The Rise of Oil Palm Forests: small-scale oil palm cultivation as a livelihood strategy

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Abstract

Oil palm cultivation is a major source of income for many living in Sarawak, Malaysian Borneo. Since the introduction of *Konsep Baru* (New Concept), oil palm cultivation increasingly happens on Native Customary Rights territory. The present case study was conducted during a field trip of 10 days living among an Iban community to investigate the impact of small and large-scale oil palm cultivation on their livelihoods as well as their land use practices related to oil palm. Our findings show a trend in the popularization of small-scale cultivation in particular. Thus, our analysis focused on this as a livelihood strategy and analyzed how it impacts both their livelihoods as well as the surrounding physical environment. Specifically, we adopted the Sustainable Livelihoods Framework to analyze our results. To measure the environmental impact we looked at soil health, biodiversity, carbon storage, and water quality. Our results show that there are many socio-economic benefits to small-scale cultivation although there are barriers to entering into it. On the environmental side, we found a relatively small negative impact from small-scale cultivation. While our results mainly seemed in favor of small-scale oil palm cultivation, the concerns about deforestation which are often voiced may still be relevant if the cultivation of oil palm continues to expand.

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Introduction

"A hungry monkey is better than a hungry man." - Key informant.

Oil palm has been at the center of controversies over the last 20 years. It has become increasingly stigmatized because of its relation to deforestation, its impact on biodiversity and natural forest ecosystems, and its contribution to climate change. Oil palm production releases large amounts of carbon dioxide from converted peatlands and forested areas into the atmosphere (Koh & Wilcove, 2008; Danylo et al., 2021). However, oil palm has also contributed to economic development and lifted people in rural areas out of poverty (Hasan & Nur Hidayat, 2018). It is a highly productive crop with an exceptionally low land footprint compared to annual oilseed crops (Murphy, Goggin, & Paterson, 2021). As a result of this efficiency, there has been a drastic increase in palm oil production compared to other vegetable oils over the last 40 years. Oil palm, indigenous to Africa, was first introduced to Malaysia in 1875 and planted for commercial purposes in 1917 (Cramb & Curry, 2012). In 2021, Malaysia, Indonesia, and Thailand accounted for 88.2% of the global production of palm oil (Food and Agriculture Organization, 2022). In 2020, the oil palm matured area in Malaysia was 5.23 million hectares (Ghulam Kadir, 2021). In January 2023, Malaysia exported approximately 1.9 million tonnes of oil palm products that are currently the third most exported products in terms of value (Malaysian Palm Oil Board (MPOB), 2023).

Sarawak is a major oil palm producing state and it has the largest cultivated area in Malaysia, 1.58 million hectares (Ghulam Kadir, 2021). It has a population of nearly 3 million, made up of 26 different ethnic groups. Non-Muslim indigenous communities are known as Dayaks, and account for about 40% of Sarawak's inhabitants (Minority Rights Group International, 2018). The two biggest ethnic groups are the Iban (30% of population), and the Bidayuh. Traditionally, the indigenous population of Sarawak were engaged in shifting cultivation which was successful due to the incorporation of smallholder cash crops, mostly rubber and pepper (Cramb & McCarthy, 2016). In 1981, the chief minister of Sarawak introduced the 'Politics of Development' policy which focused on the development of agricultural and manufacturing industries (Jomo & Hui, 2003). After the 1980s, the practice of small-scale agriculture in Sarawak decreased due to agricultural development and an increasing global demand for palm oil. Most of the agricultural expansion in Sarawak took place in state forests (80%), but in the last three decades

new plantations were established on land under Native Customary Rights (NCR) (Andersen et al., 2016). Approximately 20-25% of total land area in Sarawak is claimed as native customary land (Cramb et al. 2009). Much of the remaining land that is biophysically suitable for oil palm falls under this category (Andersen et al., 2016). The expansion of large-scale oil palm plantations transformed Sarawak from a mostly small-scale agricultural producer to a large-scale oil palm producer. These large plantations were primarily managed by private estates or government schemes (Cramb & McCarthy, 2016). Thus, socioeconomic development has not reached all groups equally, especially excluding indigenous peoples (Osman, 2000).

Since the mid-1990s when *Konsep Baru* (New Concept) was introduced (Cooke, 2002), an oil palm development model of joint-venture companies (JVCs) on customary lands has been heavily pushed by the government (Cramb, 2013). Despite this, independent smallholder plantations increased at a similar rate to the joint-venture schemes from 2001-2009 (Cramb & Sujang, 2013). At this point in time, small-scale and large-scale oil palm plantations are spread across Sarawak. These plantations have changed the way of life and physical environment in the rural areas of Sarawak.

Research has been done on the effects of the plantations on the environment and the livelihoods of people. When looking at smallholder farmers, studies show that the transition to oil palm cultivation can have beneficial impacts on the livelihood of local people, as it is a way to escape poverty and obtain a stable income (Cramb & Curry, 2012; Mertz, Egay, Bruun, & Colding, 2012). From an environmental perspective, evidence suggests that smallholdings are more successful at integrating biodiversity conservation in palm oil production (Azhar, Saadun, Prideaux, & Lindenmayer, 2017). According to a case study by Cramb and Sujang (2013) based on a questionnaire survey of 72 Iban households, smallholder oil palm cultivation is a livelihood strategy that generates relatively high returns to labor and capital. No other case studies that focus on oil palm cultivation as a livelihood strategy have been found. Also, the drivers and impacts of these small-scale plantations on the communities that cultivate oil palm have not been further investigated. Thus, this study will use the Sustainable Livelihoods Framework to structure the drivers and impacts of small-scale oil palm cultivation on longhouse communities in Sarawak. To understand the drivers and impacts on livelihoods better, a case study in a longhouse in Sarawak is conducted.

To guide the study, the following research question has been developed: “What is the role of small-scale oil palm cultivation in the livelihoods of longhouse inhabitants in Sarawak, Malaysia?”. The following sub-questions will complement the main research question:

1. What are the drivers of the livelihood strategies of longhouse inhabitants in relation to oil palm cultivation?
2. How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of social impacts?
3. How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of environmental impacts?

Conceptual Framework

In this case study, the Sustainable Livelihoods Framework is used to structure and analyze our results. A livelihood can be defined as “the assets (natural, physical, human, financial, and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household” (Ellis, 2000, p.35). The Framework clearly marks the concepts and components that are influencing the way of life of an individual or group of people. The assets are the capitals that the individual or group has access to and what shapes their situation. This access is not the same for everybody and can vary depending on one's position or identity. The way the livelihood is shaped is also influenced by processes like laws, culture, policies and institutions. Additionally, there are also external factors that can influence the individual’s or group's situation. These can be trends or shocks that happen locally or even globally. Figure 1 illustrates the Sustainable Livelihoods Framework and the connection between the vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies, and livelihood outcomes.

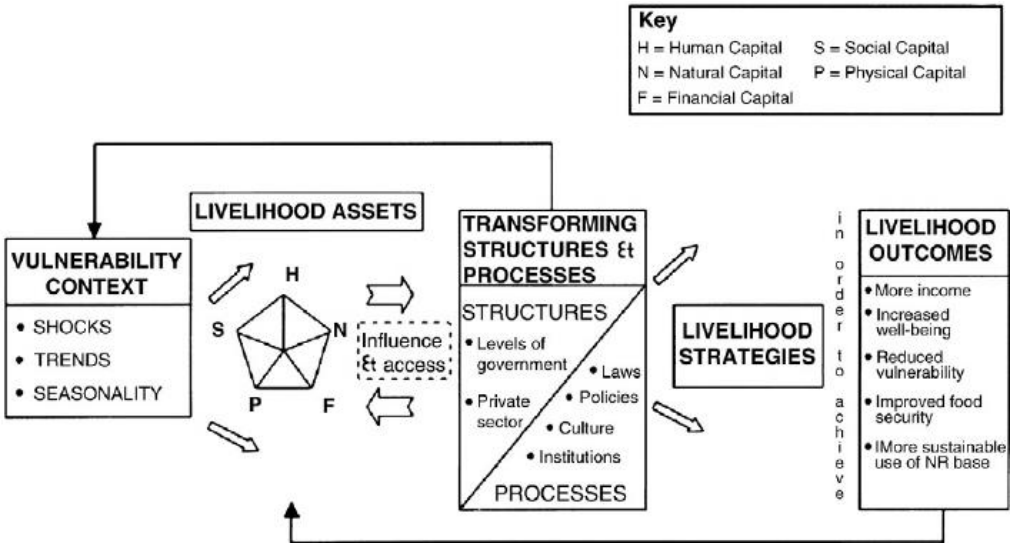


Figure 1: The Sustainable Livelihoods Framework (Ellis, 2000).

