Practicing Interdisciplinary Field Research on the Environment

2025

Assessment of livelihood strategies from before 2019 and in 2025, natural resource management and investigation of future assisted agriculture development in Temong Mura, Malaysia.

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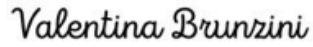

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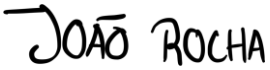

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Abstract

This study investigates changes in rural livelihood strategies, natural resource use and perceptions of agricultural development in the Bidayuh village of Temong Mura, Sarawak, Malaysia, by comparing conditions before 2019 and in 2025. The objective was to assess if the community has changed regarding their livelihood strategies in response to the impact of the COVID-19 pandemic. A mixed-methods approach was used, combining household surveys, focus groups, semi-structured interviews, participatory mapping and environmental assessments, including soil and water sampling. Findings show that while traditional agricultural activities such as rice and pepper cultivation remain, there is a visible shift among younger villagers toward wage labour and non-agricultural income sources. Forest resources continue to be important, though commercial use has declined, particularly among youth. Soil samples revealed consistently low-quality levels across all land uses, suggesting baseline environmental limitations rather than degradation. Water quality was generally good. Overall, the study highlights a gradual transition in livelihood strategies, shaped by generational shifts and economic diversification. Future development initiatives should prioritize culturally sensitive, community-informed approaches that address both environmental constraints and emerging livelihood aspirations.

Keywords: Rural livelihoods, livelihood strategies, assisted agricultural development, land use change

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However, our deepest gratitude goes to the Temong Mura community for their residents' hospitality and kindness. Being welcomed so openly and being introduced to so many parts of villagers' lives made us feel happy during the whole field trip. Residents' curiosity in our study and their interest in what we do helped us understand the importance of *Practicing Interdisciplinary Field Research on the Environment* course. Thank you for being a part of this research.

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Introduction

Rural livelihoods are an important topic being explored by researchers in relation to different locations across the world. It is a complex notion, which is the reason why numerous sources explain it with slight differences. This research uses the definition proposed by Chambers and Conway (1992): "livelihood comprises the capabilities, assets and activities required for a means of living", which highlights the importance of connections between capabilities to obtain assets which then enable pursuing specific activities. Moreover, rural livelihoods are shaped by a dynamic interplay of social, economic and environmental factors, particularly in communities relying heavily on natural resources for their subsistence (Chambers & Conway, 1992). Land use changes which are driven in rural areas by villagers attempting to adapt their livelihoods to such factors can both have positive results, such as improved income, and negative results such as soil and water quality degradation (Mertz et al., 2009).

Livelihood strategies

Furthermore, apart from access to assets, livelihood strategies in rural areas are determined by environmental pressures and economic shifts which influence villagers' ability to sustain or increase the same standard of living (Chambers & Conway, 1992). They embrace activities leading to both earning income (farm sources ex. cash crops; off-farm sources ex. wage labour on another farm and non-farm sources ex. non-agricultural wage labour) as well as ensuring subsistence (crops cultivated for household use). Additionally, social relations can help with intensifying diversification of strategies through for example providing remittances. Another important factor impacting livelihood strategies is access to services, such as roads and education, provided by social and public agencies (Ellis, 1998).

It is important to mention that rural livelihood strategies are frequently closely connected to the environment as people in rural areas often depend on natural resources (Chambers & Conway, 1992). K. Neefjes (2000) presents an interesting understanding of the environment, according to which it is an entity consisting of human beings, animals, land, forests and natural resources, which coexist in a special relationship. This research uses this explanation of the

environment as means to explore the connection between rural livelihood strategies and impact on the natural resources such as soil, water and forests.

Rural livelihood strategies in Sarawak, Malaysia

This research focuses on Sarawak state - one of two Malaysian parts of Borneo. This region is inhabited by 2.5 million people in total, including numerous ethnic communities such as Iban and Bidayuh. Bidayuh is the 4th largest ethnic community in Sarawak (Malaysia, 2024). They live mainly in the south-west part of the state. Their main occupation is cultivation of hill rice as well as rubber trees, although with time less and less farmers tend to extract rubber. Additionally, their livelihoods are dependent on forest products (Nelson et al., 2016).

Throughout the past three decades, cultivation of oil palm has become an important topic among Malaysian farmers - both inland and living on Borneo. In 2024, 21% of Malaysian oil palm was cultivated in Sarawak (*Palm Oil Explorer*, 2024). Large-scale plantations developed in the first place, however small-scale farmers also became interested in producing this crop, encouraged by the promise of significant profits (Soda et al., 2016). Smallholders in Sarawak state are characterized by the ability to autonomously develop according to changes of conditions necessary for production of their crops. They are aware that education and infrastructure are key factors conditioning the success of oil palm, so that it could become a significant part of their livelihood strategies (Cramb & Sujang, 2012).

The topic of livelihood strategies of particular indigenous communities of Sarawak in relation to growing interest in oil palm cultivation has not yet been deeply studied. Therefore, this research aims to explore this connection concerning one of several Bidayuh communities present in the south-west part of Sarawak. In order to do that, this paper aims to investigate research questions described in the next part.

Research questions

This paper's main objective is to assess changes in livelihood strategies of a rural ethnic Bidayuh community living in Kampung ('village' in Bidayuh language) *Temong Mura*, as well as investigate how they manage natural resources and explore their views on assisted agricultural development concerning the future of oil palm in their village. This research uses a specific time frame: before 2019 and now (2025), in order to identify and compare changes happening throughout time. Choice of this time frame can be justified by wanting to provide villagers an easier period of time to recollect their experiences more accurately.

This report attempts to answer the following research questions:

1. How have livelihood strategies in Temong Mura (rice and pepper cultivation) changed over the past 6 years (comparing the time before and after Covid-19)?
2. Which forest products are Temong Mura villagers most reliant on?
3. What are the impacts of different types of farmlands in Temong Mura on soil quality?
4. What are the impacts of farming areas and residential areas in Temong Mura on water quality?
5. How do villagers in Temong Mura perceive future assisted agricultural development (AAD) in relation to oil palm cultivation?

Research area description

This research was conducted in Kampung Temong Mura, Sarawak, Malaysia (see fig.1). It is a rural area inhabited by approximately 667 people, primarily Bidayuh, living in 130 households. Among main activities can be found subsistence farming of upland rice (nearly all households), cash crop farming of pepper (most common cash crop), rubber (declining popularity as it became unprofitable) and oil palm (new cash crop). Apart from agriculture, villagers engage in non-farm income activities such as wage labour in the nearby town or jobs in the private sector in bigger cities enabling sending remittances to family members staying in the village.

Figure 1. Map of research area.

Methodology

The Temong Mura community in Sarawak, Malaysia, has long relied on a blend of traditional subsistence activities and natural resource management for its livelihood. This study adopts an interdisciplinary approach to assess the evolving livelihood strategies within the community, focusing on the past, present, and future management of natural resources and the limited agricultural development assistance available in the area. By integrating perspectives from both social sciences and natural sciences this research seeks to provide a comprehensive understanding of the dynamic relationship between changing environment and livelihoods in the Temong Mura area, and local adaptation strategies.

Given the complexity of these issues, the methodology employed in this study includes both qualitative and quantitative methods of research. This interdisciplinary framework allows for a more holistic view of socio-economic changes in the village, and the role (or absence) of external agricultural development support. By understanding these factors, it is possible in the future to identify sustainable and community-driven solutions to enhance resilience and long-term livelihood security in Temong Mura.

The purpose of this chapter is to introduce the research methodology and outline the research design, methods used (data collection, sampling strategy and data analysis), and ethical considerations, ensuring a rigorous and transparent methodological approach to address our research questions.

Research design

A mixed-methods approach is used to integrate quantitative and qualitative data, ensuring a comprehensive analysis of livelihood changes. The research incorporates quantitative methods, such as household surveys, to capture statistical trends, agricultural shifts, and changes in the environment, and qualitative methods, including semi-structured interviews or focus group discussions to explore community perceptions.

Participatory mapping

This method was used in order to gain a comprehensive understanding of the village layout and strategically select sampling sites, a participatory mapping exercise was conducted (see fig.2 and fig.3). Participatory mapping is a PRA technique that empowers local communities to create visual representations of their environment, allowing them to share their insights and knowledge about the area (Cochrane & Corbett, 2018). Two local guides and a translator, who was also a local, were asked to draw a map of the village with the farming areas. The drawn map was based on a topographic map of Temong Mura and Google Earth. Such locations were indicated as residential areas, the church, main road, a river, agricultural fields, a private pond, a community forest reserved for conservation and a resource forest situated further away, which is used by villagers to collect forest products. In the end, sites suitable for collecting soil and water samples were chosen, as well as a general understanding of the relation between residential areas, farming areas and forest was acquired.

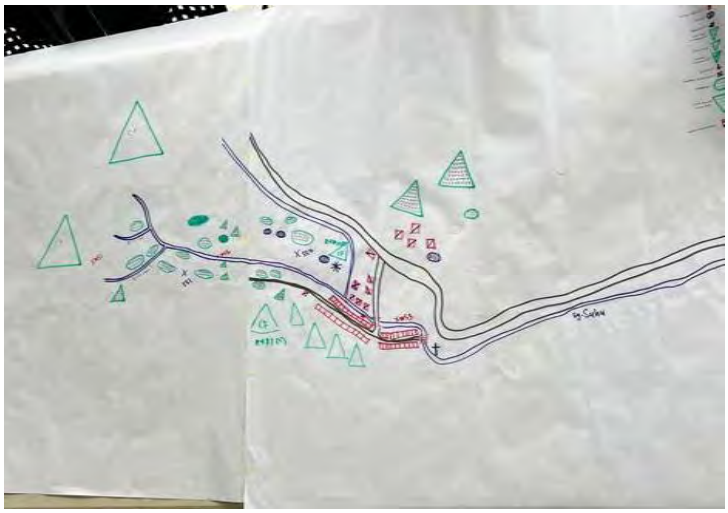

Figure 2. Participatory mapping.

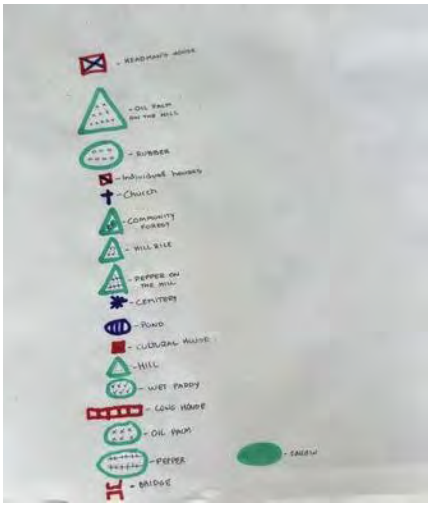

Figure 3. Participatory mapping - legend.

Community walk

Accompanied by a local translator, a series of informal conversations took place with residents during a walk through the village. These casual interactions provided insights into the types of crops grown by the community, forest resources they collect, as well as any potential changes in land use. This method was spontaneous and took place in the afternoon when the villagers finished work. The sample size came out small (5), as it was getting late. The sample strategy was convenience; as only nearby participants were chosen. Despite its simplicity, this method served as a great way to gather some basic information that informed further research and helped us with what forest resources to put for the ranking and scoring exercise.

Ranking and scoring exercises

These exercises were used to assess villagers' dependency on the forest and their perceptions of forest products. These methods enabled local participants to systematically evaluate the importance of various forest resources. To conduct this method, a list of the most used forest resources in the region was created, based on insights collected during the community walk with local residents. From their answers, a list of 13 products was made: bamboo, ratan, bemban, firewood, timber, wild fruits, wild vegetables, wild nuts, shoots, resin, raffia leaves, wild animals and medicinal plants. The option "other" was also included in case some participants collected resources not specified in the list. These exercises were simultaneously conducted among two groups, which were divided by age: one with participants under 45 years of age and the other including or above 45 years of age. An age division was decided after general participatory observation of local demographics in the community. The younger group had 5 participants (4 women and 1 man), while the older group was composed of 15 participants (5 women and 10 men). Additionally, this method was used as an "icebreaker" before focus group discussions - both methods were conducted during the same day, one after the other.

Focus groups discussions

This qualitative method allows for interactive discussions among community members, facilitating the exchange of experiences and collective perspectives. It was conducted to gain deeper insights into community perceptions of livelihood changes, agriculture shifts, challenges

villagers face and their views on the future of Temong Mura. The two discussions were meant to bring together people from different socio-economic backgrounds, occupations and demographic groups (men and women, farmers and community leaders). Two focus groups were simultaneously conducted with the same participants as during Ranking and Scoring exercises, using the same division by age. The younger group had 5 participants (4 women and 1 man), while the older group was composed of 15 participants (5 women and 10 men). Both discussions were led by one main and one supporting moderator. Conversations were audio recorded, with participant consent, and supplemented by detailed note-taking by two other researchers who also observed the dynamics in the group. As a data analysis method, thematic analysis was used to identify common patterns and divergences in responses. Afterwards, findings were triangulated with other methods to ensure a comprehensive understanding of the community's perspectives.

Semi-structured interviews

This qualitative method was utilized to gain insight into how Temong Mura residents perceive assisted agricultural development, especially concerning oil palm cultivation. A stratified sampling strategy was used, where only farmers were taken into consideration (except for one participant who was not a farmer but interested in oil palm). From this stratum, they were chosen randomly. These interviews were conducted individually and in a semi-structured manner, where participants were guided by certain questions and then, they could freely describe their perspectives on cultivating oil palm and getting different types of agricultural support. Moreover, they also expressed their opinions regarding the interest of the young generation in agriculture. A total of 7 participants were interviewed.

Household surveys

To get quantitative data to support the social methods, household surveys were conducted. These surveys allow collecting standardized data from a representative sample of a population (Grosh & Glewwe, 2000). Out of 130 households in the village, 51 were successfully surveyed, primarily during evening hours due to residents' work schedules. However, some of the villagers either worked late or were out of town, so in the end it was not possible to interview every household. The surveys focused on gathering information about land-use changes for rice and pepper cultivation over the past six years, forest resource utilization and oil palm cultivation practices. Before every survey, an audio of the participants' consent was recorded. After data collection, the process of analysis began with a descriptive approach, which helped visualize trends and patterns within gathered information. It was followed by statistical analysis to provide a relevant understanding of the findings. Finally, conclusions drawn from the analysis were visually presented using graphs.

