pembinaan/Pan Borneo)
    - Households (Suri Rumah, cleaning, cooking, etc)
    - Retired (Pesara Perintah/Kerajaan)
    - Income from non-forest products
    - Other non-farming sources (private companies, manufacturing, NGOs, etc). Please specify

- follow-up for each category: [for own use, selling or both]
- follow-up for each category: [Compared to 20 years ago: income increased, decreased, stable]

- Do you remember any unexpected events that affected your income and if so which ones? [MULTIPLE: droughts, floods, political reasons, death, migration, other]

EXPENDITURES (RQ 2)

- On what three things do you spend the most money on today?
    1. (highest expenditure)
    2. (2nd highest)
    3. (3rd highest)
- On what three things did you spend the most money on 20 years ago?
    1.
    2.
    3.
- Options: Food, clothes, medicine and health care, education, items/tools for agriculture including fertilizer/pesticides, luxury items (mobile devices), transportation (car, petrol, public transportation), household items and repairs on house, rent, bills, other

PERSONAL OPINIONS (all RQ, more sensitive information)

- How important do you think oil palm plantations are for your current life? [Likert scale of importance]
- If you do not take part in the oil palm plantation, how likely is it that you will join in the future? [Likert scale of likelihood]
- Likert scale: agreement
  The palm oil plantation should get bigger and use more land in our area.
  There is a need to protect wildlife and forests in our area.
  I have enough access to education.
  I have enough access to wage work opportunities.
  I have enough access to roads, electricity, equipment, buildings, etc.
- The oil palm plantations have _____ the availability and amount of animals and plants in our area. [MULTIPLE: increased/decreased/no effect on]

FUTURE PERCEPTIONS (RQ 4)

- Likert scale: agreement
    - My household will have enough food to eat in the next 10 years.
    - I will still live in Empelanjau Asal in the next 10 years.
    - Big oil palm plantations in our area will help our community to develop in the next 10 years.
    - My main source of income will remain the same for the next 10 years.
    - In the next 10 years, more people will leave Empelanjau Asal to move to cities.

7. Limitations

There are a variety of uncertainties that could arise as we begin fieldwork. We expect these limitations and challenges to occur and plan to deal with them accordingly in the field. These factors may require us to add, remove, or change what methods we use and when we do them:

Local conditions	We might discover during our time on-site that certain aspects of our research might not be feasible due to local conditions. Therefore, it is essential for us to remain adaptable and be open to revising our research focus as needed. Moreover, it might rain on some days, so we need to assume that we may have to adjust our schedule accordingly, for instance the transect walks - it would be ideal to be dry so we can discuss everything calmly.
Cooperation with Malaysian counterparts	Our Malaysian counterparty might want to focus on a different research topic and might also carry out differing methods. Hence, it is crucial that we collaborate effectively as a team in the initial days of the fieldwork and integrate our approaches.
Cultural differences	Managing cultural differences might be a challenge that could occur during this field trip, given our diverse cultural backgrounds. Therefore, maintaining patience and discussing various viewpoints is important.
Language barriers	With numerous languages involved, there is a risk of misunderstanding within our own group but also with our Malaysian counterparts and the Iban community members. Consequently, it is important to have an open approach to communication. Moreover, for the interviews, it is imperative that we provide comprehensive briefings to interpreters and emphasise the importance of seeking clarification if anyone is uncertain about the intended meaning.
Time constraints	We intend to employ a wide range of different methods, but due to time constraints, we may not be able to implement all of them. Therefore, it is crucial that we prioritise the methods most pertinent to our research objectives.
Participant availability, willingness, and honesty	Participant availability might influence the size and diversity of our samples, potentially limiting the generalizability of our study. For example, younger community members could potentially be underrepresented in our study as many of them have relocated to urban areas due to career opportunities.

8. Proposed timeline of methods

Date	**Activity**	**Who?**
4/03	- Arrive in PM and settle in	All
5/03	- Revising fieldwork proposal with Malaysian counterparts - Initial conversations with community leaders (resource mapping) - Re-evaluate time plan	All
6/03	- Revising fieldwork proposal with Malaysian counterparts - Initial conversations with community leaders - Try conversations, revise methods/questions we are unsure of - Method testing (Questionnaire, Interview, focus group?)	All
7/03	- Fieldwork proposal presentation for community and teachers	All
8/03	- Photovoice intro - Questionnaires (continuous, if we have time) - Transect walks	In groups
9/03 - Saturday	- Focus group - Interviews for Photovoice - Questionnaires (continuous in evenings)	All
10/03 - Sunday	- PRA + interviews	In groups
11/03	- Biodiversity assessments	All
12/03	**Wrap up everything / check methods and finish everything**	All
13/03	**Wrap up everything / check methods and finish everything** - Presentation preparation	All
14/03	- Presentation of research at Pantu District Office's hall - Wrap-up and farewell in PM	All

Appendix

- I. Contribution of authors

Section	Primary Author(s)	Editing Authors
1. Introduction	Marie	Sophie Chiara Jessica
2.1 Biodiversity	Marie	All
2.2 Focus Groups	Ayesha	All
2.3 Informal Interview	Sophie	All
2.4 PRA	Jessica	All
2.5 Photovoice	Sophie	All
2.6 Questionnaire	Chiara	All
2.7 Ranking Exercise	Ayesha	All
2.8 Soil Sampling	Marie	All
2.9 Water Sampling	Chiara	All
2.10 Analysis	All	All
2.11 Limitations (paragraph) (Table)	 Chiara and Sophie Marie and Jessica	
3.1 Results on the Composition of the Livelihood Diversification Strategy	All	Sophie
3.2 Presentation of Reasons for the current Livelihood Diversification	All	
3.3 Results on the Main Effects of Diversification on the Environment and the Community, Now and in the Future	All	Chiara Jessica
4.1 Livelihood Diversification in Empelanjau Asal	Sophie	
4.2 Reasons for Livelihood Diversification	Ayesha Jessica Chiara Marie	

4.3.1 Effects on the Environment	Jessica	
4.3.2 Effects on the Community	Chiara	
4.3.3 Expected Sustainability in the Future	Chiara	
4.4 How Land Use Change Affects Livelihood Diversification in Empelanjau Asal	Chiara	
5. Conclusion	Jessica Chiara Sophie	

Authors declaration

Hereby, we confirm that this report has been our own work.

Copenhagen, the 5th of April 2024

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