Outline

The next section elaborates on the methodology used in this study. The second section dives into the shocks and trends affecting the livelihoods of those involved in small-scale oil palm plantations. The third section explains the different assets involved, divided into the five capitals. In the fourth section, the processes and structures influencing the livelihoods are explained. Lastly, the livelihood strategies and outcomes are discussed in the fifth section.

Methods

Social Sciences

The research aims to be interdisciplinary. Data collection stemming from both the disciplines of social sciences and natural sciences complement each other (Krishnan, 2009). Concerning the social sciences, the use of a questionnaire, interviews, focus groups, participant observations, a transect walk, and mapping were the means of data collection. This triangulation of methods ensures a broader scope of collected data (Thurmond, 2001).

The first method used during the fieldwork was a questionnaire created with the aim to collect introductory information about the longhouse's community members (Figure 2). Fourteen answers provided information about the locals' identity, assets, cultivation of oil palm and other crops, non-agricultural work, and committees involvement. Descriptive statistics based on the quantitative data from the questionnaire were developed. The answers to the questionnaire were compiled and coded within Excel to allow for clear visualization of the information.

Figure 2: Questionnaire session.

Semi-structured interviews with the available household members followed the questionnaire. An in-depth interview was conducted on the first day of the field work with the headman to gain an overview of the longhouse. Fourteen other interviews took place with the

inhabitants later in the week. They answered questions about their different crops including oil palm if they had it, their harvesting practices, concerns about land ownership, leasing land to JVC, changes, costs, and challenges due to oil palm cultivation, Malaysian Sustainable Palm Oil (MSPO) guidelines, and future hopes. To read the detailed interview guide, see Appendix 4. One final interview was done with a former member of the MPOB, to gain some in-depth knowledge about the functioning of such organizations. The participants were found through convenience sampling because of the time constraint and limited population size (Etikan, Musa, & Alkassim, 2016). The interview notes were coded manually through the different categories of the Sustainable Livelihoods Framework. Study participants' name have been anonymized.

Five social mapping activities took place (Figure 3). The first two were divided by gender and delivered two maps about the longhouse and its surroundings. The third one happened with children who drew a detailed map of each unit's (*bilik*) inhabitants. The fourth one was conducted with elders including the headman (*Tuai Rumah*), with the aim to create a resource map about the state of the area around the longhouse thirty years ago. The last one was conducted with a group of six women to develop a mind map of the advantages and disadvantages associated with oil palm cultivation around the longhouse. Moreover, the resource mapping and the mind map sessions were accompanied by a set of additional questions developed beforehand to obtain a focus group setting and guide the process in the desired direction.

Figure 3: Social mapping.

The research team followed the headman on a transect walk on the second day of the field work. This transect walk allowed the researchers to be introduced, acquire a general picture, and develop a first connection with the field site (Kanstrup, Bertelsen, & Madsen, 2014). Places of importance were pinpointed in the GPS to create a map of relevant waypoints for additional visualization of the area (Figure 4).

Figure 4: Transect walk path (Google Earth, 2023c).

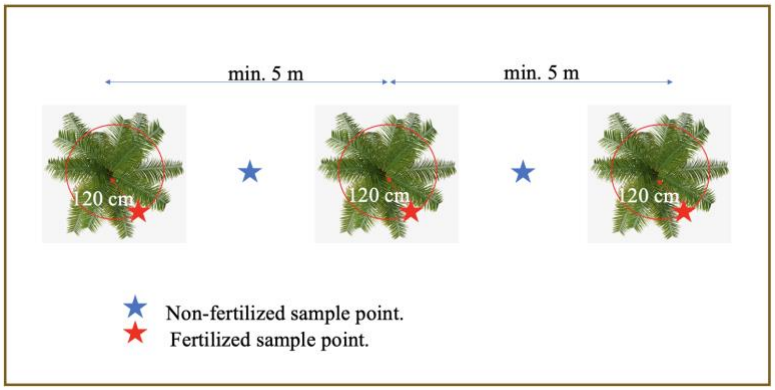
Finally, participant observations continuously took place during the stay during activities such as cooking, playing with the children, bathing, walking around, cleaning, ceremonial events, and soil sampling. They provided us with a better understanding of the environment around the village, oil palm plantations, and the community members' activities (DeWalt & DeWalt, 2011).

Natural Sciences

Reviews of the on-site environmental impacts of oil palm plantations show that the major impacts are found on soil quality, soil erosion, water quality, and biodiversity (Hartemink, 2003, 2005;

Nelson et al., 2010; Comte, Colin, Whalen, Grünberger, & Caliman, 2012). Due to time constraints, we did not look at soil erosion issues in this study.

Soil quality was evaluated by taking a total of nine topsoil samples comparing the soil in three secondary forests to three small-scale oil palm plantations (Figures 5 & 6). In each plantation, three fertilized (4 feet from the tree) and three unfertilized (as far away from the tree as possible) soil areas were sampled and averaged. A composite sample of three sub-samples per area, at least five meters apart and on homogenous terrain was collected for increased validity. We tested the samples for a range of soil properties including soil organic carbon (% SOC), total nitrogen (N), available phosphorus (P), acidity (pH), and soil moisture content. We originally collected samples on a large-scale plantation with the intention to compare the results to the small-scale plantations, but decided to abandon that site as we discovered it has not been used for harvesting oil palm in years and would not fit the most recent direction of the research.



Figures 5 & 6: Soil sampling and soil sampling technique.

Different water quality tests were conducted as the literature shows that oil palm plantations can impact the quality of rivers negatively through nutrient leaching and because the longhouse inhabitants perceived negative changes in the river due to the oil palm cultivation in the region (Comte et al., 2012). The first sampling site (ST1) is located downstream from a large-scale and the headman's small-scale plantations. It is also the river segment closest to the longhouse, which is used for bathing. The second sampling site (ST2) is located upstream from both plantations, in a forested area. The rationale behind the selection of these sites was to compare whether the downstream river segment would be more polluted due to nutrient leaching from the

plantations. The laboratory analyses focused on the amount of dissolved oxygen (DO), biochemical and chemical oxygen demand (BOD and COD), ammoniacal nitrogen (AN), total suspended and dissolved solids (TSS and TDS), salinity, conductivity, and temperature. Microbiology testing evaluated fecal and total coliform count (FCC and TCC). The National Water Quality Standard for Malaysia (Ministry Of Natural Resources, Environment and Climate Change, 2021) was used to classify the water quality of the two sites. Macroinvertebrates were used as bioindicators to assess the water quality using the Biological Monitoring Working Party (BMWP) and the Malaysian Family Biotic Index (MFBI), as shown in Figure 7 (Zakaria & Mohamed, 2019; Arslan et al., 2016).

Figure 7: Macroinvertebrates identification.

The biodiversity assessment took place in three different sites: a primary forest (40x10m), a secondary forest (20x20m), and an oil palm plantation next to the longhouse (20x20m). Estimates of carbon storage capacity were made based on their biomass calculation. The carbon storage capacity can vary based on changes in the environment such as changes in land use and management, human-induced disturbances and recovery (e.g. deforestation, logging), and physiological changes associated with growth and decay (Krankina et al., 2005). Biodiversity scores from comparison of the species frequency to the Shannon-Weiner Diversity Index were created (Ali et al., 2021).

A map of the sampling sites for each of the above-mentioned environmental tests can be found below (Figure 8).