Participatory observation

During the whole field trip, the team was gathering supplementing information through participatory observation. Villagers shared elements of their daily lives with us, such as a resident soaking white pepper in the river and the drying process, which involves spreading the pepper on a long mat using a specialized tool and leaving it to dry. There was also the observation of rice being dried on mats in front of residents' houses, and some of the students were even invited to step on the paddy, moving it with our feet. Finally, an opportunity was provided to attend in two church masses: one on Sunday and another on Ash Wednesday. During these events, the community came together to sing and recite prayers in their native Bidayuh language. These experiences gave our research deeper insight into the livelihoods of Temong Mura residents, particularly their cultivation of two essential crops: pepper and paddy.

Transect walk

To gain on-site knowledge about the farming areas, the team went on a transect walk led by two local guides and two translators. This method is used to gather spatial data by observing

people, surroundings and resources, while walking through an area (Ajaz & Zakir, 2022) . The guided tour took place through diverse agricultural landscapes, including pepper farms, rice fields and oil palm plantations. Following each place, the guides were consulted to gather information such as the age of the farm and what type of farm it was previously in order to evaluate its suitability as a potential soil sampling site. Apart from information concerning specifically agricultural fields, on the way the team passed through certain medicinal plants, wild vegetables and fruit trees which allowed to gather insights concerning forest resources used by villagers. During this walk, it was also possible to see the infrastructure that allowed farmers to access their fields and transport yield, such as bridges, roads and storage spaces, which broadened our understanding of villagers' problems concerning not having good-quality roads, which made transportation of crops, fertilizers and pesticides difficult.

Soil sampling

Soil sampling was an essential component of this study, providing empirical data on soil quality. The impact of past and present land use practices was assessed through the analysis of soil characteristics. This method was used to address the third research question and to get insight into how current different types of farmlands and past land-use practices affect the soil quality. To get that, a comparison of soils from 3 different types of active fields was made (rice, pepper and oil palm fields) and used soil from the nearest community-owned forest as a control sample.

The sampling strategy was decided right before soil sampling. For each sampling spot, the research team separated into 2 halves, each collected 2 core samples for pH and nitrate analysis, which were mixed to create composite samples, and 3 bulk density core samples. The plots were decided randomly in each half but also chosen so that they were not near the road, path or on a slope. In the case of the oil palm field and community forest, it was also considered that they were not near trees. All samples were stored in sterile, labelled bags to prevent contamination, and GPS coordinates and field notes were recorded for each sampling site.

The samples were then analyzed in 3 ways: core samples were used for measuring pH levels and nitrate concentrations, and for visual soil assessment; bulk density cores were used to analyze the bulk density.

Selection was based upon 3 soil characteristics (2 chemical - pH level and nitrate concentration, 1 physical - bulk density) to analyze the samples. The team chose to measure pH level, because it is a critical factor influencing nutrient availability, microbial activity, and overall soil fertility; the nitrate concentration, because it is a key nutrient essential for plant growth, as it is a primary form of available nitrogen in soils and provides insights into soil fertility; and bulk density, because it shows that soil compaction and porosity, and it affects root penetration, water retention and overall soil health.

Soil pH was measured using a benchtop pH meter. Nitrate concentrations were assessed through spectrophotometric analysis following extraction with a potassium chloride (KCl) solution. Bulk density was determined by collecting undisturbed soil cores, drying them at 105°C, and calculating the ratio of dry soil mass to total soil volume (g/cm^3).

For each half of the sampling plot was then calculated an average from the 3 collected bulk density core samples. In the end the comparative analysis was used for all 3 measured soil characteristics to compare them between themselves and with the control samples from the community forest.

A simple visual soil assessment was conducted on the samples. Soil texture was identified by hand-feeling. Root size, colour, and the approximate amount of organic matter were determined through simple visual observation. Although root and biodiversity of soil was not included in the research, as the word count is limited. 5 people participated, while two took notes of the results. Overall, the process was brief and straightforward.

Water sampling

Water sampling is conducted in order to evaluate the impact of farming areas and mix-residential and farming areas on water quality in Temong Mura. Samples were collected from three locations: forest area, as a control site, farming area (near the forest), and residential and farming area (near the village). These sites were chosen to understand the impact of villagers' livelihood on water quality, and participatory mapping with villagers was helpful for deciding on that. Firstly, physical and chemical parameters including temperature, dissolved oxygen, pH, conductivity, salinity, TDS were measured by putting a water quality sensor directly in the water. And after

collecting water samples in each site, the Phosphate and Ammonia were tested in the samples at the field lab conducted by the group. The water samples were taken randomly in each site by rinsing each bottle 3 times and filled the bottles by putting them deep in the river and had to close the bottles in the water (not out in the air). The PhosVer 3 reagent and ammonia salicylate were used to detect phosphate ions and Ammonia in water samples, respectively. Also to accurately evaluate Nitrogen level, it is essential to know the total amount of nitrogen in the water. However, in the laboratory, the ammonia salicylate method is specifically designed to detect and quantify ammonia in the sample, not other forms of nitrogen.

A visual water assessment was conducted by using macroinvertebrates as bioindicators. The fauna data was assessed by using the BMWP (Biological Monitoring Working Party) Index, which evaluates water quality based on aquatic invertebrates, particularly insects. Species are collected, identified, and assigned scores based on their sensitivity to pollution, with higher scores indicating greater sensitivity. The index is calculated by summing the scores of all species found, and higher scores reflect better water quality. A score of >150 is considered excellent water quality. This method is widely used to monitor and manage the health of aquatic ecosystems in rivers and lakes (Wan Abdul Ghani et al., 2018).

Additionally, the Malaysian Family Biotic Index (MFBI) was calculated using the BMWP. A higher MFBI score suggests a greater presence of pollution-sensitive species. A score greater than 5.9 typically indicates very good water quality, while a score between 4.6 and 5.9 indicates good water quality.

Remote sensing

As an additional method to assess changes in land use for oil palm cultivation, satellite images were used. In order to conduct a comparative analysis of changes happening over time 2 photos of agricultural fields in Temong Mura from Google Earth were used - one representing 2016 and the other 2025. The same location has been pinpointed in the images and then a visual analysis conducted. To facilitate a clearer interpretation of the photos, the boundaries of the oil palm plantations have been highlighted.

Ethical considerations

1. Informed consent

Before each interview, the translators would provide a clear explanation of the interview's purpose and the type of information being gathered. Following this introduction, informed consent was obtained from each potential respondent. It was emphasized that participation was entirely voluntary and that respondents had the right to withdraw from the interview at any time. For the focus group discussion and the semi-structured interviews, in addition to the procedure above, a consent for recording would be obtained. This approach ensured that participants were fully aware of the process and felt comfortable throughout the conversation.

2. Confidentiality

When describing the results, no personal information was used. Regarding the semi-structured interviews and focus group discussions, the data was stored on the recorders, to which only the owner of the phone had access. Again, no personal information was used while conducting the analyses.

3. Cultural sensitivity

It is essential to approach the research with cultural sensitivity to ensure ethical engagement, mutual respect and the accurate representation of local people and their perspectives. It is important to take it into consideration when working with indigenous and rural communities. Before conducting the fieldwork, some background research was done and obtained information on local customs and traditions during the lectures. Also, any photographs, recordings, or written materials were used only with explicit permission from participants and community representatives. Areas considered sacred, restricted or culturally significant were avoided or approached with permission and respect, e.g. the house where we stayed during our fieldwork. By incorporating cultural sensitivity measures, we upheld ethical integrity, trust within the community and tried to ensure that the findings of our research are ethical and reflective.

4. Compensation

A compensation to participants was provided in the form of food after the focus group discussions and during our going away ceremony, where food and drinks were given to the villagers to thank them for their time and energy before leaving the village.

Results

Livelihood strategies before 2019 and in 2025

In order to investigate research question 1 which concerns the changes of livelihood strategies in Temong Mura (rice and pepper cultivation) over the past 6 years, a variety of methods were used and then triangulated in order to receive a comprehensive analysis.

The study reveals minimal changes in rice cultivation land use across both age groups (see Fig. 4). However, when changes occurred, they primarily involved an increase. The younger group (below 45) attributed this phenomenon to shifts in employment for ex. retirement of a household member. Insights gathered during the community walk indicated that after villagers retire, they often tend to start crop cultivation, which explains the increase in land use. The older group (above 45) linked the change mainly to the high cost of pesticides and fertilizers, as well as plant diseases. They explained that they need more land in order to gather more yield when the amount of fertilizers/ pesticides they receive is not enough to get the same yield from a smaller area.

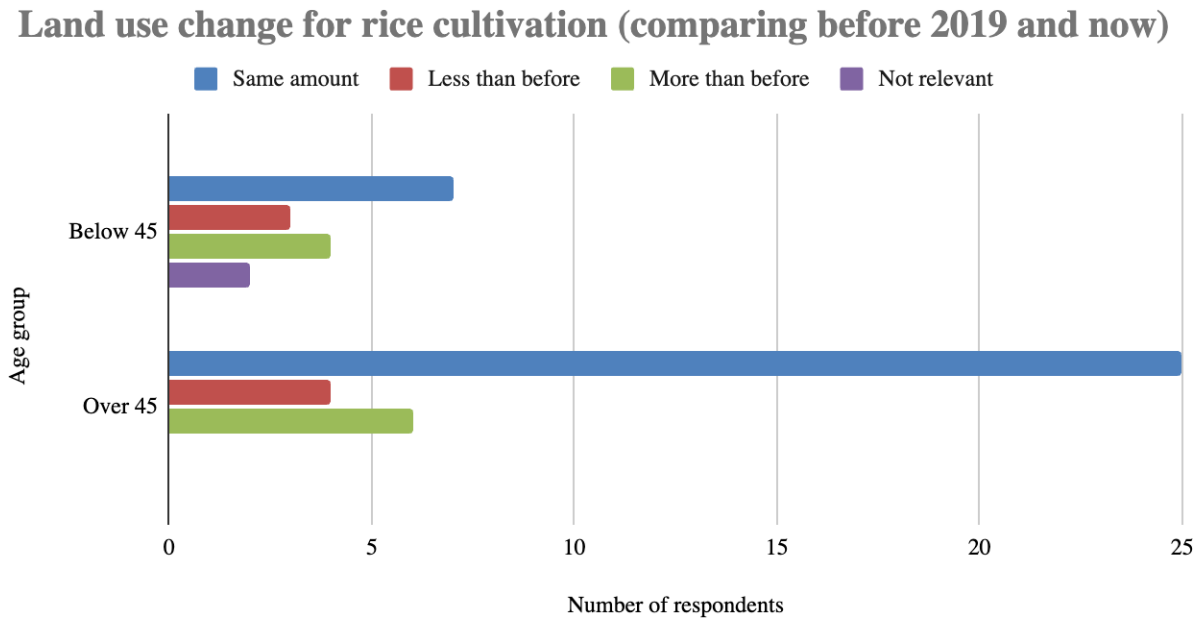

Figure 4. Survey results regarding land use change for rice cultivation (comparing before 2019 and 2025).

Pepper cultivation exhibited a similar general trend of minimal changes, however if they occurred, they primarily involved decrease in land use (see Fig. 5). Main reason indicated by the younger group was labour shortage and soil infertility emerged as a secondary factor for both age groups. Additionally, participants of both the community walk and focus group discussions also didn't mention any major changes in their crop cultivation. Interestingly, while conducting the transect walk with local guides, they informed the group that most of the rice, pepper and oil palm plantations that were observed were at least six years old, indicating farmers' continuous cultivation of the same lands before 2019 and now.

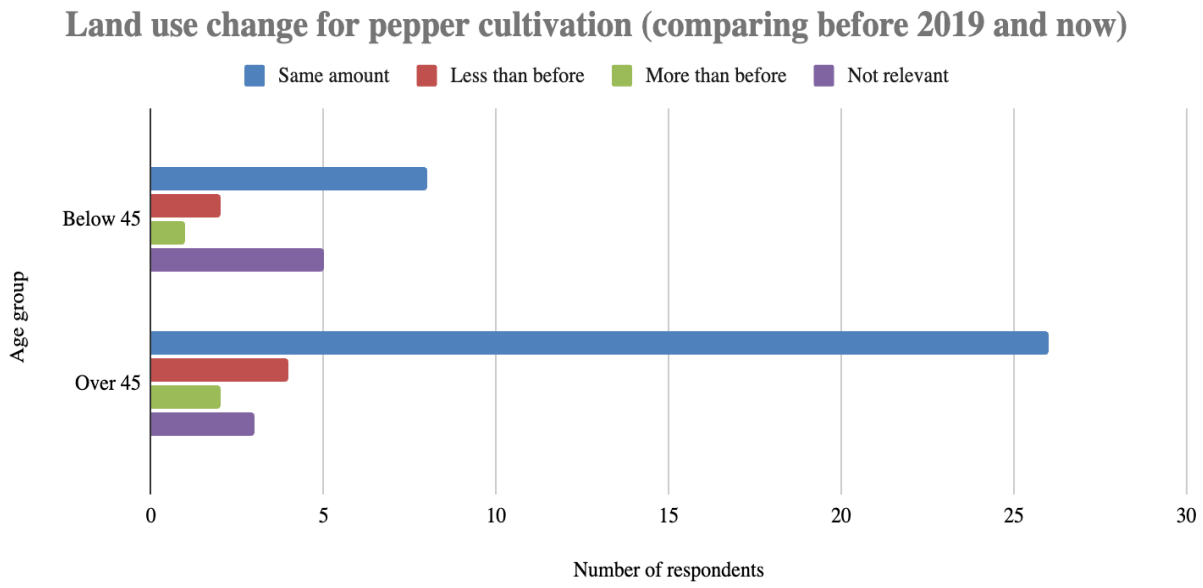

Figure 5. Survey results regarding land use change for pepper cultivation (comparing before 2019 and 2025).

Regarding other changes, in the focus group discussion, the participants were asked about such aspects as fertilizers and subsidies. Both older and younger individuals underscored their heightened dependence on fertilizers and pesticides. Furthermore, they observed that they now receive more subsidies than they did six years ago. Concerning the most significant challenges encountered six years ago in rice cultivation, the younger group noted the minimal support they received from the government for pesticide procurement. In contrast, the older group identified the absence of adequate road access and insufficient fertilizer availability as a major obstacle.

Presently, the challenges in rice cultivation are different. The younger group identified weather conditions as a primary concern, as excessive or insufficient rainfall is detrimental to rice cultivation. The older group continued to express concerns about inadequate road access and insufficient fertilizers, although they acknowledged that these issues have improved somewhat compared to six years ago. A similar answer emerged in semi-structured interviews as almost every response to the question about what could be done to help the farmers increase income from agriculture, pointed out fertilizers and pesticides as well as help from the government as essential to them.

Villagers' reliance on forest products

The research indicates a significant reliance on forest products, with age-specific preferences:

- Below 45 years: Primarily using bamboo and firewood
- Above 45 years: Primarily using wild vegetables and bamboo

Overall, the community's most collected forest products are bamboo, rattan, and wild vegetables. Bamboo and rattan are utilized for handicrafts, including baskets for harvesting crops and forest products. These results were gathered from the ranking and scoring exercise and household surveys (see Fig. 6 and Fig. 7). Resin was considered unimportant for both groups in terms of frequency and usefulness. The young group ranked it as 13 and 10, and the old group ranked it as 14 or "nothing" due to scarceness. Additionally, medicinal plants were ranked by the young group as 11 for frequency and 6 for usefulness, while the old group ranked them as 7 for both frequency and usefulness and the old group scored them as 4 for accessibility while young as 3. This possibly indicates that the older group may rely more on or use medicinal plants than the younger group.

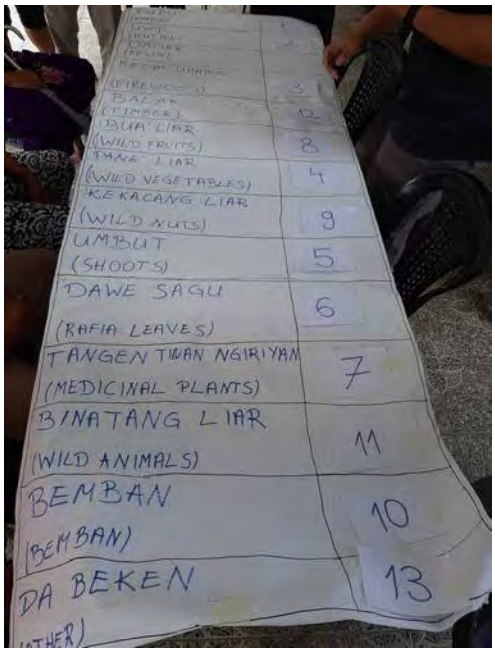

Figure 6. Ranking exercise.

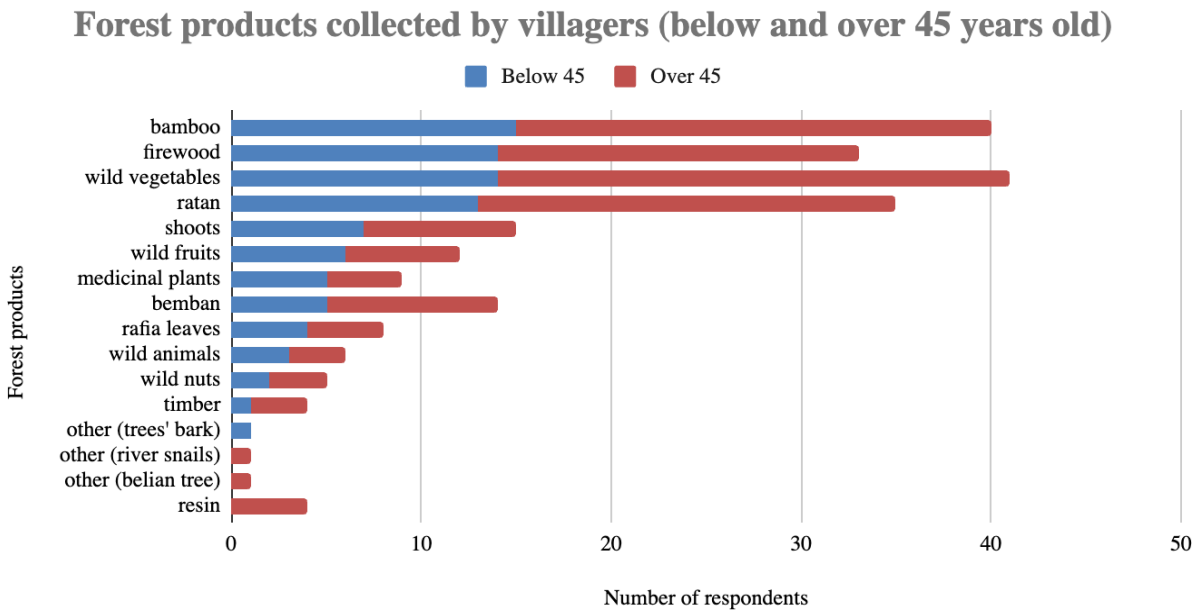

Figure 7. Types of forest products collected by villagers (comparing villagers below and over 45 years old).

An analysis of forest product utilization by age group reveals notable generational differences in engagement with the sale of forest resources. Among respondents over the age of 45, eight individuals reported both collecting and selling forest products, indicating a higher level of market engagement within this age group. In contrast, only one respondent under the age of 30 and one between 30 and 45 years reported similar involvement. Most respondents across all age groups indicated that they do not sell forest products, with 24 individuals in the over-45 group, 13 in the 30–45 group, and three in the under-30 group expressing no involvement in forest product sales. One individual in the youngest group and one in the oldest group indicated that they do not collect forest products at all. These findings suggest that while forest dependency remains significant, especially among older villagers, commercial engagement with forest resources is limited and appears to decline among younger cohorts. This trend may reflect shifting livelihood priorities and a reduced reliance on forest-based income among younger generations, consistent with broader patterns of rural transition observed in Southeast Asia (Cramb & Sujang, 2012).

Impact of different farmlands on soil quality

To explore the impact of farmlands on soil quality in Temong Mura, three sites were chosen (an oil palm plantation, a pepper field and a rice field) and a community forest as control site, as seen in Fig. 8.

Figure 8. Soil sampling sites.

To assess the quality of the soils, four indicators were chosen: pH levels, nitrogen, bulk density and organic matter. The results can be seen in Table 1.

Soil sample	Soil parameters			
	pH	Nitrogen	Bulk density	Organic matter
CF1 (Community Forest)	3.84	12.91	0.82	very low
CF2	3.86	14.80	0.68	low
RF1 (Rice Field)	3.96	13.2	0.75	low
RF2	4.11	15.11	0.87	low
OPF1 (Oil Palm Field)	3.74	16.37	0.82	low
OPF2	3.79	8.84	0.82	high
PF1 (Pepper Field)	3.88	8.88	1.11	medium
PF2	3.91	10.14	1.04	low

Table 1. Results of the soil samples' laboratory and visual analysis.

Highlighted results (red) - inaccurate data

The soil sampled from the community forest, serving as a control sample, yields result remarkably similar to the agricultural lands which are explained in the following paragraphs. The pH level of 3.8 is very low, while the bulk density ranges from 0.68 to 0.82 and it is the lowest among all samples. Nitrate levels are measured at an acceptable level of 14.8 mg/kg and 12.9 mg/kg of soil. The results of organic matter, indicating very low and low levels, may be attributed to the fact that the samples were collected in a slope, where much of the organic matter could have been washed away.

The soil in the rice field exhibits notable acidity, with pH values ranging from 3.96 to 4.11. This level of acidity may lead to nutrient deficiencies, potentially impacting plant growth, as the ideal pH for most crops exceeds 6.0. Such conditions may lead to nutrient deficiencies, potentially impacting plant growth (Fernández & Hoeft, 2012). On the other hand, bulk density results for rice field samples, ranging between 0.75 and 0.81, indicate optimal soil conditions for agricultural purposes, particularly for clay soils (Natural Resources Conversation Services, 2019). Nitrate levels vary between 13 mg/kg and 15 mg/kg, which, based on the literature, is also optimal for crop growth as it falls between 10 mg/kg and 50 mg/kg (Laqua, 2015). The organic matter content in both samples is observed to be low.

The soil sampled from the pepper fields presents low pH levels of 3.9 and 3.8, which again is too low for crop growth. Bulk density measurements of 1.11 and 1.04 indicate suitable soil density for cultivation. However, the nitrate levels of 10 mg/kg and 8.8 mg/kg are lower than those observed in the case of rice fields, which indicates too low levels for good pepper growth. Notably, organic matter in this soil type is also oscillating between moderate and low, which significantly impacts soil ability to produce good yield.

Lastly, samples collected from oil palm plantations demonstrate even lower pH levels than those from the rice field, with values of 3.79 and 3.74. It suggests a potentially lower nutrient availability. However, the bulk density of 0.82 remains favorable for agricultural use. Nitrate levels show significant variation between samples (8.8 mg/kg and 16 mg/kg of soil), therefore they cannot be included in the comparison as representative parameters. According to the villagers, fertilizers are applied by hand, which may affect the evenness of spreading them across the plantation. Unfortunately, due to time and weather constraints it wasn't possible to collect more samples, which could make the results more representative. Similarly, organic matter content varies considerably between samples, with one exhibiting high level and the other low. This could be attributed to the fact that the assessment was done visually by multiple people, and aside from human error, each person may have a slightly different approach to evaluating this parameter.

The comparative analysis of soil samples from various agricultural sites and the control sample from the community forest suggests that farming activity has not significantly altered soil characteristics. The similarity in the results between the farmlands and the control samples indicate minimal anthropogenic impact on soil properties. It's also important to note that people do not use machinery for agricultural activities, and poor road access further limits such practices.

Impact of farmlands and residential areas on water quality

This research aimed to understand the impact of farming and residential areas on water quality in Temong Mura. In the beginning, in the same way as before collecting soil samples, participatory mapping helped with identifying and choosing appropriate sites for taking water samples (see Fig. 9). Samples were collected from three locations: forest area, as a control site (WS1), farming area (WS2), and combined residential and farming area (WS3). WS1 and WS2 were situated near the community forest and farmlands, while WS3 was near the village (see Fig. 9).

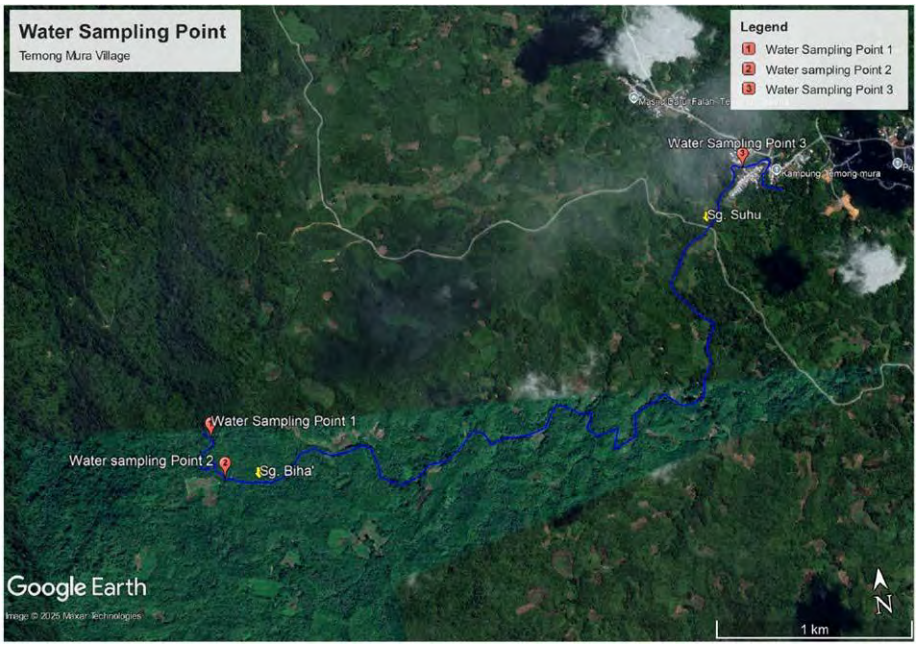

Figure 9. Water sampling sites: forest area (WS1), farming area (WS2), and combined residential and farming area (WS3)

While collecting samples WS1 and WS2, the weather was sunny, however it rained during the sample WS3 collection. The effect of rainfall on the studied water quality parameters can vary depending on factors such as: amount, timing and land use. During the analysis of WS3, the general effect of rainfall and soil runoff was taken into consideration, although in order to better

understand the influence of rain on the sample's accuracy, more specific field data would be needed. As an additional limitation, according to the villagers, even though the rainfall near the village was minimal, heavy rain upstream could have occurred and potentially caused runoff that couldn't be measured. Due to these constraints, the results from WS3 were compared with those from WS1 and WS2 in a more general manner within the report.

The following table presents the data of the physical and chemical parameters of all three water samples (WS1, WS2, WS3) (see Table 2.)

Water parameters	Water sample		
	Forest area (WS1**)**	**Farming area (**WS2**)**	**Residential and Farming area (**WS3**)**
Temperature(°C)	23.00	24.13	27.50
Dissolved Oxygen(mg/L)	2.05	2.31	1.99
pH	7.01	7.08	7.10
Conductivity(µS/cm)	111.73	115.60	148.7
Salinity (%)	0.05	0.05	0.07
Total Dissolved Solids	72.58	75.18	95.98
Phosphate	0.34	0.23	0.36
Ammonium Nitrogen (NH_4^+)	0.10	0.11	0.05

Table 2. Results of physical and chemical parameters from the three sampling points.

Highlighted results (red) - inaccurate data

First, the temperature variation across the sites was a limitation beyond control, making direct comparison challenging, as temperature is known to significantly influence various water quality parameters (Wetzel, 2001).

Next, Dissolved Oxygen (DO) levels are low across all sites, suggesting poor water quality. Dissolved oxygen is crucial for aquatic life, and low levels can cause stress to organisms (US EPA, 2015). However, it was confirmed by the resource person's assistants, that the water quality sensor

used for measuring DO did not provide accurate readings. Due to this information, there is the awareness that these results might not be precise (red color in the table), especially given the results of bio-indicators analyzed further in this report showcasing an excellent water quality.

The pH levels across all sites are near neutral, typical for freshwater systems, with values ranging from 7.01 in the forest area (WS1) to 7.10 in the farming and residential area (WS3). These small variations in pH are within acceptable limits and do not indicate immediate concerns, as a pH range of 6.5 to 8.5 is ideal for most aquatic organisms (US EPA, 2025). The effect of rainfall and runoff on pH is less clear, and it is uncertain whether it was a significant factor influencing the results obtained from WS3.

Both conductivity and Total Dissolved Solids (TDS) indicated an increase across the sampling sites, moving from WS1 to WS3. Collected data suggests that land use influences these parameters: when forests generally have lower both values, farming areas usually have them higher. Values obtained from WS3 were significantly higher, and that could be influenced by both farming runoff and possible residential area impacts. Additionally, the data suggests that salinity is slightly impacted by land use, remaining the same in both forest and farming areas, and increasing by 0.02 at the last sampling site. Additionally, the potential effect of rainfall and runoff on representativeness of results from WS3 is uncertain.