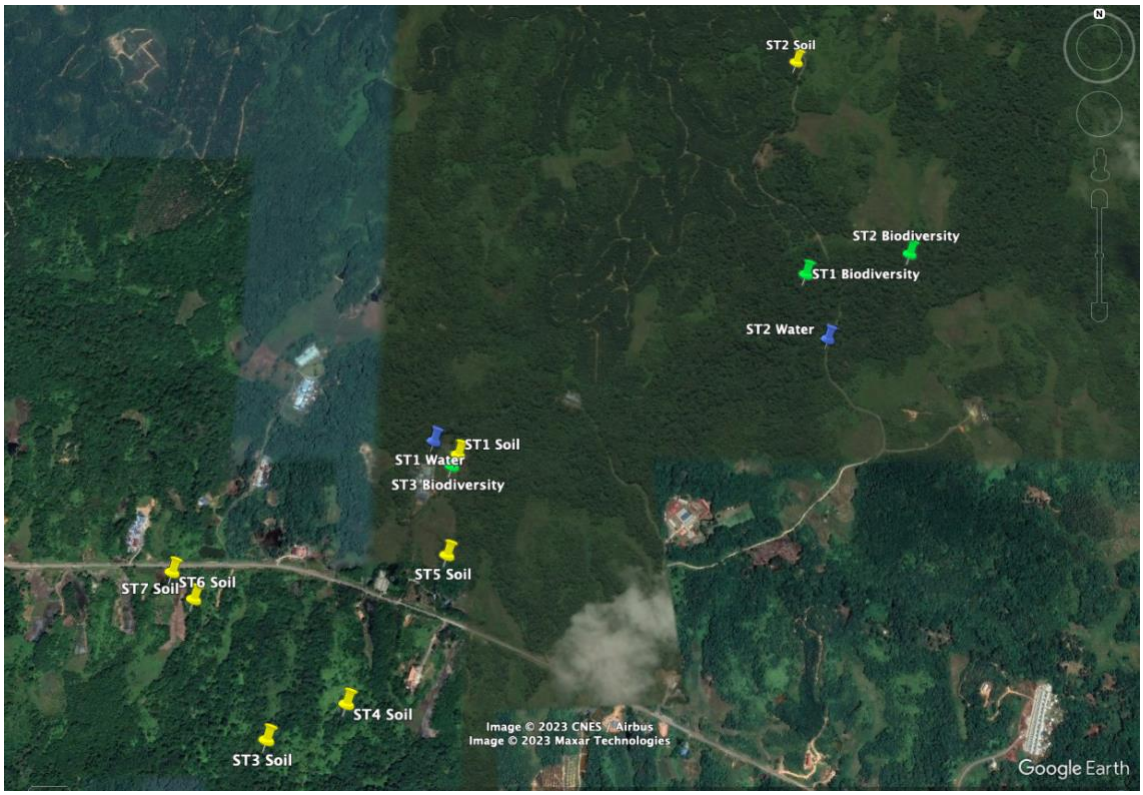


Figure 8: Localisation of all environmental impacts sampling sites (Google Earth, 2023a).

Field Site

Our study was conducted in an Iban longhouse located along the Sungai Bawan river, a tributary of the Rajang River which flows through the district of Kanowit, in the Western part of Sarawak (Figure 9). The main ethnic group that lives in this district is the Iban (*Sea Dayak)* and the main religious practice is Christianity (Kanowit District Council, 2020). Iban people traditionally live in longhouses which are houses linked together in a single row (Ngidang, 1995).

Figure 9: Localisation of the field site (Google Earth, 2023b).

According to our surveys, the longhouse consists of 19 separate households (*bilik*), and has a population of approximately 80 people, of which 48 permanently live there. The population in the longhouse is quite young, with 35 out of 48 of inhabitants aged below 50. The main occupations in the longhouse are teacher, policeman, cook and security guard. The majority of households engage with polyculture farming. The most common cultivations are paddy rice, fruit and vegetable gardens, pepper, oil palm, and rubber. Concerning oil palm, five households have been leasing part of their land to a JVC since 1993 and have a 60-years contract. On top of this, six households have begun in the last 10 years to cultivate small-scale oil palm. The social structure comprises the headman and the so-called JKKK which refers to several committees. These committees include welfare, education, development, agriculture, sports, youth and religion.

Results and analysis

To analyze the results, the Sustainable Livelihoods Framework has been adapted for this research (Figure 10). This picture shows all elements related to small-scale oil palm cultivation in the longhouse in Sarawak. It gives a clear overview of the circumstances at the moment including assets, the external factors (vulnerability context, processes & structures) and how they relate to small-scale oil palm cultivation and its impacts (strategies and outcomes).

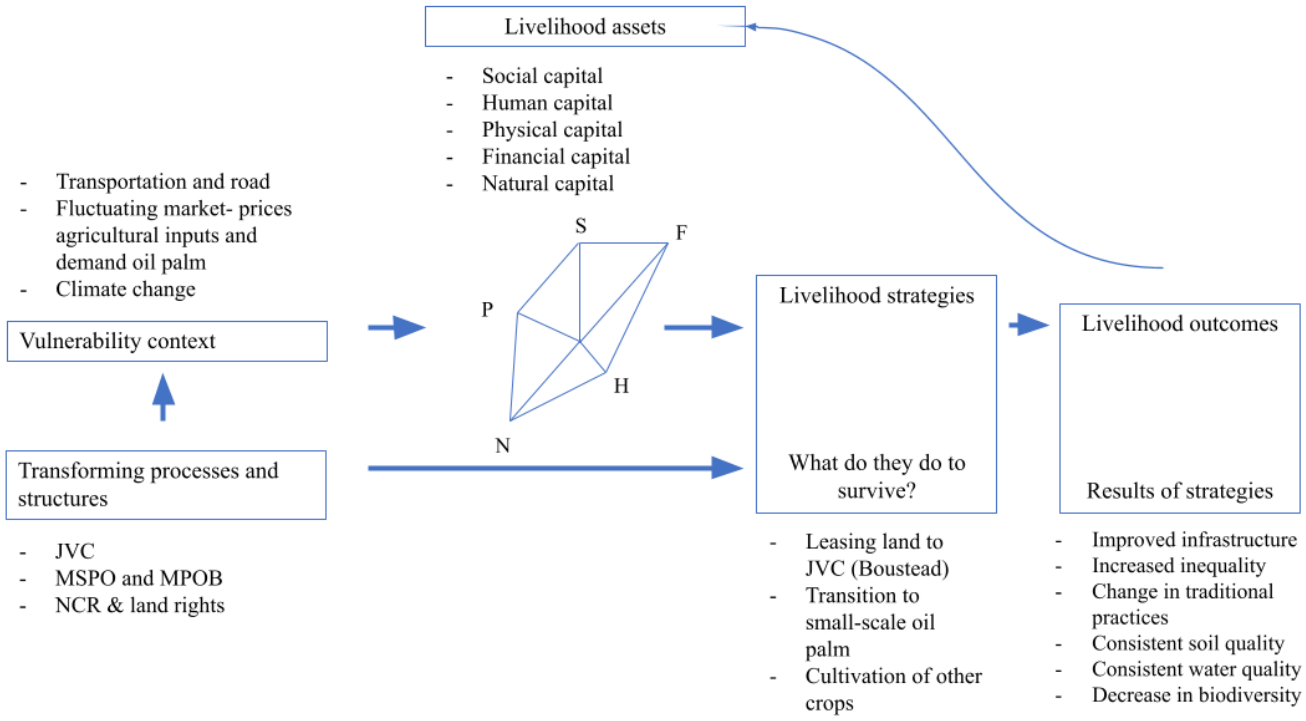


Figure 10: Adapted Sustainable Livelihoods Framework.

Vulnerability Context

The world in which people live is framed by the vulnerability context. Critical trends, shocks, and seasonality—over which people have little to no control—have a fundamental impact on people's livelihoods and the wider availability of assets (Department for International Development (DFID), 1999). The data collected among the inhabitants of the longhouse reveal multiple aspects pertaining to the vulnerability context of the longhouse in relation to small-scale oil palm cultivation.

One of the main vulnerabilities that we discovered in the longhouse is the road and transport accessibility. Even though the longhouse is located near a paved road, access to the inhabitants' fields is obstructed by small roads that flood in times of heavy rain (HH 1). Oil palm plantations are often scattered and far from the longhouse, lacking adequate roads to reach them easily. The location of the oil palm plantations also complicates how oil palm fruits and saplings are transported since not all of the inhabitants own a car.

Another vulnerability for the longhouse is the fluctuating market price of fresh fruit bunches, of agricultural inputs and the changing landscape of the palm oil market. When planting, or aspiring to plant oil palm, the price of fertilizer and pesticides is encountered as an obstacle. The price of DAP (nitrogen and phosphorus fertilizer) reached a price of about 4000 Malaysian ringgits (MYR) per tonne in 2022 while the prices in 2019 were below 1000 MYR per tonne (IndexMundi, 2022). Those who are already involved in small-scale oil palm plantations mention that it is increasingly difficult to cultivate oil palm due to the rising prices (HH 1, 4, 6, 7, 16, 17). At the same time, the palm oil market is also facing challenges. In 2017, the global demand for oil palm was almost 70 million tonnes, of which 20 million tonnes were produced by Malaysia (Ritchie & Roser, 2021). In 2018 the largest importer of oil palm was India, with Europe as the second largest importer (Kannan, 2021). However, the consumption of oil palm in Europe has been steadily declining due to environmental concerns such as deforestation (Wunsch, 2022; Russel, 2020). Many international companies and European countries have vouched to solely buy sustainable oil palm (Russel, 2020). The expectation is that other markets will follow this example in the near future (Kannan, 2021). Certification schemes help to identify sustainable oil palm. The longhouse inhabitants are familiar with these certifications but do not actively pursue them. This indicates an imbalance between the increasing cultivation of uncertified oil palm by the inhabitants and the increasing global demand for certified palm oil.

Lastly, climate change creates vulnerability for the longhouse inhabitants. Climate change has brought an increase in rainfall in Sarawak (Climate Change Knowledge Portal, 2021). This, in conjunction with oil palm plantations reducing the infiltration rate due to soil compaction and clearing of vegetation, can result in flooding (Dislich et al., 2016). The visible trend in our study area is an increase in flooding which not only complicates road access but also has implications for crop cultivation.