Phosphate level was 0.34 mg/L at the control site. At the farming area, the concentration slightly decreased to 0.23 mg/L. At combined residential and farming areas, the phosphate level increased to 0.36 mg/L, indicating the combined influence of agricultural runoff and potential residential area impacts. These data suggest that land use has an impact on phosphate concentration, with higher values obtained in areas influenced by both farming and residential runoff. Additionally, farming areas alone show slightly lower levels compared to the control site. Such results may be possible due to e.g. lower phosphate inputs or different farming practices. Furthermore, phosphate levels in both forest and residential-farming areas exceed the standard level for rivers 0.1mg/L. This observation raises moderate concern for water quality in Temong Mura, especially regarding algal blooms and oxygen depletion. Although phosphate in WS2 (only farming area) is slightly less above the threshold, it should still be monitored (Fried et al., 2012).

Nitrogen concentration is highest at farming areas (WS2), with a value of 0.11 mg/L, which could be potentially attributed to fertilizer usage in agricultural practices. This parameter in WS1 was slightly lower at 0.10 mg/L and in WS3 it dropped to 0.05 mg/L, which could be due to potential lab issues, as this site (combined farming and residential area) shows a significant difference compared to the other two. According to the EPA guidelines, ammonia levels in all 3 sites are below the toxic threshold of 0.5 mg/L, meaning that ammonia is not a concern for water quality in Temong Mura (EPA, 2013).

To strengthen this water quality analysis, biological parameters were also investigated through visual water assessment using macroinvertebrates as bioindicators. The river fauna mostly consisted of shrimp, crabs, small fish, crustaceans, and insects. During water sampling, species that indicate healthy water quality were identified (see Fig. 10).

Figure 10. River fauna, gathered during the water sampling. Includes fish, crab, shrimp here.

Standards	Water samples		
	WS1	WS2	WS3
Biological Monitoring Working Party Index for Malaysia (BMWP)	469	257	382
Malaysian Family Biotic Index (MFBI)	6.72	6.26	5.54

Table 3. Water quality using macroinvertebrates as bioindicators, results for BMWP and MFBI in the three sampling sites.

Furthermore, the species observations were used to calculate two indices (see Table 3.). These two indices were selected because, as noted by Wan Abdul Ghani et al. (2018), both the Biological Monitoring Working Party (BMWP) index and the Malaysian Family Biotic Index (MFBI) are designed to provide biological assessments of water quality. Moreover, indices that incorporate local macroinvertebrate fauna and environmental conditions are considered to offer a more relevant and accurate understanding of water quality than generalized indices (Wan Abdul Ghani et al., 2018).

Based on these considerations, the BMWP index results demonstrated that all sites scored above 150, classifying the water quality as 'Excellent' according to established thresholds. Similarly, the MFBI indicated a 'Very Good' water quality rating at WS1 and WS2, and a 'Good' rating at WS3.

Perceptions of assisted agricultural development in relation to oil palm in Temong Mura

The study assessed villagers' attitudes towards assisted agricultural development concerning oil palm cultivation. Findings reveal that out of all household survey respondents (51) only 19 villagers (37,3%) explicitly expressed their interest in growing oil palm in the future (see fig.11).

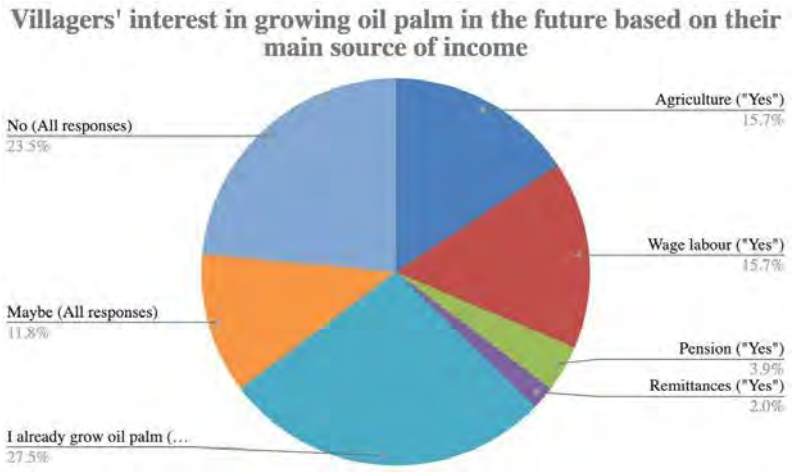

Figure 11. Interest in growing oil palm based on villagers' main source of income.
**All responses represent a combined number of responses without dividing them based on the main source of income*

Among participants with agriculture as their primary income source (28 villagers), only 29% declared their interest in future oil palm cultivation. On the other hand, among respondents primarily dependent on non-farm income sources (23 villagers), 47,8% expressed such interest, with the biggest group being represented by respondents relying on wage labour - 73% (see Fig. 12 and 13).

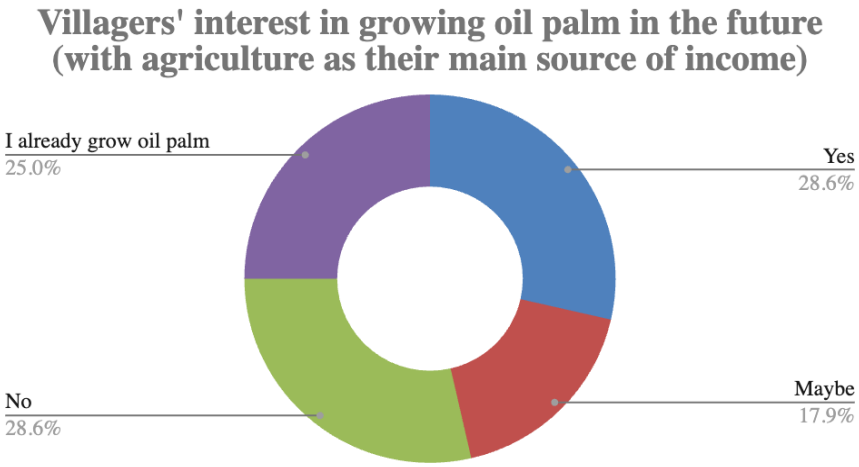

Figure 12. Interest in growing oil palm in the future among villagers with agriculture as their main source of income.

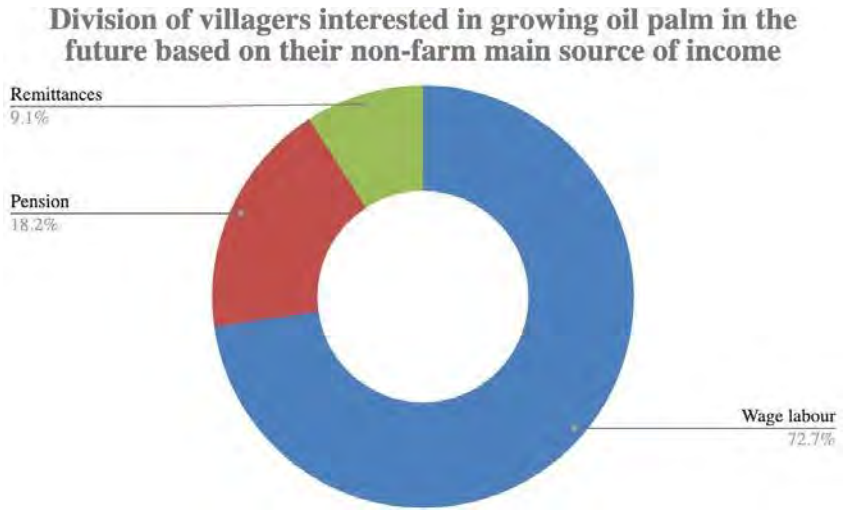

Figure 13. Division of villagers interested in growing oil palm in the future according to their non-farm main source of income.

These results link well with findings indicating that 50% of respondents below 45 years old are interested in growing oil palm in the future and only around 31% of people over 45 years old (see Fig. 14).

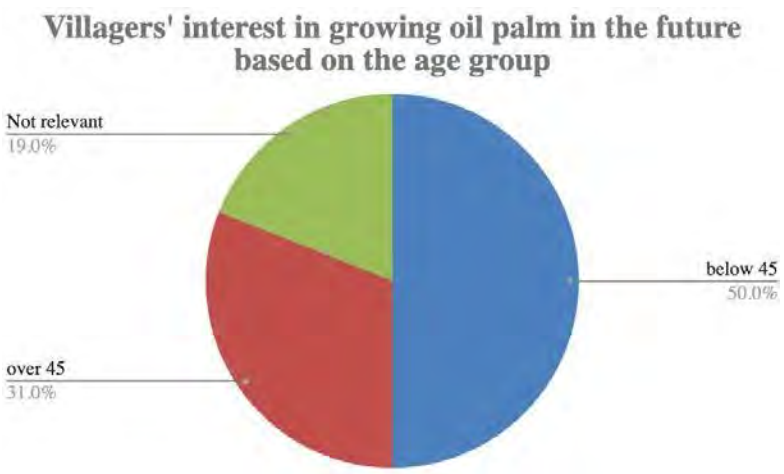

Figure 14. Interest in growing oil palm based on the age group: below and over 45 years old.

**Not relevant represents the sum of answers: "maybe", "no", "I already grow oil palm" without dividing them based on the age group*

This could be since younger villagers, who are primarily depending on non-farm activities as their main source of income face less risks while deciding to start growing a new crop, than people relying only on agricultural income - oil palm is an investment that requires land, manpower and fertilizers.

To further analyze the observation related to the age groups, a statistical test was conducted to assess whether a significant association exists between villagers' age groups – categorized as below and over 45 years – and their interest in growing oil palm in the future. A Chi-square test was used for this purpose. The null hypothesis states that there is no significant association between these two variables, then the calculated P-value was 0.3998. Since this value exceeds the significance threshold of 0.05, there is no significant association between villagers' age groups and their interest in growing oil palm in the future.

Moreover, insights collected during semi-structured interviews reveal a widespread interest in oil palm among villagers - with several respondents even unable to think of any potential negative aspects of planting oil palm. Respondents consistently predicted an increase in oil palm production, driven by anticipated price increases. However, despite this optimism, farmers were generally unwilling to replace their current crops with oil palm, reinforcing the hypothesis that

they are hesitant to fully engage in oil palm production. Furthermore, household surveys showcase, that both among villagers, who already grow oil palm and those who are interested in starting to do so in the future, in both age groups: below and over 45 years' old everyone was interested in receiving government support in the form of e.g. subsidies for oil palm cultivation. What is even more interesting, is that villagers who explicitly said they do not want to start growing oil palm in the future, would be also interested in changing their current view if they received governmental aid (see Fig. 15). Additionally, focus group discussions revealed that both age groups identify pepper, rice and oil palm as crops for which they would like to receive support, however, the young group mentioned oil palm only as a secondary crop because it is not yet so widespread among the villagers. This result is supported by findings from the semi-structured interviews, during which all participants stated their interest in receiving even higher support for growing pepper than they currently do because pepper is villagers' main cash crop and current subsidies are not enough.

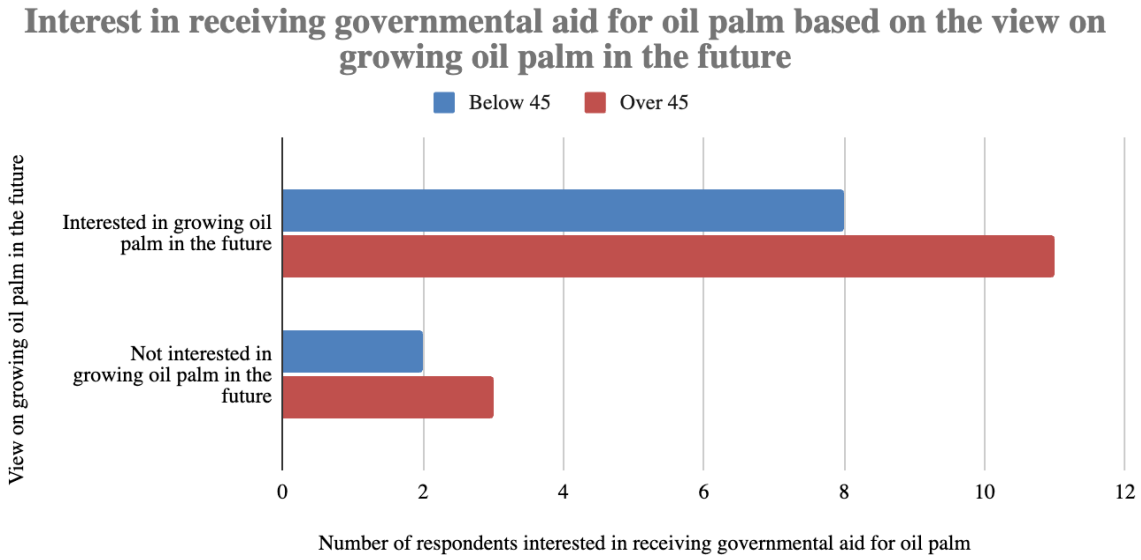

Figure 15. Interest in receiving governmental aid for oil palm (comparing villagers below and over 45 years old).

Furthermore, nearly all participants in the semi-structured interviews demonstrated an interest in learning more about oil palm cultivation and collaborating with agencies or government bodies.

All household survey respondents below and over 45 years old, no matter whether they already grow oil palm or would like to start in the future, expressed their interest in participating in any community-based programme for oil palm cultivation. Again, similarly to the case of governmental aid, respondents primarily not interested in growing oil palm in the future also expressed their interest in participating in a community-based programme which could potentially help them change their view on starting to grow this new cash crop (see fig.16).

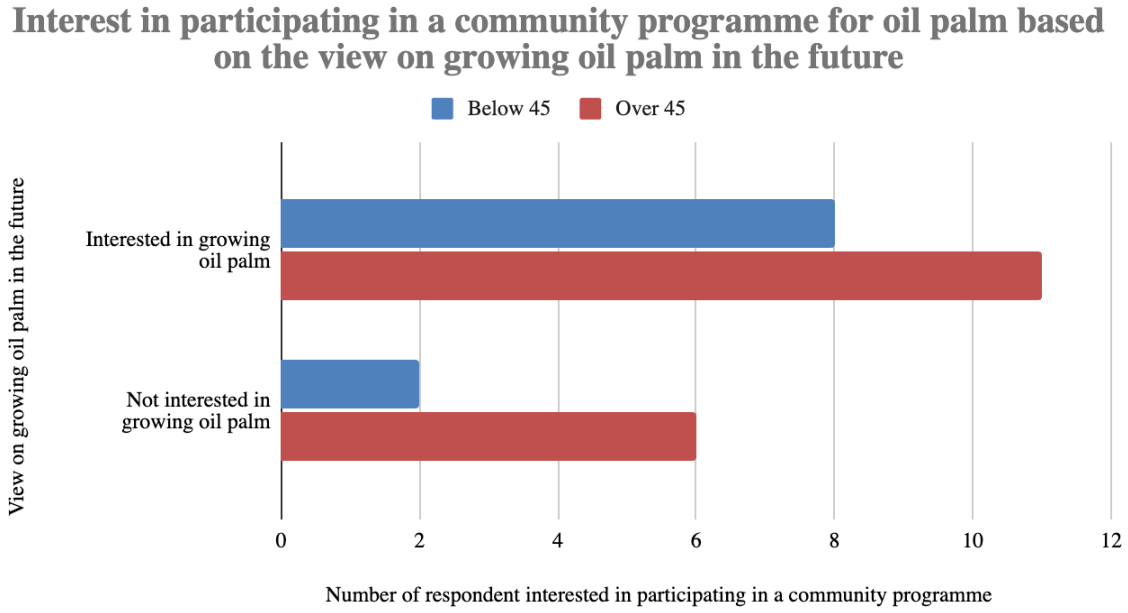

Figure 16. Interest in participating in a community programme for oil palm cultivation (comparing villagers below and over 45 years old).

As a last method to confirm the above claim, a comparison of two aerial images from 2016 and 2025 from Google Earth was made to assess if there has been an increase in oil palm cultivation. Turns out, the amount of oil palm farms is higher now than it was several years ago (see Fig. 17 and Fig. 18). In the first image there are no oil palm plantations, compared to the image that was taken during the research period where oil palm plantations can clearly be seen.

Figure 17. Area next to Temong Mura in 2016.

Figure 18. Same area as in Fig. 17 in 2025.

Red lines - oil palm plantation borders

These findings highlight a nuanced perspective: while there is significant interest in oil palm production and recognition of its economic potential, farmers remain cautious about transitioning from their existing agricultural practices.

Discussion

This discussion brings together the main findings of the study and connects them to broader ideas about rural livelihoods and agricultural development. It looks at how the Bidayuh community in Temong Mura is adapting their ways of making a living, showing how social and economic changes interact with their cultural traditions. The results demonstrate that while traditional forms of subsistence farming and forest resource use remain central to the community's way of life, these practices are increasingly mediated by generational shifts, external economic forces, and varying degrees of access to institutional support. This discussion combines different types of information to explore how the community benefits from having various ways to make a living and why they are cautious about growing oil palm. It also seeks to discover more inclusive and effective ways to support rural development.

Livelihood diversification remains a central strategy, consistent with Ellis' (1998) observation that rural households combine multiple sources of income. Our results show that while traditional practices such as rice and pepper cultivation persist, their scale is diminishing, especially among younger villagers. Labor shortages, urban employment opportunities, and changing aspirations have caused a shift in younger groups toward non-agricultural work and wage labour in cities. This is consistent with broader trends in Southeast Asia, where youth dissociation from traditional agriculture is increasingly common and sponsored by the parents that support this new trend with the funds that they obtain from palm oil and other monetary crops (Cramb & Sujang, 2012).

Both younger and older age groups in Temong Mura demonstrate a notable reliance on forest resources—particularly bamboo, rattan, and wild vegetables—highlighting the important role of forests in sustaining rural livelihoods. Nevertheless, the character of this dependency shows a generational difference, reflecting broader socio-economic transformations within the community. Survey findings reveal a significant reduction in forest product commercialization among younger respondents. This decline suggests a decreasing dependence on forest-derived income among younger villagers, likely influenced by a transition in their livelihood strategies. Younger groups are increasingly opting towards wage labour and non-agricultural employment, moving away from subsistence and forest-based activities. This shift aligns with wider regional trends across Southeast Asia, where rural youth are increasingly drawn to urban and service-sector

employment opportunities (Cramb & Sujang, 2012). Such changes resonate with Neefjes' (2000) conceptualization of the environment as a lived and relational space, shaped by evolving cultural and economic practices, detaching the new generations from the forest reliance.

The environmental assessments provided critical insights about the current land use. Soil samples from rice, pepper, and oil palm fields all show low pH values and nitrate levels. However, similar results in the community forest may suggest that inherent soil characteristics, rather than land use alone, are a primary limitation. This is particularly relevant for development planning - improvements in crop yield may require soil management interventions more than land-use changes, such as more efficient usage of fertilizers or allocating the different crops in specific locations (Tanaka et al., 2009). That being said, it is also important to mention that there are farmers that only copy what other farmers do, showing the lack of farming specific knowledge on applying fertilizers for example. Ending up on the possibility of causing more water pollution due to the run-offs from the farmlands (Tanaka et al., 2009).

Water quality analysis shows relatively stable pH and low to moderate nitrate/phosphate levels, suggesting limited fertilizer pollution, but they should still be monitored to avoid potential problems. Yet, conductivity and total dissolved solids increase in farming and residential zones, reflecting potential runoff effects. Also, the results here suggest that dissolved oxygen levels were inaccurately measured. Although bioindicator assessments show excellent ecological quality, future development should consider cumulative impacts of agricultural intensification on water bodies (Scanlon et al., 2007)**.**

A key contribution of this study is its insight into local decisions towards oil palm. Although interest in oil palm cultivation is growing, particularly among the younger and non-agriculture-dependent population, hesitancy persists due to financial and labour constraints but also due to the specific topography of the region, making it hard to plant and harvest palm oil. This ambivalence mirrors Soda et al.'s (2016) observation that smallholders see oil palm as both an opportunity and a risk. Villagers' desire for more support—both financial subsidies and educational training — indicates that any future Assisted Agricultural Development (AAD) should be co-designed with the community and responsive to their diverse needs.

Limitations and Reflections

This study had several limitations. Cultural dynamics may have influenced participant responses, particularly in group settings where male dominance shaped discourse. Consequently, the outcomes of our group methods, including focus group discussions and ranking exercises, primarily reflect male perspectives.

It is also worth mentioning that the 2 focus group discussions were held next to each other. The discussions were then affected by the noise of the other group, and it disrupted the dynamics inside, especially when participants from the "older group" were leaving and wanted to join the "younger group" discussion, some of them even interrupting the conversation.

Another limitation may be the overall reliance of the study on participant recall for past livelihood strategies, which could have been affected by memory bias. Also, an important limitation to mention is the language barrier between us and the villagers. This could have led to misinterpretation of both questions and responses, even with translation assistance.

For the household surveys, the intention was to interview one person per household. However, it was often found that in a household where several people lived, chosen respondents felt more comfortable in the presence of other family members, thus some surveys may reflect input of several individuals. multiple household members were present and wanting to contribute. Therefore, it is important to note that some surveys may reflect input from several individuals, potentially influencing the consistency of the responses.

The limited two-week fieldwork period restricted the ability to conduct comprehensive environmental sampling. Because of the limited time, only single-time soil sampling was conducted, which may not capture seasonal variations in soil properties. This constraint may explain the significant variations observed in nitrate and organic matter levels in soil samples from oil palm cultivation areas. A more extensive sampling process could have yielded more accurate and representative results and even specific interviews with the farmers of the sampled farming lands could have given more insights regarding the results, history of those specific pieces of land and soil management practices, whose variability could introduce inconsistencies. Regarding the water sampling, repeating the sampling on different days could have helped increase the reliability of the results. However, due to time limitations, staff and transport availability, and the lack of access to the necessary tools and field laboratory on other days, it was not feasible. The results suggest that the river control site has been impacted by nearby activities in the forest, likely

contributing chemicals to the river through runoff. To improve the reliability of future results, it would be beneficial to select a more upstream location as the control site. This would help determine whether runoff would occur even without human disturbance. Additionally, if there was more time, soil samples from the forest near the control site could have been taken to assess the potential impact of soil disturbance there on chemical contributions to the river. Also, to accurately evaluate nitrogen levels in the future, method that can measure all forms of nitrogen, not just ammonia, should be used. This will provide a more comprehensive assessment of nitrogen in the water. Additionally, better time management could have lessened some of these challenges. For example, incorporating social science methods earlier, rather than only focusing on natural science approaches at the beginning, may have alleviated some of the time constraints and reduced the feeling of being rushed toward the end of the fieldwork.

Regarding specific methods, when looking at the intermittent rainfall during soil sampling may have affected the consistency of our samples. Furthermore, for water sampling, rain is a critical factor as it can rapidly alter the chemical composition of water bodies, particularly due to surface runoff. These weather-related disruptions might account for the inconsistencies in our data, especially the unexpected low dissolved oxygen levels in water samples.

Despite these limitations, the research successfully triangulated diverse data sources— qualitative interviews, participatory methods, and environmental assessments—providing an in depth understanding of livelihood change in Temong Mura.

Conclusion

This research provides a nuanced understanding of the evolving livelihood strategies, forest resources use, and perspectives on future agricultural development in Temong Mura, a mainly Bidayuh community in rural Sarawak that relies on small-scale agriculture. Our findings show a complex but consistent story of change. This change is influenced by generational differences, limited support from institutions, and changing economic goals. Traditional practices such as rice and pepper cultivation remain present but have become increasingly constrained by labour shortages and farming costs — particularly among younger villagers who are pursuing a formal education or moving toward wage labour and outside urban employment.

Villagers now receive more support for fertilizer and pesticides than six years ago and have more road access, however, these remain ongoing challenges in agriculture, as some villagers still find the improvements to be insufficient.

While forest resources continue to play a central role in the daily lives of the community, their commercial use is declining, especially among younger groups. The comparative analysis of soil samples from agricultural sites and the community forest control suggests minimal anthropogenic impact from farming activity, as results are similar, and farming relies on non-mechanized methods with limited road access. Water sampling showed an excellent result with the biological indicators. Nonetheless, the chemical composition of the water may be affected by the extraction of forest products, beside the agricultural activities and residential area as well, as the river is located at the edge of a forest used for resource extraction.

Overall, Temong Mura is changing slowly over generations. The village neither resisted nor fully embraced change. Although oil palm cultivation is not widespread yet among Temong Mura residents, interest and future hope in this activity is definitely prevalent, with several residents mentioning its potential economic profitability but it is also seen with caution, particularly among those most economically dependent on farming. This underscores the need to create development programs that match the needs and concerns of rural communities. Future farming programs should involve local people in planning and include more than just financial support for fertilizer and pesticides, such as offering technical training or classes to farmers that

introduce modern farming techniques, as several villagers have recommended in the interviews.

Future research should take a longitudinal and comparative approach to better understand rural livelihoods in Sarawak. Some key areas for further investigation include long-term environmental impacts of land use change, gendered livelihood strategies, and intra-household decision-making. Additionally, examining the effectiveness of governmental and non-governmental support for smallholder oil palm cultivation, particularly in terms of technical training, market access, and subsidy allocation could provide insights into institutional influences on livelihood transitions. Expanding the geographic scope to other indigenous communities in Sarawak could offer comparative perspectives on cultural identity and resource use. This research would enhance empirical understanding and inform policy frameworks for regional development.

From a learning perspective, this research provided a valuable opportunity to engage in interdisciplinary fieldwork. By integrating qualitative and quantitative methods, bridging social and natural sciences, and incorporating both environmental assessments and diverse community perspectives—both individual and collective—our team developed a more holistic understanding of rural change. A diverse and representative sample population was gathered, including both men and women, as well as different age groups, allowing for a more comprehensive understanding of generational and social dynamics within the community. Ethical considerations were also considered throughout the research process and compensation in the form of food and drinks were provided to participants, as well as other villagers. Challenges were also encountered—cultural dynamics in group discussions, limitations in environmental data collection, and translation constraints—all of which taught the group the importance of adaptability, reflexivity, and modesty in field research. Most importantly, the experience illustrated the importance of careful and critical listening, and of approaching research not as a way of extracting information, but as a process of building relationships and giving voice to local communities.

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Appendices

Appendix 1. Table of applied methods

Applied method	Sample size	Date
Participatory mapping	1 map	25/02/2025
Community walk	5 x villagers	25/02/2025
Transect walk	1 x walk with local guides	26/02/2025
Soil samples (collected for further analysis in the lab)	8 x samples (2 samples from 4 sites)	28/02/2025
Visual soil assessment	8 x samples (2 samples from 4 sites)	28/02/2025
Water samples (collected and analyzed in the lab)	3 x samples (1 sample from 3 sites)	01/03/2025
Visual water assessment	3 x observations in water sampling sites	01/03/2025
Ranking and scoring exercise	2 x ranking and 2 x scoring	02/03/2025
Focus group discussion	2 x groups	02/03/2025
Household survey	51 x households	02/03/2025 - 03/03/2025
Semi-structured interview	7 x villagers	04/03/2025

Appendix 2. Revised research matrix

Overall research objective	Assessment of changes in rural livelihood strategies before 2019 and now (2025), natural resource management and investigation of future assisted agriculture development in Temong Mura, Malaysia.					
Research question	**Research objective**	**Sub-questions**	**Data required (variables)**	**Data collection method**	**Data analysis method**	**Practical considerations**
1. How have livelihood strategies in Temong Mura (rice and pepper cultivation) changed over the past 6 years (comparing the time before and after Covid-19)?	To assess the pattern of changes in rice and pepper cultivation in the Temong Mura community over the past 6 years.	1.1. How has rice cultivation changed over the past 6 years?	Rice farming practices (before 2019 and now) Changes in land use for rice cultivation (before 2019 and now) Reasons for changes in land use for rice cultivation	Literature review Transect walk Community walk Participatory mapping Focus group discussion Household surveys	Literature analysis Thematic analysis Statistical analysis	Ensure equal participation of both genders as focus groups will be divided by age (below 45 and over 45) Confidentiality of survey data Address biases in self-reported adaptations
		1.2. How has pepper cultivation changed over the past 6 years?	Pepper farming practices (before 2019 and now) Changes in land use for pepper cultivation (before 2019 and now) Reasons for changes in land use for pepper cultivation			
2. On what forest products are the Temong Mura villagers dependent the most?	To assess villagers' dependance (prioritization) on different forest resources.		Types of collected forest resources Usage of forest resources (subsistence vs selling)	Transect walk Community walk Ranking and scoring	Thematic analysis Statistical analysis	Ensure equal participation of both genders as ranking and scoring groups will be divided by