Livelihood Assets

Social Capital

Social capital, according to the Sustainable Livelihoods Framework, consists of the social resources one has access to. This includes networks, groups and relationships (DFID, 1999). Longhouses are a social community that lives together, share a history and keep traditions alive. This community has a clear hierarchy with a headman (or woman), the *Tuai Rumah*, as leader of the community. It is the spoken and unspoken rule that the *Tuai Rumah* guides the longhouse and its inhabitants and should be regarded with respect. When speaking with the headman in our longhouse, it becomes clear that his vision and mission for the longhouse shape the decision-making. The vision, written down in a book which holds the longhouse's history, includes 'Live in harmony, tolerance, good discipline among the people living here' and 'People to be advanced, progressive, modern and from various ethnicities. Living harmoniously together under the same roof'. This discipline and harmony is visible in the longhouse on a daily basis with inhabitants seeking each other out socially or with the headman guiding them.

The *Tuai Rumah* is the head of the longhouse's network and the heads of the longhouse committees are under his 'command'. They in turn have a group of volunteers for whom they are responsible. These committees are presented as part of the longhouse's structure and are important to achieve the longhouse's vision and mission. However, the inhabitants themselves do not value the committees as much as the headman made it out to be. About 23% of the interviewed longhouse inhabitants are involved with the committees. When asked how much time a committee takes or the importance of it, the inhabitants could not answer easily. One of the inhabitants knew he was head of a committee but did not remember which one. In reality, the clear distinction between and importance of the committees was not part of the inhabitants' daily lives. Although the inhabitants do not seem to care about the formal structure of the committees, in reality they do take care of each other's children, cook together when there is a celebration and they teach each other how to use fertilizer.

Human Capital

According to the Sustainable Livelihoods Framework, human capital consists of the "amount and quality of labour available" (DFID, 1999). This can include the number of people living in a

household, the level of education, health, etc. (*ibid.*). Based on the data collected from the survey, the ages of adults (over 18 y.o.) residing in the longhouse range from 19-75 with a mean age of 45 years old (Figure 11). However, the distribution is not normal, showing a lack of middle-aged people who, if present, could contribute to the labor pool. From the interviews conducted, we found that while none of the respondents considered their occupation to be "farmer", nearly all of them mentioned that they help out in the field on a regular basis to maintain the households' agricultural practices. However, this is mostly the case for crops like paddy or pepper cultivation as they require less skilled labor than is needed for harvesting oil palm fruits. The inability of many longhouse residents to harvest oil palm themselves has had an impact on both the financial and social capital of the residents as well as interfering with their ability to practice *berduruk,* an Iban tradition of reciprocal aid in regards to farming, and are subsequently required to hire workers. The headman said he hires foreign workers to harvest his oil palm whereas for paddy he works in the field himself and hires people from nearby longhouses to assist him. In general, older, retired members of the longhouse are still very involved in the maintenance and harvesting of their crops as well as helping out their neighbors when possible as observed through participant observations.

In addition to the physical ability of longhouse residents to cultivate oil palm and other crops, education also plays a major role in determining the opportunity for different livelihood strategies within the longhouse. The MPOB has held education sessions nearby to the longhouse which give people the opportunity to learn about MSPO guidelines which, if followed, can lead to a license to sell directly at the market rather than to a middleman.

Beyond education on oil palm, the longhouse has a strong belief that education is very important for the younger generation. The level of education among the residents in the longhouse is quite high as the majority has completed secondary school or higher. Those not currently living in the longhouse are highly educated which has led to jobs in cities. The high level of education and resulting emigration have a significant impact on which livelihood strategies are available to those in the longhouse and the way in which the chosen livelihood strategies are carried out in the case of oil palm. The headman's children, for example, live and work in the city. This pattern of family members who have received higher education leaving the longhouse for the majority of their lives, intending to return only once they have retired, contributes to a lack of available farm labor for crops such as oil palm. This will likely result in an increase in foreign workers. One person mentioned that their children are not likely to move back to the longhouse after they pass

away but rather will hire people to maintain their fields while they continue to live in the city (HH 7).

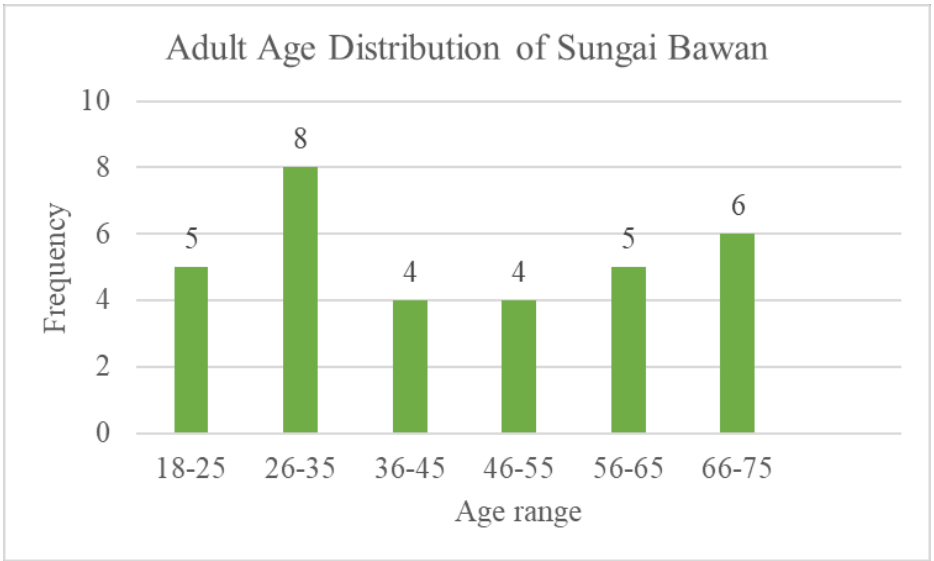


Figure 11: Age distribution of adults in the longhouse.

Physical Capital

Physical capital encompasses the different infrastructures, tools and equipment owned by a community which support their livelihood (DFID, 1999). The maps resulting from the social mapping sessions indicated the existence of roads, including the road leading to the longhouse built in 1998. Other facilities are a community kitchen, public toilets, a clinic, a boat storage space, a barbecue shelter, a wooden dock and shelter to access the river, and a playground where the inhabitants gather to play *takraw* (a volleyball-like game). These infrastructures contribute to the development and the wellbeing of the villagers. They not only support basic needs such as access to relevant places and facilities (e.g., market, town, school, hospital), but also improve the comfort and entertainment opportunities for this and other longhouses' inhabitants. Men and boys from other villages traveled everyday to the longhouse to use the *takraw* court as they did not have any other available in the area. Also, each household owns at least one vehicle, car, or scooter, with some families owning more. This is important in supporting agricultural activities as collected data shows that one car can transport up to 10 bags of fertilizer, equating to one ton of the product.

Financial capital

Financial capital is described as "the financial resources that people use to achieve their livelihood objectives" (DFID, 1999). From the survey, it emerged that 78% of respondents have a monthly income that ranges between 0 and 3000 MYR, showing an income distribution skewed to the right (Figure 12). Only two households indicated a monthly income above 4000 MYR. The headman mentioned that his goal is to have everyone in the longhouse earn above 3000 MYR per month. As a reference, in 2019 the median income in Sarawak was 4544 MYR, and the mean income was 5959 MYR (Department of Statistics Malaysia, 2021). The main sources of income are wages and cash crops, although some respondents also included remittances, pension, land leasing, and welfare assistance as sources of income (Figure 12). All the households that get income from crops mentioned that they cultivate more than one crop, with the aim of diversifying their sources of income and mitigating the financial risks that come with cultivating only one crop. For what concerns spending, the majority of respondents (93%) declared to spend the largest share of their income on food, followed by education, and bills. Three households indicated that they receive some sort of welfare assistance, either in terms of pension or in terms of unemployment benefit (HH 1, 7, 13). When looking into oil palm, 40% of households engage in small-scale cultivation of oil palm, and 33% lease their land to a JVC. These numbers overlap as leasing land and cultivating small-scale oil palm are not mutually exclusive.

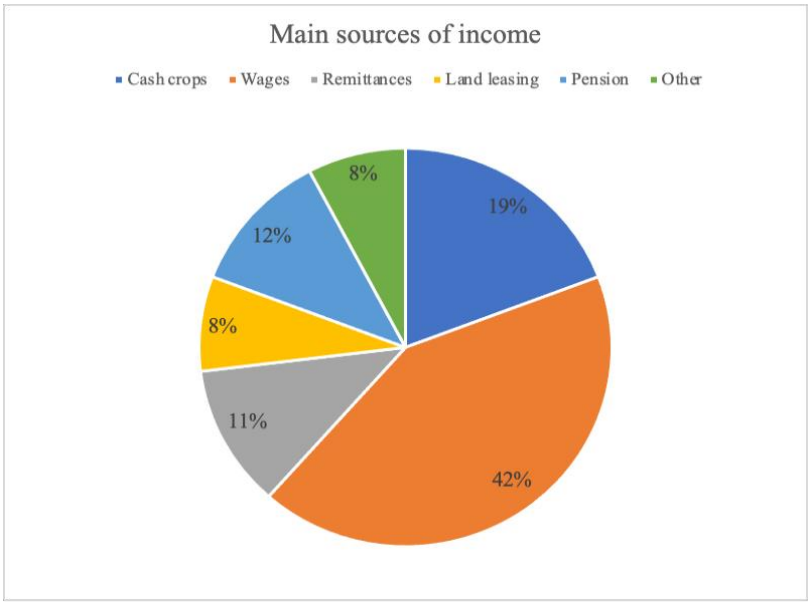


Figure 12: Main sources of income of respondents.

Natural Capital

From the data collected in our survey, we found that on average, nine out of fourteen respondents own land and five of those nine own over 10 ha. However, this may be influenced by issues regarding land titling, as much of the land is NCR, meaning that some respondents may not perceive their land as being "owned" by them. When asked during interviews if they felt that their rights to their land were secure, responses varied. For example, one inhabitant said that they did not worry about the government taking over NCR land for JVC oil palm plantations, but their daughter was concerned about it because she had heard of it happening somewhere else (HH 4). It was corroborated that it was not possible for the government to do that as NCR is quite secure (Key informant). Overall, there seemed to be more concern from the younger adults in the longhouse. This could be attributed to the fact that they depend on their parents to explain which land belongs to them and if they are not familiar with it, it can be difficult to assert one's claim to it.

The land the longhouse residents do have is used for agriculture including paddy rice, pepper, rubber, oil palm, and vegetable gardens or is left as secondary or primary forest. When asked which land they would convert if they wanted to start cultivating or cultivate more oil palm, most respondents said they would convert secondary or primary forest rather than their paddy or other agricultural land. This fact must also be reconciled with the impression given during the transect walk regarding the cultural significance of many forest products for the longhouse. At the start of the transect walk through his secondary forest along the river, previously used for paddy, our guide identified various fruit trees, rattan (important for weaving in the Iban tradition), and other plants which he believes are important to keep in order to teach the children and future generations about. Rice was also perceived as having high cultural value according to the elders of the longhouse, and one inhabitant said that rice "sustains life". Although non-timber forest products provide some cultural value to the longhouse residents, it is clear from their responses that agricultural land is the most important asset to them in terms of natural capital.

The Sungai Bawan River has also been an important resource for the longhouse in the past. It was mentioned many times during informal conversations, questionnaires, and interviews that the river used to provide fish but now, after the introduction of oil palm plantations 30 years ago, fish are no longer abundant, and the river is only suitable for bathing, laundry, and recreation. As

a result, many households now have separate fishponds where they cultivate fish including tilapia and catfish.

Transforming Structures and Processes

Transforming structures and processes encompass the different organizations, policies, legislation, and institutions shaping the livelihood of the community (DFID, 1999). Four important processes can be gleaned from the collected data relating to the private sector and institutional policies.

The first one concerns the role of the JVC. Boustead, a British company, rents land owned by the longhouse inhabitants to cultivate large scale oil palm plantations. The inhabitants lease the land to get yearly dividends, in a contract lasting 60 years. Boustead arrived in the area around the longhouse 30 years ago and now owns around 4000 ha of land (Focus group 4). Since then, the collaboration between the company and the inhabitants owning the land has brought multiple developments and benefits such as improved infrastructures.

The second important structure influencing the community's assets is local and global governments and institutions. The United Nations states that countries should implement monitoring and evaluation to make sure that the sustainable guidelines are followed (Kannan, 2021). In 2017, the Malaysian government announced that it was mandatory for all who sold oil palm to comply with the MSPO guidelines (Kannan, 2021). When small-scale oil palm producers follow MSPO guidelines, they are entitled to receive subsidies from the government to support them in growing and harvesting the product. Most inhabitants of the longhouse have heard of the MSPO guidelines but are not intimately familiar with them. Representatives of the MPOB have contacted some inhabitants since compliance with the guidelines is mandatory to sell oil palm. However, the oil palm of most inhabitants is not old enough to be sold.

The MPOB states that native landowners are allowed to operate oil palm on their land and are entitled to receive government support in terms of know-how and agricultural inputs. The MPOB provides land clearing support, seedlings, and fertilizer until the tree is three years old (Key informant). Smallholders have to apply to get certified and benefit from these. However, the subsidies are not given to every applicant, and distribution is based on need. The longhouse in this case study is quite well off compared to others, thus its inhabitants would probably not receive the above-mentioned subsidies (Key informant). The lack of subsidies can impact their ability to cultivate small-scale oil palm.

The third process relates to the land rights of the longhouse inhabitants. The issue of land rights for the indigenous peoples of Sarawak is complex. They were involved in shifting cultivation before settling on community land. Their claim on land is rooted in customary claims and generational access. The claim to land is not often based on rights the state acknowledges, which has led to dispossession and land grabbing (Cramb & Sujang, 2011). The land the inhabitants of the longhouse cultivate and live on is also not legally owned. When asked how much land they 'own', the inhabitants could easily point at where their land was located but could only give an estimation about how many hectares it would be. The NCR land is used for cultivation of the crops. As mentioned, the lack of land rights warrants insecurities among the inhabitants. One inhabitant pointed out that they could lose the land if the government decided to claim it. The best they can do is plant as much as possible on the land to be entitled to more compensation (HH 8). Since they understand the risks involved, the longhouse inhabitants have been in the process of claiming individual land titles for four years now. Even though there are insecurities and worries regarding the land titles, the inhabitants see the land as their own and are willing to invest in it.

Livelihood Strategies

Livelihood strategies are defined as the variety and combination of decisions people make in order to pursue their livelihood objectives (DFID, 1999). In this longhouse, the majority of residents are involved in primary sector work as there is a distinct lack of secondary sector jobs in the area. A few are employed in tertiary and quaternary sectors as well but we will focus on their strategies related to agriculture, specifically oil palm.

One important strategy and source of income adopted by a few households in the longhouse is the leasing of land to Boustead. Five households lease their land. They get a 10% dividend per year that they usually receive at the end of May, which accounts to 60 MYR per hectare per month. The main reasons behind this low payout are inadequate soil, poor management, and absent landowners in the cultivation process (Key informant). However, the prospect of earning income simply from leasing their land without needing to work on it is still attractive to multiple inhabitants. Collaborating with Boustead is beneficial as the company usually treats landowners well and provides infrastructures (HH 7). When one does not have enough budget to start planting one's own oil palm plantation, leasing the land is an alternative that still brings income (HH 7). In fact, large-scale oil palm cultivation typically happens on land that the local people would not be

able to farm on themselves due to lack of labor. The ability to lease land and get a profit, however small, is seen as an opportunity to get an additional source of income that comes with little trouble.

On the other hand, some inhabitants expressed reticence at leasing land to the JVC. One mentioned that they would cultivate their own small-scale oil palm plantation rather than lease their land to the JVC because they would have to follow fewer rules about the amount and types of pesticides and fertilizers to use, which would be more convenient (HH 16). Despite their favorable opinion of Boustead, it can sometimes lead to conflict with the landowners. One respondent explained that they would not lease more land than presently as they want to keep some land free for the next generation. Another reason expressed by an inhabitant is a lack of land owned in general, thus leaving the land owned only available for self-consumption or less space-demanding crops (HH 3).

Besides or alternatively to leasing land to Boustead, some inhabitants decided to start their own small-scale oil palm fields. Three participants did so after noticing the high value and demand for oil palm. Moreover, depending on rubber and pepper is not profitable anymore, thus the inhabitants needed to find a more lucrative crop. Noticing the increased income of neighbors, five other respondents made the same decision. The revenue for small-scale oil-palm farmers is estimated around 1000-1200 MYR per hectare per month, thus representing a great addendum to the monthly salary of the local people. This contrasts greatly with the 60 MYR per hectare per month obtained from leasing the land as mentioned above. The large difference among revenues partially explains the development of small-scale oil palm farming in the area. Besides the revenue per se, small-scale farming allows farmers to obtain a stable income over the year, as revenue is collected every two weeks throughout the whole year, in contrast to the annual dividend received from land leasing.