				Household surveys		age (below 45 and over 45)
3. What are the impacts of different types of farmlands used in Temong Mura on soil quality?	To assess and compare soil quality across different types of farmlands in Temong Mura.	3.1. What are the impacts of rice plantation on soil quality?	Visual soil characteristics Bulk density Ph level Nitrate level Control sample (community forest)	Soil sampling (core) in 3 places across rice plantation	Soil samples laboratory analysis Visual soil assessment Comparative analysis of chemical characteristics with control samples from community forest	Access to lab facilities for testing Having access to the land
		3.2. What are the impacts of pepper plantation on soil quality?		Soil sampling (core) in 3 places across pepper plantation		
		3.3. What are the impacts of oil palm plantation on soil quality?		Soil sampling (core) in 3 places across oil palm plantation		
				Soil sampling (core) in 3 places across community forest		
4. What are the impacts of farming areas and residential areas in Temong Mura on water quality?	To evaluate the impact of farming areas and residential areas on water quality in Temong Mura.	4.1. What is the impact of farming areas on water quality?	Dissolved oxygen level Ph level Electrical Conductivity	Water sampling after farming areas using water parameters measurement tool	Water samples laboratory analysis Water parameters analysis	Access to results provided by UNIMAS in their lab facilities

		4.2. What is the impact of farming areas and residential areas on water quality?	Nitrogen Phosphate Macroinvertebrates (water bioindicators) Control sample (community forest)	Water sampling after farming areas combined with residential areas using water parameters measurement tool	Visual water biodiversity assessment	Having access to the specific river location points for representative samples Weather conditions (crucial for how representative water sampling results are)
5. How do villagers in Temong Mura perceive assisted agricultural development (AAD) in relation to oil palm cultivation?	To address villagers' perceptions of future AAD in relation to oil palm cultivation.	5.1. How do farmers perceive future AAD in relation to oil palm cultivation?	Farmers knowledge of available AAD for oil palm cultivation Farmers' perceptions of future development of oil palm cultivation through AAD	Semi-Structured interviews Household surveys Aerial imagery	Thematic analysis Statistical analysis Image comparison	Consider local gender dynamics while interviewing women/men present at the same time in the household Address misconceptions about assisted agricultural development

Appendix 3. Questions for focus group discussions

1. Could you describe any changes that you have noticed over the past 6 years concerning the crops that you grow?
    a. Which crops did you stop growing?
    b. Which crops did you start growing?

2. Could you describe any changes that you have noticed over the past 6 years concerning rice cultivation?
    a. Why?
3. Could you describe any changes that you have noticed over the past 6 years concerning pepper cultivation?
    a. Why?
4. Could you describe what were the biggest challenges that you faced in your rice cultivation 6 years ago?
5. Could you describe what were the biggest challenges that you faced in your rice cultivation now?
6. Could you describe what were the biggest challenges that you faced in your pepper cultivation 6 years ago?
7. Could you describe what were the biggest challenges that you faced in your pepper cultivation now?
8. Could you describe any new strategies/activities/practices that you started using in order to adapt to these changes?
9. Is the younger generation interested in farming?
    a. Why yes?
    b. Why not?
10. For what crop would you like to receive support the most (government/community initiative)?
11. How can the community work together to sustain traditional farming?

The individuals were asked for consent to participate in this activity and to have the activity recorded.

Appendix 4. Interview guide for the semi-structured interviews

Introduction:

1. Could you tell us, in your opinion, what could be done to help the farmers increase income from agriculture?
2. Could you describe if young people in Temong Mura are still interested in farming? Why or why not?
3. For growing, what crops would you be interested in getting support?
    a. What kind of help for pepper/rice/other did you hear about?
    b. Have you ever received them before?
    c. Were you satisfied with the amount given?

Oil palm:

4. Could you tell us how you view the future of oil palm in Temong Mura?
5. Could you describe what are the positive and negative aspects of planting oil palm in your opinion?
    a. What about other aspects besides profitability?
6. Could you describe what challenges you see in starting oil palm production
7. Could you explain to us, if you would be willing to change the production of any other cash crop for oil palm?
    a. Which one and why?
8. Could you explain, what kind of help for oil palm production did you hear about (NGO's, association, government, etc)?
    a. If yes, how do you feel about cooperating with them?
    b. If not, would you like to learn more about them?
        i. Why?

The individuals were asked for consent to participate in this activity and to have the activity recorded.

Appendix 5. Household survey

A. Profile & Demographics

1. Name ***(Genan)***:
2. Gender: Male **(*Dari'*)** [ ] Female ***(Dayung)*** [ ]
3. What is your age ***(umur)***: _____
4. What are all your monetary income sources that currently apply to your household?
   (Anih sumber pendapatan kewangan da padan dengan abih mambe kinde?)

(household is the number of people living under the same roof and staying there permanently; in case of a longhouse, it is the number of people living in the same apartment and staying there permanently) (Select all that apply)
(pilih dapih indi da berkenaan)

a. Agriculture ***(kumenyang)***
b. Livestock ***(ngkudip binatang)***
c. Fishing ***(ngagau ikan)***
d. Wage labour ***(kerja bikuli/upah)***
e. Subsidies ***(subsidi/ bantuan kerajaan)***
f. Remittances ***(duit kirum)***
g. Rental income ***(asil sewaan)***
h. Business owner ***(pingampu bisnes)***
i. Pension ***(pencen)***
k. other ***(da beken)***_____

5. What is your main source of monetary income?
   (*Anih sumber pendapatan kinde?*)

_____

6. *If you are a farmer:* For how many years have you been farming?
   (*Kan kinde kireja birumeh: Meh kuduh sewa kinde kumenyang?*)

_____

B. Farming Practices & Crop Changes

7. What crops do you currently cultivate? (Select all that apply)
   (Anih da puruh kinden da masa iti? – pilih dapih indi da berkenaan)

a. Rice ***(pudoi)***
b. Pepper ***(lada)***
c. Oil palm ***(sawit)***
d. Rubber ***(petek)***
e. Fruits ***(bua')***
f. vegetables ***(penŭ)***
g. Others (please specify) ***(da beken – senaraikan)*** _____

8. Do you grow any crops for subsistence purposes?
   (Adehkah kinde puruh anih-anih pimuruh da beken?)

a. Yes ***(aye)*** b. No ***(kai)***

9. Compared to 6 years ago, how much land are you using for rice farming?

(Bibanding dengan 6 sewa da rimpas, mbŭh kuduh jumlah tana' da tinan kinde birumeh?)

a. Same amount ***(samah)***
b. Less than before ***(bikurang)***
c. More than before ***(bitambah)***
d. I do not grow rice ***(anyap mpuruh pudoi dayŭh)***

(If the inquired individual did answer "a. Same amount" or"d. I do not grow rice"" in question 9, then skip to question 11.)

10. In case of any change in your rice farming land use, what is the main reason?
(Anih pinyebab utama sekira nŭ adeh perubahan da tana' tinan kinde mpuruh pudoi dayŭh? – Cth: mbeh bitukar puruh keyuh. Pilih da padan dengan kinde)

a. Lower market price (not profitable) ***(rega da market kurang – anyap untung)***
b. Expensive fertilizers/pesticides ***(rega abok/racun mahar)***
c. Weather conditions ***(cuaca)***
d. Soil is no longer fertile (low yield) ***(tana' meh kai subur)***
e. Pests and plant diseases ***(binatang perosak/penyakit pimuruh)***
f. Not enough labor (young people prefer other jobs) ***(kurang tenaga kerja – bala pimujang lebih suka ngundah kerja beken)***
g. Government policy/land use change ***(polisi printah-perubahan pinguna tana')***
h. Subsidies ***(subsidi/pimantu printah)***
i. Health issues ***(mandam/ kai' sihat/masalah kesihatan)***
j. Change of employment ***(tukar kerja)***
k. I do not grow rice ***(anyep ngundah umeh dayŭh)***
l. Others (please specify) ***(da beken – senaraikan)*** _____

11. Compared to 6 years ago, how much land are you using for pepper farming?
(Bibanding dengan 6 sewa da rimpas, mbŭh kuduh jumlah tana' da tinan kinde mpuruh lada?)

a. Same amount ***(samah)***

b. Less than before ***(bikurang)***

c. More than before ***(bitambah)***

d. I do not grow pepper **(*anyap mpuruh lada)***

(If the inquired individual did not answer "a. Same amount" or "d. I do not grow pepper" in question 11, then skip to question 13.)

12. In case of any change in your pepper farming land use, what is the main reason? (Select all that apply)

    (Anih pinyebab utama sekira nŭ adeh perubahan da tana' tinan kinde mpuruh lada? – Cth: mbeh bitukar puruh keyuh. Pilih da padan dengan kinde)

a. Lower market price (not profitable) ***(rega da market kurang – anyap untung)***

b. Expensive fertilizers/pesticides ***(rega abok/racun mahar)***

c. Weather conditions ***(cuaca)***

d. Soil is no longer fertile (low yield) ***(tana' meh kai subur)***

e. Pests and plant diseases ***(binatang perosak/penyakit pimuruh)***

f. Not enough labor (young people prefer other jobs) ***(kurang tenaga kerja – bala pimujang lebih suka ngundah kerja beken)***

g. Government policy/land use change ***(polisi printah-perubahan pinguna tana')***

h. Subsidies ***(subsidi/pimantu printah)***

i. Health issues ***(mandam/ kai' sihat/masalah kesihatan)***

j. Change of employment ***(tukar kerja)***

k. I don't grow rice ***(anyep ngundah umeh dayŭh)***

l. Others (please specify) ***(da beken – senaraikan)*** _____

13. On a daily basis do you use any modern farming techniques?

    (Adehkah kinde minan chara/teknik pertanian moden?)

a. Yes ***(aye - senaraikan)*** _____ b. No ***(kai)***

C. Forest Products

14. Do you collect forest products? ***(Adehkah kinden ngegau keyuh da terun?)***

a. Yes ***(aye)*** _____ b. No ***(kai)***

(If the inquired individual did answer "b. no" in question 14, then skip to question 16.)

15. What forest products do you collect? ***(Anih keyuh terun da gagau kinde?)***

_____

16. Do you sell any of the forest products that you collect?

(Adehkah keyuh terun si'en tinan bijua?)

a. Yes ***(aye)*** _____ b. No ***(kai)*** c. Both ***(duweh-duweh)***

D. Future Support for palm oil production

(question for individuals that do not grow oil palm) :

(*soalan dadag inya da anyap mpuruh sawit*)

17. Do you plan on growing oil palm at any time in the future?

(Adehkah kinde merancang ira mpuruh sawit wang masa ije?)

a. Yes ***(aye)*** _____ b. No ***(kai)*** c. Maybe ***(Mungkin)***

(questions for both individuals that grow oil palm and that do not):

(soalan dadag inya da adeh mpuruh sawit dengan da anyap)

18. Would you be interested in receiving help from any governmental association?

    (Adehkah kinde berminat ira nerima bantuan masu anih-anih persatuan ato agensi printah?)

a. Yes ***(aye)*** _____ b. No ***(kai)*** c. Maybe ***(Mungkin)***

19. Would you be interested in participating in a community programme for oil palm production?

    (Adehkah kinde berminat ira suwe ngajah program komuniti dadag penghasilan sawit?)

a. Yes ***(aye)*** _____ b. No ***(kai)*** c. Maybe ***(Mungkin)***

Appendix 6. Household surveys (collected data)

Household surveys data

Appendix 7. Water quality lab analysis (physical and chemical parameters) results

Water sampling results

Appendix 8. Soil lab analysis and visual soil assessment results

Soil sampling results

Appendix 9. Synopsis

Practicing Interdisciplinary Field Research on the Environment
2025

Synopsis

Assessment of changes in livelihood strategies in Temong Mura community (Sarawak, Malaysia) between 2020 and 2025 due to the impact of COVID-19, as well as, the past, present and future management of natural resources and exploring the lack of assisted agricultural development in the area.

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1. Introduction

Rural livelihoods are shaped by a dynamic interplay of social, economic, and environmental factors, particularly in communities that rely heavily on natural resources for their sustenance. This report uses the Chambers and Conway (1992) understanding that rural livelihoods 'comprise the capabilities, assets and activities required for a means of living.' Livelihood strategies are influenced by access to these assets (human, social, physical, natural, financial) as well as environmental pressures and economic shifts.

Shifting cultivation, also referred to as swidden agriculture, is a traditional farming practice that has played a crucial role in sustaining livelihoods in regions such as Sarawak, Malaysia (Cramb & Sujang, 2013). This form of cultivation involves rotating fields rather than crops, where land is cultivated for a few years before being left fallow for an extended period, allowing the soil to regain its fertility. It predominantly relies on household labour, which retains autonomy and self-determination in farming practices, although practitioners are often embedded within communities that share resources and adhere to customary regulations. While traditional methods and tools are primarily employed, certain tasks, such as milling, have the potential for mechanization (Cramb & Sujang, 2013). Shifting cultivation affects rural livelihoods in our study site to a certain extent due to its provision of food security, and income and it can also be closely tied to communities' cultural identity (Erni, 2015). However, over time people in communities have been discarding this type of cultivation over cash crops or even economic migration in order to improve their level of livelihood. (Nwanesi & Samat, 2021)

1.1. Study site

Our study is based in the Temong Mura community, Sarawak, Malaysia. This primarily Bidayuh settlement is inhabited by about 130 households with a population of 667. While most of the inhabitants make their living in the village, about 20% of this population work and live in towns. Most households continue shifting cultivation of upland rice as their subsistence activity. For cash income, they cultivate pepper. A new crop in Temong Mura is oil palm. However, very few households cultivate it because of the hilly terrain and inconvenient transport. Moreover, villagers who do not earn either subsistence or cash income in the village, engage in jobs and contract work outside Temong Mura in neighbouring villages or small towns or work in public and private sectors in further located urban towns.

1.2. Research objective and questions

Through this research, there is the aim to assess the changes in livelihood strategies in the Temong Mura community, examining how these strategies have evolved from the past to the present, and projecting future trends. Additionally, it will investigate the management of natural resources over time and explore the implications of limited agricultural assistance in the area. The

study focuses on the period of the last 5 years (2020-2025) in order to take into consideration local community members' memory recollection ability and due to the great impact of COVID-19 pandemic that affected multiple communities all around the world.