Despite the profitability of small-scale oil palm cultivation being more than 15 times higher, the challenges it comes with have discouraged some households from engaging with it. There seems to be a correlation between income level and adoption of oil palm. In fact, from our interviews we found that income is a barrier to entry in the oil palm sector, as the initial investment, averaged from various answers, requires a starting amount of 6000 MYR per hectare (HH 4). Given the average income levels, only a handful of the households can afford to enter the oil palm business as small-scale farmers. Five participants expressed that they were not able to start planting oil palm despite wanting to because of the high starting expenses. Besides the initial investment,

the maintenance of the oil palm trees was also indicated as being expensive, due to the price of fertilizers, herbicides, pesticides, and due to the need to hire labor to harvest the fruits.

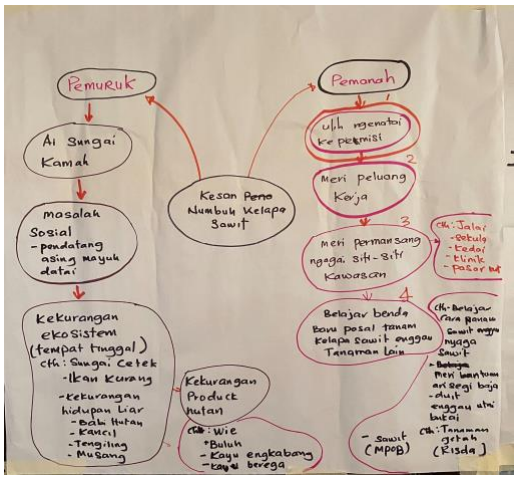
Oil palm is deemed as the most lucrative crop to cultivate. However, inhabitants still cultivate other crops to diversify their sources of livelihood as mentioned earlier. This strategy has been followed by the longhouse inhabitants since long before they started to plant oil palm, as shown during the resource mapping focus group. Thirty years ago, the land around the longhouse was covered in such assets. Today, much has been converted to oil palm but some of these crops remain crucial. Rice is being grown by almost all households for their own consumption. Rubber trees are still owned by a few inhabitants. However, the price of rubber dropped, and most villagers stopped tapping the trees for lack of revenue. Pepper is still considered as an important crop for added income but would not be sufficient alone, as it can only be harvested once a year and is not as profitable. Fruits and vegetables are mostly grown for self-consumption, although the excess is sometimes sold at the market. This is also the case for fish. Those products can be sold in various ways. Some sell them to a middleman, others rent a stall at the marketplace or have someone else sell their products when they are unable to attend the market hours, and some sell products such as pepper directly to the factory.

Livelihood Outcomes

Social Sciences

Livelihood outcomes are the results of the aforementioned livelihood strategies (DFID, 1999). Concerning the collaboration between the community and Boustead, important outcomes are related to the physical development the company provided to the area. The JVC improved various infrastructures such as roads, shops along the roads, electricity supply, the nearby school, and water supply (Figures 13 & 14). The school in question is where most of the kids living in the longhouse get their education. It used to be made of wood but has now been upgraded to a concrete building thanks to Boustead. This improvement enhances the children's education level. A tarmac road accessing the school, shops, a clinic, and the closest town is also a result of the company's settlement in the area. This development ameliorates the accessibility of multiple important facilities for the inhabitants. Electricity and water supply can also be considered great improvements to the living standards of the community. Longhouse inhabitants perceive the road

access and other infrastructures provided by the JVC to be the third most important benefit stemming from oil palm cultivation, following income and job opportunities, and before the acquisition of new knowledge regarding oil palm crops management. In this respect, large scale oil palm cultivation has brought many positive developments to the livelihood of the longhouse's inhabitants.



Figures 13 & 14: Original bubble map developed during the focus group and translated bubble map from the focus group.

Another important outcome relates to the social dynamics within the longhouse. The longhouse inhabitants own small-scale oil palm plantations but are not actively engaged with the cultivation itself, at least not in the same way as they are engaged with their paddy fields. As mentioned in the interviews, oil palm is an economically attractive investment since the gains are high and the supposed workload is low (HH 13). Others mentioned that the harvest and upkeep of the small-scale plantations is hard work and therefore the inhabitants are more interested in pursuing an education (HH 6). The dynamics within the longhouse related to crop production changed due to the cultivation of small-scale oil palm. Where before *berduruk* was practiced for multiple crops and most inhabitants cultivated the same type of crops, oil palm has brought a change. Not all of the inhabitants have the financial means to start cultivating oil palm, resulting in financial inequality between the inhabitants. 79% of the inhabitants earn less than 3000 MYR per month while 14% earn more than 5000 MYR per month. Oil palm in the longhouse is presented as important which makes inhabitants want to invest in it as well. Even though some inhabitants want to start oil palm cultivation, the fertilizer's cost and the initial cost of starting to restrict them

to commence (HH 4, 6, 13, 17). Oil palm cultivation creates an economic distinction between those that cultivate and those that do not. There is still social cohesion in the longhouse, as the inhabitants keep their rice fields and share a common culture. However, the contrast between those living in the longhouse is exacerbated by the different paths the inhabitants take regarding oil palm.

The *Tuai Rumah* was the first in the longhouse to start oil palm cultivation. Presently, only the *Tuai Rumah* has oil palm old enough to produce fruits which can be sold. His decision influenced the direction towards small-scale oil palm cultivation that the longhouse is following. It is unclear if the shift to small-scale oil palm cultivation would have happened without the influence of the *Tuai Rumah*. As mentioned before, other factors like lack of a secondary sector could have also influenced the shift to small-scale oil palm. However, during the interviews and observations it became clear that the *Tuai Rumah* is a driver for the decision-making process in this longhouse.

As mentioned, the practice of *berduruk* in relation to oil palm cultivation occurs less often. One interviewee mentioned that they do not cultivate oil palm because there is no one to help them manage it (HH 15). In the longhouse, the community feeling is strong. However, in the fields, there seems to be a shift away from this exchange between inhabitants. As oil palm requires less labor from themselves than a paddy field, this explains the lack of *berduruk* in relation to oil palm. Presently, this shift does not seem to have an influence on the community in the longhouse.

Natural Sciences

Livelihood outcomes are also concerned with the sustainable use of natural resources (Figure 1). Soil health can be a good indicator regarding the sustainability of certain agricultural practices, in this case oil palm. In the area of the field site, we found that the pH for both land uses (small-scale oil palm plantation and secondary forest) was quite low. The average pH of the oil palm sites was 4.84 compared to a slightly higher average at the forest sites of 4.94. The available P was too low to be detected through our method of analysis in the lab for six out of the nine sample sites. In Field 1, however, the average available P (fertilized and not fertilized) was 14.15 mg/kg. At Field 3 the fertilized sample had 5.4 mg/kg of available P. The average total N percentage in the small-scale oil palm fields was 0.155% compared with 0.18% found in the soil of the secondary forests. The average total carbon percentages followed a similar pattern with the secondary forest being just slightly higher with 2.20% as opposed to 1.955% for the oil palm sites. It is important to note

that when the samples were taken from Field 1, it had not been fertilized for four months, and the owner was preparing to add fertilizer soon after we left as he typically fertilizes about 3 times per year. Additionally, the oil palm trees at Field 3 were still very young and not receiving much fertilizer. From these results, it seems as though small-holder oil palm plantations do not have much impact on soil health as we did not find excessive amounts of nutrients, or especially low levels of carbon. The acidity of the soil however is suited to oil palm, making it a logical choice in terms of livelihood strategies. Those results are summarized in Table 1.

Metric	Oil Palm Mean	Forest Mean
Available P (mg/kg)	11.2	not detected
Total N (%)	0.16	0.18
Total C (%)	1.96	2.20
pH	4.84	4.94
Soil Moisture (%)	9.16	20.23

Table 1: Soil quality tests results.

The results of the water quality assessments are as follows. From our lab analysis of the water of the two sites, we found that ST1 can be categorized as class IIa, meaning that the water can be used as a water supply after conventional treatment (Table 2). Instead, ST2 falls under Class IIb, thus water can be used exclusively for recreational purposes.

Parameters	Column1	ST1	Average	Class	ST2	Column 2	Averag e3	Class 4
DO (mg/L)	4.91 (59.3%)	4.84 (59.2%)	4.87	3	5.43 (65.4%)	5.41 (64.8%)	5.42	2B
BOD (mg/L)	4.87 - 1.015 = 3.855		3.855	3	5.42 - 0.06 = 5.36		5.36	3
COD (mg/L)	23	~	23	1	65	68	66.5	3
Ammoniacal Nitrogen (NH3-N | mg/L)	0.04	0.05	0.045	1	0.14	0.15	0.145	2A
TSS (filtered from 250 mL | 0.25L | mg/L)	0.076g	0.104g	0.090g (360mg/ L)	5	0.077g	0.091g	0.084g (336 mg/L)	5
TDS	22.75	22.75	22.75	1	35.75	37.05	36.55	1
Salinity (ppt)	0.01	0.01	0.01	1	0.02	0.03	0.025	1
Conductivity (ms/cm)	0.035	0.035	0.035	1	0.054	0.056	0.055	1
Temperature (°C)	24.4	24.4	24.4	1	24.3	24.3	24.3	1
FCC	1450	1150	1300	2B	650	625	637.5	2B
TCC	1800	1325	1562.5	1	800	675	737.5	1
pH	~	~	6.53	1	~	~	6.48	2A

Table 2: Water quality test results.