In doing so, it will try to answer four main research questions:

1. How have the livelihood strategies in the Temong Mura community evolved over the past 5 years regarding, among other factors, the effects of Covid-19?
2. What cash income sources do villagers prioritise and what's their perception of them?
3. How do different types of farming and agroforestry practices impact soil fertility, soil structure and forest regrowth?
4. How do local farmers and regional representatives perceive the future potential for assisted agricultural development in Temong Mura?

The first research question aims to identify whether any changes have occurred in subsistence farming, cash crop farming, and off-farm employment over the past five years. Additionally, the study seeks to examine coping mechanisms that may be present in the research area in response to potential shifts in livelihood strategies, such as agroforestry.

The second research question focuses on investigating the prioritization of cash income sources by villagers and their perceptions of these sources. The study aims to gain deeper insights into how the local community perceives different cash income-generating activities and the factors that influence these perceptions.

The third research question explores the impact of various farming and agroforestry practices on soil fertility, soil structure, and forest regrowth. To assess soil fertility and soil structure, soil pH levels and nitrate concentrations will be analyzed, as well as a visual soil assessment will be conducted, while forest regrowth will be examined through changes in vegetation cover.

Lastly, the fourth research question addresses how local farmers and regional representatives perceive the future potential for assisted agricultural development in Temong Mura. The investigation seeks to identify the factors that influence local farmers' attitudes toward adopting new agricultural practices, including both perceived benefits and barriers to adoption. Additionally, the study will examine the factors shaping regional support for agricultural development, with a particular focus on institutional policies and funding availability as potential constraints on the implementation of assisted agricultural initiatives in the region.

2. Methodology

This section delineates the research design, data collection methods, and analytical approaches employed to examine the evolution of livelihood strategies within the Temong Mura community. As outlined previously, this study seeks to investigate the temporal progression of these strategies,

identify key drivers of change, and project future trajectories. The adoption of a mixed methods approach ensures a comprehensive and multi-dimensional understanding of these transformations by integrating diverse methodological frameworks (Bergman, 2008). This approach enhances the depth and broadness of the analysis, facilitating a more nuanced exploration of the complexities surrounding the topic of research (Nightingale, 2003).

2.1. Focus group discussions

Beginning with a more qualitative approach, this study will conduct a focus group discussion. It is a small-group discussion guided by a moderator to gather in-depth insights on a specific topic or product. Participants share their opinions, beliefs, and attitudes. Moreover, it enables us to analyze the group dynamic and processes that might be helpful to answer the first research question (Flick, 2022). It is aimed at providing deep insights into participants' experiences and perspectives concerning changes of livelihood strategies, in this research specifically subsistence agriculture, cash crop agriculture and non-farming employment outside the village. Besides, these focus group discussions aim to create a suitable environment to talk about different coping mechanisms villagers created in order to adapt to changes they observed throughout the past 5 years as the effect of Covid-19. There will be 2 focus groups divided in terms of age: a. below/ including 35 years and old b. over 35 years old, as perspectives regarding changes that occurred in the past might differ among generations. The collected data will be analyzed through coding and triangulated with additional insights gathered from household surveys.

2.2. Household income surveys

This study wants to complement data gathered through focus group discussions with a more quantitative approach - two short household income surveys. This method aims to address specifically sub-questions regarding changes in cash crop agriculture and non-farming employment outside the village. It will inform us about what changes concerning these two livelihood strategies generating income households experienced, whether they perceive their general income levels to change over the past 5 years and what factors they think caused this. Conducting household income surveys at the beginning would create the opportunity to choose potential focus group discussions participants based on their responses.

2.3. Ranking and Scoring exercises

To gather the necessary data for addressing the second research question, another Participatory Rural Appraisal (PRA) method—ranking and scoring exercises—will be employed. This approach will enable participants to prioritize their monetary income sources and evaluate them based on specific criteria, providing insights into villagers' preferences.

The first step in this process involves asking participants to rank ten monetary income sources in order of perceived importance, from most to least significant. Subsequently, participants will be asked to assign a score (ranging from 1 to 5) to each income source, assessing its reliability,

sustainability, and profitability. The data obtained through this method will be further complemented by information gathered from semi-structured interviews with participants.

2.4. Semi-structured interviews

To complement the second research question and fully address the fourth research question, semi-structured interviews will be conducted. This method allows for an in-depth exploration of individual perspectives and experiences that cannot be captured through surveys, as it facilitates a dialogue between the interviewer and interviewee (Brinkmann, 2020).

The first set of interviews will focus on the sub-question regarding the factors that influenced participants' choices in the ranking and scoring exercises. This will help determine whether cultural, environmental, or governmental factors played a role in shaping their decisions.

Furthermore, to address the final research question, additional interviews will be conducted with local farmers and regional representatives. A purposive sampling approach will be employed to ensure the inclusion of respondents with relevant experiences. Interviews with local farmers will seek to understand their perspectives on the potential adoption of new agricultural practices, including perceived benefits and barriers. Additionally, insights will be gathered from a regional representative of SALCRA, an organization involved in local agricultural development. These interviews are expected to provide valuable data on the factors influencing regional support for agricultural development, such as funding availability and institutional regulations.

2.5. Soil sampling

Another employed method in this study will be soil sampling, which is essential for assessing how different agricultural practices and land use types influence soil quality. The sampling strategy will be determined based on the terrain, which will be evaluated during initial site visits.

For flat areas, a random sampling approach will be utilized. In contrast, for hilly areas, stratified sampling will be implemented, as different sections of the hill may exhibit varying soil characteristics. Collecting samples from multiple sections will allow for a more accurate estimation of average soil conditions.

Soil samples will be collected from all identified farmland types using core sampling. The analysis will focus on pH levels to assess nutrient availability and nitrate concentrations, providing insights into soil fertility. Additionally, this assessment will help determine the extent of fertilizer use, particularly whether excessive application may pose risks to biodiversity and other natural resources, such as water quality.

2.6. Visual soil assessment

Furthermore, to obtain additional data on soil fertility and soil structure, the study will incorporate visual soil assessment. This method aims to provide insights into variations in the A

horizon across different land types, including secondary forests, farmland, fallow land, improved fallow, and managed fallow.

Utilizing this approach will offer a clearer understanding of how various land-use practices influence soil fertility and structure, as humus, a key component of soil fertility, is located within the A horizon. Notable differences are expected to be observed between secondary forest areas and farmland, reflecting the impact of land-use changes on soil properties.

2.7. Remote sensing

To assess forest regrowth, remote sensing will be utilized, which allows for the examination of an area without direct physical contact (Kirman, 1997). This method will facilitate a comparison between primary and secondary forests, enabling an assessment of forest regrowth in post-agricultural areas.

Historical satellite images from 2019 will be used alongside aerial imagery captured by drones to analyze changes in forest cover over time. This approach will provide a comprehensive evaluation of vegetation recovery and landscape transformation in the studied areas.

3. Limitations

Every research method has its limitations. In the case of social science methods, household surveys often face challenges such as high non-response rates or inaccurate reporting, particularly due to the sensitive nature of income-related information. To mitigate this issue, specific income figures were excluded from the survey.

In focus group discussions, there is a potential risk of dominant voices, particularly among vocal male participants, as selection will be based on age rather than gender. Additionally, personality differences may influence participation, with more extroverted individuals contributing disproportionately, while others may feel reluctant to share their views. To address this, moderators will actively encourage fewer vocal participants to contribute by directly engaging them in the discussion.

Semi-structured interviews present additional challenges, as they are less structured than surveys, making them more difficult to plan and analyze. Since these interviews aim to facilitate open conversations, they may require more time than anticipated. To accommodate this, flexibility has been built into the research schedule to allow for extended interview sessions if necessary.

Regarding remote sensing methods, challenges may arise due to image resolution limitations or cloud cover in satellite imagery. While drone images are intended to supplement this data, adverse weather conditions, such as rain, may prevent their collection. In such cases, reliance on local villagers' knowledge of the area may serve as an alternative means of verification.

For soil sampling, representativeness may be an issue, particularly in large or topographically diverse areas. Sampling in hilly terrain poses additional challenges, as soil characteristics can vary significantly depending on the location within the slope. Furthermore, if farmland diversity within the village is limited, comparisons of soil quality may be constrained.

4. Positionality

While conducting fieldwork, it is essential to remain aware of positionality, as it can influence both the research process and its outcomes (Holmes, 2020). Upon arrival, there will be limited knowledge of the social norms within the Temong Mura community, and it remains uncertain to what extent this gap may affect the research. Researchers may be perceived as outsiders or unfamiliar with local customs, which could impact interactions and data collection.

To address this, flexibility and transparency will be prioritized throughout the research process. If necessary, methodological adjustments will be made to foster trust within the community and ensure that the research is conducted in a manner that is both ethically sound and mutually beneficial.

5. Planned schedule of field work

Day	Testing+ translating	Income surveys	Focus groups	Ranking and scoring	Interviews for ranking and scoring	Soil sampling	Remote sensing	Interviews with farmers	Interview with SALCRA	Visual soil assessment
1	Whole day									
2		Evening (split into two groups)				Morning				
3		Evening (split into two groups)				Morning				
4			Evening (split into two groups)				Morning			
5				Evening			Morning			
6					Evening (split into two groups)					Morning
7					Evening (split into two groups)					Morning
8								Evening (split into two groups)		

9								Evening (split into two groups)	Whole day (until evening)	
10									Just in case day: for repeating methods or unplanned issues	

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7. Appendix

7.1. Research matrix

Overall research objective	Assess the changes in livelihood strategies in Temong Mura community between 2020 and 2025 due to the impact of COVID-19, as well as, the past, present and future management of natural resources and address the lack of assisted agricultural development in the area.				
Research 9uestions	**Sub-questions**	**Data required (variables)**	**Data collection method**	**Data analysis method**	**Practical considerations**
1. How have the livelihood strategies in the TemongMura community evolved over the past 5 years regarding, among other factors, the effects of Covid-19?	**1.1** How have subsistence farming activities changed over the past 5 years?	Farming practices Crop varieties Productivity trends	Literature review Focus group discussions Income surveys (for 1.2 and 1.3.)	Thematic analysis of responses Comparative analysis	Ensure participation through culturally sensitive discussions Confidentiality of income data Anonymity of income data
	l.2. How have cash crop income activities changed over the past 5 years?	Changes in types of cash crops Changes in cash crop income levels Types of employments			
	1.3. How have non-farming sources of income outside the village changed over the past 5 years?	Changes in non-farming cash income levels			
	1.4 Are there any adaptive strategies being adopted by the villagers to address changes of livelihoods?	Changes in work patterns Coping mechanisms			Address biases in self-reported adaptations
2. What cash income sources do villagers in TemongMura community prioritise and what's their perception of them?		Types of cash income sources Villagers' prioritisation of income sources Villagers' perception of factors influencing these monetary income sources	Semi-structured interviews Ranking and Scoring exercises	Thematic analysis of responses (using nVivo)	
3. How different types of farming and agroforestry	3.1. How are different types of farmland/ agroforestry (taungya, shifting cultivation, home garden...) affecting soil fertility and soil	Soil pH Nitrate concentration Type A horizons	Quadrat soil sampling (space per time) Visual soil assessment	Comparative soil analysis	Access to lab facilities for testing - having access to the land

impacting soil fertility, soil structure and forest regrowth?	structure?				
	3.2. How are different types of farmland/ agroforestry (taungya, shifting cultivation,...) affecting forest regrowth?	Changes of vegetation cover	Satellite data Drone images	Comparative satelite/ drone images analysis	Availability of satellite imagery Accuracy of drone images
4. How do local farmers and regional representatives perceive the future potential for assisted agricultural development in Temong Mura?	4.1. What factors influence local farmers' attitudes towards adopting new agricultural practices?	Perceived benefits Perceived barriers	Semi-structured interviews with farmers	Thematic analysis	Address misconceptions about assisted development
	4.2. What factors influence regional support for agricultural development?	Benefits for farmers Way of addressing existing barriers Institutional policies Funding availability	Semi-structured interviews with regional representatives (eg. SALCRA)	Thematic analysis Policy evaluation	Ensure representation of key stakeholders

7.2. Draft income survey nr 1

How have cash crop income activities changed over the past 5 years?

Introduction: Thank you for your participation. Your answers are going to be used in our research project which aims to investigate livelihood strategies, natural resource management and assisted agriculture development in the Temong Mura community in Sarawak, Malaysia. This survey is about exploring how your cash crop income activities changed over the past 5 years due to the influence that COVID-19 had on livelihoods in Temong Mura. The survey is voluntary, confidential and anonymous, your personal information will not be shared and you have the possibility to withdraw from the study at any point. .

(*) - mandatory questions, just for us to know when we'll do the survey in Google forms/SurveyXact

1. **Do you consent to participate in the survey? (*)**

   □ Yes
   □ No

2. **What is your age? (*)**

   □ Under 20
   □ 20-30
   □ 31-50
   □ 51-60
   □ Above 61

3. **What is your gender? (*)**

   □ Male
   □ Female
   □ Other
   □ Prefer not to say

4. **How many people live in your household? [household - the number of people living under the same roof (in case of a longhouse divided into separate apartments - the number of people living in a separate apartment)] (*)**

□ 1-2
□ 3-5
□ 5-8
□ Above 8

5. **Please check <u>all</u> the monetary income sources that currently apply to your household: (*)**

□ Agriculture
□ Livestock
□ Fishing
□ Wage labour
□ Subsidies
□ Remittances
□ Rental income
□ Business owner
□ Other
If "other", please specify: ……

6. **Which types of crops do you currently grow? (Select <u>all</u> that apply): (*)**

□ Coffee
□ Cocoa
□ Tea
□ Sugarcane
□ Fruits
□ Vegetables
□ Rice
□ Oil palm
□ Black Pepper
□ White Pepper
□ Rubber
□ Other
If "other", please specify: ……

7. **Are the crops you grow currently different from the ones you grew 5 years ago? (*)**

□ Yes
□ No
□ Some of them

If 'no' to question 7, please go to question 10.

8. **To your best knowledge, what crops did you grow 5 years ago?) (only if answer to q.8. Is "yes" or "some of them")**

□ Coffee
□ Cocoa
□ Tea
□ Sugarcane
□ Fruits
□ Vegetables
□ Rice
□ Oil palm
□ Black Pepper
□ White Pepper
□ Rubber
□ Other
If "other", please specify: ……

9. **Rank your top 3 monetary income sources <u>from 5 years ago</u> based on their profitability (1st - the most profitable): (only if answer to q.8. Is "yes" or "some of them")**

1st ……..
2nd ……
3rd …….