When looking into the assessment of stream quality using bioindicators, more sensitive species were found at ST2. ST1's quality is classified as "Fair" according to the BMWP, whereas ST2's quality is classified as "Moderately Good". Under the MFBI, both sites fall under the category of "Good" (Table 3).

	BMWP-My	Water Quality Rating	MFBI (Average)	Water Quality Rating
ST1 (Rh Michael Jalak)	29	Fair (17-50)	5.8	Good (4.5-5.8)
ST2 (Upstream Sg. Bawan)	59	Moderately Good (51-100)	4.9	Good (4.5-5.8)
Overall	69	Moderately Good (51-100)	4.9	Good (4.5-5.8)

Table 3: Water quality assessment using bioindicators.

To summarize, the water quality in the area is moderately good, as water can be used after treatment and for recreational purposes, and sensitive aquatic species have been found. ST1 appears to have a slightly poorer water quality compared to ST2. This can be attributed to the anthropogenic activities and proximity to oil palm plantations at ST1. In fact, according to Comte et al. (2012), the increase of surface runoff given by the increase in eroded soil particles, the use of fertilizers and pesticides, and the release of oil palm mill effluent in the streams are expected to affect the aquatic life and drinkable water quality of the receiving water bodies. Without a baseline measurement it is hard to assess the change in quality over time, but we can conclude that the water is no longer drinkable and aquatic life is present but not abundant.

For what concerns the flora, we looked at carbon storage and biodiversity (Table 4). The calculations were based on allometric equations elaborated by Basuki, van Laake, Skidmore, and Hussin (2009), and Pearson, Walker, and Brown (2005) for the primary forest. For the secondary forest, the equation was based on Kenzo et al. (2009), and for the oil palm the study by Asari, Suratman, Jaafar, and Khalid (2013) was the base for our calculations. The results show that the primary forest has by far the largest amount of aboveground biomass per hectare. When comparing the secondary forest and the oil palm plantation, it seems like oil palm plantations only contain 60% of the biomass of the secondary forest, meaning that the carbon storage is lower, if we assume that carbon storage is 50% of the biomass (Pearson, Walker, and Brown, 2005). Thus, on top of the harm caused by deforestation for land clearing, oil palm cultivations also show lower ability to store carbon. When compared to primary forest, oil palm cultivations only have 8% of its carbon storage capacity.

	Primary forest	Secondary forest	Oil palm plantation
Total aboveground biomass (kg)	37862.9	5583.8	9989.2
Total aboveground biomass per hectare (kg)	946.6	139.6	83.2

Table 4: Biomass calculation of three plots in the surroundings of the field site.

When looking at the biodiversity of the three plots (Table 5), the primary forest showed the highest diversity, with a Shannon-Weiner diversity value of 6.38. The secondary forest and oil palm have similar values, 2.47 and 2.13 respectively.

Survey area	Total frequency (no. of individual)	Shannon-Weiner diversity index
Primary forest	184	6.377
Secondary forest	27	2.474
Oil palm	158	2.127

Table 5: Biodiversity assessment.

Discussion

We started our research with the idea that small-scale oil palm cultivation would create economic and social benefits to a community but would have a negative impact on the environment. We expected those living close to oil palm plantations to have a positive view on oil palm, regardless of small-scale or large-scale plantations. Our hypotheses were based on the various literature found when developing our research proposal regarding large-scale oil palm plantations and our preconceptions (see Appendix 6). We were interested to see what the role of small-scale oil palm is in the case of an indigenous longhouse community. As the results have shown, not all of our hypotheses were confirmed, and other results have been found.

The impact on the environment regarding small-scale oil palm cultivation was not as large as expected. Literature shows that intensively cultivated monocrops, like oil palm, can acidify soil and decrease nutrients (Mahmud & Chong, 2022). In our study, the quality of the soil of the small-scale plantations did not differ much from the quality of the secondary forest. The low pH at all sites can, for example, be attributed to other factors such as the parent rock rather than the type of land use. It is also important to mention that these findings are in connection to small-scale oil palm plantations and secondary forest. If we were to compare large-scale plantations, we may find different results due to factors such as fertilizer inputs and the intensity of the land use in general.

Although we found that the water quality was slightly poorer downstream from the plantation, we cannot say with certainty that oil palm is the cause as the water quality was only measured in two places. It is difficult to generalize these findings since we cannot exclude external influences on the quality at the time of measurement and determining cause and effect for non-point source pollution is very difficult.

Regarding biomass and biodiversity, we did see a difference between the oil palm plantations and forest plots. Oil palm plantations are seen as a threat to biodiversity since it is cultivated as monoculture (Ferdous Alam, Er, & Begum, 2015). This is in line with our findings. For both the primary and secondary forest, the carbon storage is higher than for the oil palm plantation. Regarding biodiversity, the diversity in the primary forest is the highest. The diversity in the secondary forest is also higher than the oil palm plantations. However, this difference is not as substantial as we thought. The reason for this could be the age of the secondary forest and the time it needs to increase the biodiversity.

Even though the environmental impacts on the soil and water quality were not as damaging as expected, planting oil palm does change the environment. However, the long-term global implications of these changes have not been the focus of this study.

Regarding the economic drivers and impacts of oil palm, one incentive for the longhouse inhabitants to start oil palm was the financial benefits it would bring. Small-scale oil palm cultivation has been known to strengthen people's economic position (Hasan & Nur Hidayat, 2018). In this longhouse, the idea that small-scale oil palm cultivation would bring financial benefits came from other longhouse inhabitants, especially the headman. The influence of the *Tuai Rumah* on the decision making and the perceived realities of the longhouse made it difficult to differentiate between his voice and the voice of the inhabitants. When talking with and observing the inhabitants, the distinction between their voice and that of the *Tuai Rumah* becomes clearer. However, the influence the *Tuai Rumah* has on the choices made in the longhouse should be kept in mind.

The choice to convert secondary forest to plantations and not convert other crop fields was initially surprising. It would, for instance, take more investments to convert the forests. Investments that not all inhabitants have the means to make. However, this choice is less surprising when cultural heritage is taken into account. The value of rice fields and rubber trees exceeds the economic value they might have, as they are part of the Iban culture and traditions. On top of that, all land the longhouse inhabitants claim is NCR land. This land is not legally owned by the inhabitants; therefore, the government can theoretically take it at any time. When the government takes the land, those who have cultivated on their claimed land receive higher compensation than those who did not. This might also influence the decision to convert secondary forest, since the compensation for the inhabitants will be higher if the government takes the land.

Additionally, longhouse inhabitants view small-scale cultivation as a good way to improve their financial position. The inhabitants know that oil palm increases income and trust others in the community who present oil palm as a lucrative investment. However, concerns resulted from the rise of certified sustainably produced oil palm. Small-scale producers often do not have the resources to meet the certification requirements (Niaghia & Azmi, 2012). The inhabitants of our longhouse were generally not fully aware of the certification schemes nor had the means to meet the requirements. It is difficult to predict the future, but the trends show that sustainably produced

oil palm will eventually be standardized. From this case study it became clear that small-scale farmers are not sufficiently aware of these trends.

Positionality

Coming to the longhouse as outsiders, we wanted to be open to the ideas of the Malaysian students. While they were also outsiders to the longhouse, they had better knowledge of the political context of Sarawak as well as a smaller cultural gap with the longhouse residents. Initially, as we had completed our research proposal much earlier than them, it was difficult to not feel as though we were dominating many of the conversations about our plan of action. This could also be due to cultural differences and how comfortable we feel in voicing our opinions. The team-leader structure of the Malaysian group compared to our more Socratic way of working also exacerbated this dynamic in the beginning. As the fieldwork progressed, we found a way of working together while accepting that we had different goals for our separate reports which resulted in successful data collection as well as the opportunity to learn from each member's unique academic background and ways of knowing stemming from all our different cultures.

Limitations

Our study comes with some limitations. First, the limited time frame to collect data and the limited knowledge of the study field before the data collection made our research quite broad. Second, concerning our sampling method, we were only able to collect 14 surveys and conduct 16 interviews. This implies that our results are not completely representative of the longhouse's population.