10. **Rank your <u>current</u> top 3 monetary income sources based on their profitability (1st - the most profitable): (*)**

1st ……
2nd ……..

3rd ……

11. Have you started to grow any new crops in the past five years? (*)

□ Yes
□ No

If 'no' to question 11, please go to question 13.

12. What crop have you started to grow in the past five years? (only if answer to q.11. is "yes")

□ Coffee
□ Cocoa
□ Tea
□ Sugarcane
□ Fruits
□ Vegetables
□ Rice
□ Oil palm
□ Black Pepper
□ White Pepper
□ Rubber
□ Other
If "other", please specify: ……..

13. Have you stopped growing any cash crops in the past five years? (*)

□ Yes
□ No

If 'no' to question 13, please go to question 15.

14. What cash crop did you stop growing in the past five years? (only if answer to q.13. is "yes")

□ Coffee
□ Cocoa
□ Tea

□ Sugarcane
□ Fruits
□ Vegetables
□ Rice
□ Oil palm
□ Black Pepper
□ White Pepper
□ Rubber
□ Other
If "other", please specify:.....

15. How do you perceive the change in your monetary income from cash crops over the past 5 years? (*)

□ Increased significantly
□ Increased slightly
□ Remained the same
□ Decreased slightly
□ Decreased significantly
□ I don't know

If 'remained the same', *end of survey.*

16. If there has been a change in your monetary income from cash crops, what factors do you think contributed to this change? (Select all that apply) (only if answer to q.15. is different than "remained the same")

□ Improved transportation
□ New skills or education
□ Changes in family situation (eg. family migration)
□ Economic changes in nearby urban areas
□ Government policies or programs
□ Adoption of new agricultural practises or technologies
□ Changes of natural environment in your village (e.g., changes of soil quality, changes of climate conditions necessary for crop cultivation)
□ I don't know
□ Other
If "other", please specify:.....

7.3. Draft income survey nr 2

How have non-farming sources of income outside the village changed over the past 5 years?

Thank you for your participation. Your answers are going to be used in our research project which aims to investigate livelihood strategies, natural resource management and assisted agriculture development in the Temong Mura community in Sarawak, Malaysia. This survey is about finding out how non-farming monetary income sources outside the village have changed over the past 5 years due to the influence that COVID-19 had on livelihoods in Temong Mura. The survey is voluntary, confidential and anonymous, your personal information will not be shared and you have the possibility to withdraw from the study at any point.

(*) - mandatory questions, just for us to know when we'll do the survey in Google forms or other tool

1. **Do you consent to participate in the survey? (*)**

   □ Yes
   □ No

2. **What is your age? (*)**

   □ Under 20
   □ 20-30
   □ 31-50
   □ 51-60
   □ Above 61

3. **What is your gender? (*)**

   □ Male
   □ Female
   □ Other
   □ Prefer not to say

4. **How many people live in your household? [household - the number of people living under the same roof (in case of a longhouse divided into separate apartments - the number of people living in a separate apartment)] (*)**

□ 1-2
□ 3-5
□ 5-8
□ Above 8

5. **Do you currently earn <u>any monetary income</u> from non-farming activities outside your village? (*)**

□ Yes
□ No

If 'no' to question 5, please skip to question 9.

6. **What types of non-farming monetary income sources outside your village do you currently have? (Select <u>all</u> that apply): (only if "yes" to q.5.)**

□ Permanent job with regular salary (you receive a fixed amount of income on a regular basis)
□ Odd job/ contract work (e.g., carpentry, house building)
□ Small business ownership
□ Remittances from family members
□ Rental income
□ Pension
□ Other
If "other", please specify: ……..

7. **Rank your top 3 non-farming monetary income sources outside your village based on their profitability (1st - the most profitable): (only if "yes" to q.5.)**

1st …….
2nd ……
3rd ……..…

8. **How often do you engage in non-farming income activities outside your village? (only if "yes" to q.5.)**

□ every day
□ few times a week
□ once a week
□ once every two weeks
□ once a month
□ Other

If “other”, please specify:.....

9. **To your best knowledge, did you earn <u>any monetary income</u> from non-farming activities outside your village 5 years ago? (*)**
□ Yes
□ No

If "no" to question 9, please skip to question 12.

10. What types of non-farming monetary income sources did you have outside your village 5 years ago? (Select <u>all</u> that apply): (only if “yes” to q.9.)

□ Permanent job with regular salary (you receive a fixed amount of income on a regular basis)
□ Odd job/ contract work (e.g., carpentry, house building)
□ Small business ownership
□ Remittances from family members
□ Rental income
□ Pension
□ Other
If “other”, please specify: ……..

11. Rank your top 3 non-farming monetary income sources outside your village from 5 years ago based on their profitability (1st - the most profitable): (only if “yes” to q.9.)

1st …….
2nd ……
3rd ……..…

12. How do you perceive the change in your non-farming monetary income outside your village over the past 5 years? (*)

□ Increased significantly

□ Increased slightly
□ Remained the same
□ Decreased slightly
□ Decreased significantly
□ I don't know

If 'remained the same', *end of survey.*

13. If there has been a change in your non-farming monetary income, what factors do you think contributed to this change? (Select all that apply) (only if answer to q.12. is different than "remained the same")

□ New job opportunities
□ Loss of a previous job
□ Improved transportation
□ New skills or education
□ Changes in family situation (eg. family migration)
□ Economic changes in nearby urban areas
□ Government policies or programs
□ Changes of natural environment in your village (e.g., changes of soil quality, changes of climate conditions necessary for crop cultivation)
□ I don't know
□ Other
If "other", please specify:.....

7.4. Draft focus group discussion guide

How have the livelihood strategies in the Temong Mura community evolved over the past 5 years?

(focus group discussion aims to address all sub questions of R.Q.1.: subsistence farming, cash crop agriculture, non-farming income sources outside the village; coping and adaptation mechanisms; we would like to conduct 2 focus group discussion where participants will be differentiated by age)

1. Could you describe any changes that you have noticed over the past 5 years (since COVID-19 until now) concerning crops that you grow for subsistence?

    a. Follow-up: Have you stopped growing certain crops? Have you started growing new crops?
2. Could you explain, due to what factors/reasons do you think that these changes happened?
3. Could you describe any new strategies/activities/practises that you started using in order to adapt your subsistence agriculture to effects caused by COVID-19 over the past 5 years?
4. Could you describe any changes that you have noticed over the past 5 years (since COVID-19 until now) concerning cash crops that you grow in order to sell them?
5. Could you explain, due to what factors/reasons do you think that these changes happened?
6. Could you describe any new strategies/activities/practises that you started using in order to adapt your cash crops agriculture to effects caused by COVID-19 over the past 5 years?
7. Could you describe any changes that you have noticed over the past 5 years (since COVID-19 until now) concerning non-farming employment outside your village?
8. Could you explain, due to what factors/reasons do you think that these changes happened?

7.5. Draft Ranking & Scoring exercises

7.5.1. Ranking exercise

Please rank the following monetary income sources based on how you prioritize them in terms of importance to you. (ranking on a scale 1-10; 1 - the most important, 10 - the least important)

> *Importance - the overall value that you derive from work, encompassing both material financial compensation and immaterial benefits.*

Monetary income source	**Ranking**
Cash crop agriculture	
Livestock	
Fishing	
Odd job/ contract work	
Business ownership	
Remittances from family members	
Pensions	
Rental income	

Subsidies from the government or organizations	
Other (please specify, which other source of monetary income applies to you): ……	

7.5.2. Scoring exercise

For each of the following monetary income sources, please score your perception of its:

a) *Reliability* - to what extent does this source guarantee you earn consistent monetary income, to what extent this source is resilient to different risks (e.g., economic shocks, natural disasters, demography fluctuations) (1 = the least reliable, 3 = neutral, 5 = the most reliable)
b) *Profitability* - how efficiently your work is converted into monetary income that you can use (1 = the least profitable, 3 = neutral, 5 = the most profitable)
c) *Sustainability* - this source allows a consistent earning of a consistent income that lasts for a long time (1 = the least sustainable, 3 = neutral, 5 = the most sustainable)

Cash income source	**Reliability**	**Profitability**	**Sustainability**
Cash crop agriculture			
Livestock			
Fishing			
Odd job/ contract work			
Business ownership			
Remittances from family members			
Pensions			
Rental income			

Subsidies from the government or organizations			
Other (please specify, which other source of monetary income applies to you): ……			

7.6. Draft semi-structured interview guide nr 1 (respondents: villagers from Ranking & Scoring exercises)

Introduction: Thank you for joining us today. We would like to inform you that your participation is voluntary and you can withdraw at any point during our conversation. Your answers are going to be used in our research project which aims to investigate livelihood strategies, natural resource management and assisted agriculture development in the Temong Mura. We would like to discuss with you in a more detailed way what factors influenced your choices in the earlier conducted ranking and scoring exercises.

1. What is your primary source of income - from which activity do you earn the most money?
2. Could you describe any cultural practices that influenced your ranking of monetary income sources, if there are any?
3. Could you describe any environmental factors that influenced your ranking of monetary income sources, if there are any?
4. Could you describe any governmental practices that influenced your ranking of monetary income sources, if there are any?
5. In what ways did access to resources (e.g., land, capital, skills) influence your ranking?
6. In the future, would you like to make any changes to your current primary source of income?

   Follow-up: if yes, could you explain why?

7. In the first exercise (ranking) how did you understand the "importance" of the monetary income source?

   Follow-up: To what extent did the "profitability" factor of each monetary income source influence your ranking?

8. In the second exercise (scoring) what did you take into consideration while scoring "reliability" of each monetary income source?
9. In the second exercise (scoring) what did you take into consideration while scoring "sustainability" of each monetary income source?

7.7. Draft semi-structured interview guide nr 2 (respondents: farmers from the village)

What factors influence farmers' attitudes towards new agricultural practices?

Introduction: Thank you for joining us today. We would like to inform you that your participation is voluntary and you can withdraw at any point during our conversation. Your answers are going to be used in our research project which aims to investigate livelihood strategies, natural resource management and assisted agriculture development in the Temong Mura. We would like to discuss with you the future of agriculture in your community, particularly regarding any new farming practices that may be introduced. Your responses will help us understand the attitudes and perceptions of local farmers regarding future agricultural development.

Introductory question

1. Could you please introduce yourself?

Overall understanding

2. Could you tell me, how do you view the future of agriculture in Temong Mura? (How do you view the future of oil palm production in Temong Mura?)
3.
4. Could you describe any new agriculture technologies being used in Temong Mura, if there are any?***examples not for reading out loud**, only if they don't have any idea what to answer: eg. new farming equipment like tractors, irrigators, harvesters)
5. Could you describe any agricultural practices being applied in Temong Mura, if there are any?

   (* **examples not for reading out loud**, only if they don't have any idea what to answer:eg. agroforestry, crop rotation, irrigation methods, harvesting)

Follow-up: Could you explain in what way technologies or practices that you mentioned/ described are being introduced with the help of the government or organizations?

Awareness of New Agricultural Practices

6. What agricultural practices are you aware of that are not used in Temong Mura?

Follow-up: How do you feel about these practices? How do you feel about practices already being used in Temong Mura? (what to look for in the answers: if they are interested in trying them or not really)

Factors Influencing Farmers' Attitudes Toward New Practices

7. What factors influence your decision about adopting a new agricultural practice?

Follow-up.: if they don't mention - What economic factors (eg. cost, income potential) influenced your decision making? (Bias-leading question)

Follow-up : if they don't mention - What environmental factors (eg. soil degradation, water pollution) influenced your decision making?

Perceived Benefits of New Agricultural Practices

8. What outcomes do you expect to obtain from adopting new agricultural practices?
9. What do you see as the main benefits of adopting new agricultural practices? (e.g. economic: increased crop production, increased total household income; social: increased food availability, better community relations; environmental: improved soil quality, …..)

Follow-up: if they don't see benefits - What do you see as main disadvantages of adopting new agricultural practices?

Barriers to Adoption

10. What challenges or barriers do you face when considering new agricultural practices (eg. financial costs, lack of knowledge, lack of training, uncertainty about long-term results?)
11. In what way do traditional farming methods conflict with modern practices?

Role of Local Representatives and Support

12. Could you tell me what you think about receiving help from local government or regional representatives with adopting new agricultural practices (e.g. financial support, access to technologies, access to market, training)?

Follow-up: As for now, what do you think about the current support of the government or NGOs in Temong Mura to help farmers with transition to new agricultural practices?

7.8. Draft semi-structured interview guide nr 3 (respondent: representative from SALCRA organization)

What factors influence regional support for agricultural development?

Introduction: Thank you for agreeing to participate in today's interview. We would like to inform you that your participation is voluntary and you can resign at any point during our conversation. Your answers are going to be used in our research project which aims to investigate livelihood strategies, natural resource management and assisted agriculture development in the Temong Mura community in Sarawak, Malaysia. We chose you as a participant, as your organization plays an important role in helping different parts of Sarawak region in agricultural development, mainly through oil palm plantations, however not only. Therefore, we are interested in your responses connected to these other supporting activities in which your organization is engaged.

Introductory questions

1. Could you introduce yourself?

Overall understanding of SALCRA

2. Could you tell me more about the presence of SALCRA across Sarawak region?

Follow-up: What factors influence SALCRA activity in new areas?

3. Could you describe in what way SALCRA engages in agricultural development across Sarawak region?
4. Could you explain, in what way SALCRA can engage in agricultural development of those parts of Sarawak in which terrain is not suitable for developing oil palm plantations? (context-specific question, as palm oil development is SALCRA's main activity, however it's not really feasible in Temong Mura due to hilly terrain)

Potential outcomes of assisted agricultural development for local communities

5. When SALCRA expands to new areas, in what way local farmers are receiving support needed to implement new projects?
6. What long-term benefits SALCRA brings to areas where it's active (e.g. increased crop production, improved food security, increased income, improved soil quality)?
7. In what way can SALCRA address barriers to assisted agricultural development perceived by local farmers (e.g. financial costs, lack of knowledge, lack of training, uncertainty about long-term results, distrust towards modern technologies)?

Funding availability and institutional policies

8. Could you describe what factors influence participant selection for *Aktiviti Ekonomi Tambahan (AET)* programme funded by the *Ministry of Rural and Regional Development* to support economic activities of SALCRA participants, through which local landowners could receive funding assistance?
9. What specific incentives or assistance programs does SALCRA offer to smallholders to improve their productivity and income?
10. In what way, does SALCRA collaborate with other state agencies?