Moreover, our interactions with the headman strongly shaped our view of the longhouse and our research's direction. This point leads to another pitfall of our research, i.e. the generalization of our case study. Several sources indicated that our longhouse was "special" in many ways, thus making us suspect that our case study is not representative of Iban longhouses in the Kanowit area. In spite of this, we believe it is still relevant in showing general trends and livelihood strategies adopted in the area by farmers and longhouse inhabitants.

Concerning our natural science methods, our water sampling was conducted after heavy rainfall and we could spot some anthropogenic interference upstream, thus making the validity of our results questionable. The macroinvertebrate assessment was also not as thorough as it would

ideally have been with less time and resource constraints. Looking at the social science methods, we believe that our cultural background and preconceived ideas about the palm oil industry, coupled with the language barrier and cultural differences, may have made our research biased. However, the ability to have translators mediate between us and the local people helped in narrowing the gap and our bias.

Lastly, our research is primarily focused on small-scale oil palm cultivation. We found that the large-scale plantation close to the longhouse is influential for the livelihoods of the longhouse inhabitants. This influence has been mentioned in this report but since our focus was somewhere else, it is difficult to generalize our findings regarding large-scale plantations.

Conclusion

Oil palm has become quite a controversial plant in the last few decades with major increases in its cultivation accompanied by much negative press. At the end of the day, like any other plant, it is not inherently good or evil. The relationship between rural livelihoods, oil palm, and the environment is complex and the cultivation of oil palm yields both positive and negative outcomes. Going into this research, we were familiar with all of the stories which vilify palm oil and its production. Our results, however, reflected mostly positive impacts on people's livelihoods and the impacts on the environment were relatively minimal. There is also some economic inequality that is stressed by the financial barriers to begin small-scale oil palm. That said, our results are based only on the reality of a single longhouse which we believe to be quite unique in terms of its cultural values and socioeconomic standing. More research would need to be conducted to determine whether the benefits and drawbacks of oil palm are accurately represented in this case study and could be generalized on a broader scale.

In general, it seems that oil palm is simply a means for the people of this longhouse to achieve their other goals. The children in the longhouse do not dream of being oil palm farmers nor do their parents/grandparents wish that for them. Oil palm can sustain their livelihoods in order to reach their aspirations; for their children and grandchildren to become the police officers and veterinarians they want to be. Of course, it would be ideal if the livelihood strategy which could lead to these outcomes did not come at any cost to the environment. The potential conversion of secondary or primary forest to oil palm is indeed worrisome but we think the residents of this longhouse would agree with the words of a key informant: "a hungry monkey is better than a hungry man".

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Appendices

Appendix 1: List of abbreviations

AN	Ammoniacal Nitrogen
BMWP	Biological Monitoring Working Party
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DAP	Nitrogen and Phosphorus Fertilizer
DFID	Department for International Development
DO	Dissolved Oxygen
FCC	Fecal Coliform Count
HH	Household
JVC	Joint-Venture Company
KU	University of Copenhagen
MFBI	Malaysian Family Biotic Index
MPOB	Malaysian Palm Oil Board
MSPO	Malaysian Sustainable Palm Oil
MYR	Malaysian ringgit
N	Nitrogen
NCR	Native Customary Rights
P	Phosphorus
pH	Acidity
ST1	Site 1
ST2	Site 2

TCC	Total Coliform Count
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UNIMAS	University of Sarawak
% SOC	Soil Organic Carbon

Appendix 2: Research matrix

Research question: What is the role of small-scale oil palm cultivation in the livelihoods of longhouse inhabitants in Sarawak, Malaysia?

Sub-questions	Objectives	Hypotheses	Data Collection	Data Analysis	Data Output	Critical Assumptions/Considerations
What are the drivers of the livelihood strategies of longhouse inhabitants in relation to oil palm cultivation?	1. To determine the livelihood strategies of the longhouse inhabitants. 2. To determine the vulnerability context affecting those strategies. 3. To determine the transforming processes and structures affecting those strategies. 4. To determine the livelihood assets affecting those strategies.	1. The inhabitants pursue agricultural activity with a focus on oil palm. 2. Lack of financial resources, climate change, and fluctuating market prices are vulnerabilities affecting oil palm cultivation. 3. Land rights issues and the JVC system affect those strategies. 4. The inhabitants have other crops they can fall back on. They also benefit from a relatively high level of infrastructures. Many are highly educated and left the longhouse. Committees organize the longhouse. The inhabitants overall benefit from a good income.	a) 1 transect walk b) 14 questionnaires c) 16 semi-structured interviews d) 2 focus groups e) Daily participant observations f) 5 social mapping sessions	a) Brainstorming of the notes and newly acquired knowledge for initial understanding of the field site. b) Questionnaire answers coded in Excel + development of descriptive statistics. c), d), e), f) Notes coded manually through the different categories of the Sustainable Livelihoods Framework.	a) Handwritten notes, pictures, map of the transect walk with points of interest from GPS tracking. b) Handwritten and digital notes, descriptive statistics shown in graphs, adapted Sustainable Livelihoods Framework graph. c), d), e) Handwritten and digital notes, adapted Sustainable Livelihoods Framework graph. f) Handwritten and digital notes, bubble map of pros and cons of cultivating oil palm, resource map, children's, men's, and women's map of the longhouse.	Availability/willingness of participants. Communication barriers. Truthfulness of answers. Limits of sample size. Researchers' biases. Inconsistencies, patterns, & tensions within data.
How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of social impacts?	1. To determine the social influence of oil palm cultivation on the inhabitants' livelihood outcomes. 2. To determine the social influence of oil palm cultivation on the inhabitants' livelihood assets.	1. Oil palm cultivation increases income and infrastructure, but decreases the quality of the environment and changes traditional practices. 2. Oil palm cultivation increases financial, physical, human, and social assets but decreases natural capital.				

How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of environmental impacts?	1. To determine the impact of oil palm cultivation on the soil quality. 2. To determine the impact of oil palm cultivation on the water quality. 3. To determine the impact of oil palm cultivation on biodiversity.	1. Oil palm cultivation leads to excessive nutrient leakages in the soil. 2. Oil palm cultivation leads to excessive nutrient leakages in the river water. 3. Oil palm fields are less biodiverse than forested areas.	a) 9 topsoil composite samples (3 secondary forest, 3 unfertilized oil palm field, 3 fertilized oil palm field). b) 2 river water samples (one upstream the oil palm field, one downstream). c) 3 sites (primary forest, secondary forest, oil palm field)	a) Nutrients (N & P), pH, SOC%, moisture content. b) Microbiology, macroinvertebrates, laboratory analyses. c) Carbon storage capacity & biodiversity scoring.	a) Table of soil quality assessments results for comparing sites. b) Tables of water quality assessments results comparing sites. c) Tables of biodiversity assessments results for comparing sites. d) Map of sampling sites.	Sample limit will impact the reliability of the conclusion. Each sample may not be done identically. Field accessibility. Costs & resources available.

Keywords: oil palm, Sustainable Livelihoods Framework, small-scale agriculture, soil fertility, biodiversity, socioeconomic, Malaysia

Appendix 3: Overview of applied methods

Research methods	
Social sciences	**Number**
Transect walk	1
Questionnaires	14
Semi-structured interviews	16
Focus groups	2
Social mapping sessions	5
Participant observations	12 days
Natural sciences	**Number of sites**
Soil nutrient content (N & P)	6 (9 samples)
Soil pH	6 (9 samples)
Soil organic carbon	6 (9 samples)
Soil moisture content	6 (9 samples)
Forest/oil palm carbon storage capacity	3
Forest/oil palm biodiversity scoring	3
River water microbiology	2
River water laboratory analyses	2
River water macroinvertebrates	2

Appendix 4: Interview guide

Research question:

What is the role of small-scale oil palm cultivation in the livelihoods of longhouse inhabitants in Sarawak, Malaysia?

Sub-questions:

1. What are the drivers of the livelihood strategies of longhouse inhabitants in relation to oil palm cultivation?
2. How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of environmental impacts?
3. How does small-scale oil palm cultivation affect the livelihood outcomes and assets of longhouse inhabitants in terms of social impacts?

Interview questions:

- If unknown: What is your name? Which house do you live in? What is your job?

LIVELIHOOD

- Do you have any crops? Which ones? Why do you plant them?
- Which are the most important crops to you (ranking) and why? → Go back to the questionnaire and ask why they gave those answers. (Q17)
- Where did you get the idea to grow what you are growing?
- Why did you decide (not) to plant oil palm trees?
- Do you cultivate on a small scale or a large scale? Why?
- If they have an oil palm field →
    - Are you aware of the oil palm guidelines in MSPO? Do you know you have to comply with it to get certification?
- Did anyone from MPOB come here to give a talk on oil palm?
  Refer to Q18 to start this Q:
- Do you see any changes due to oil palm cultivations?
- If they mention health issues or something related → please elaborate.
- If they mention something related to water/fishing → Do you fish?
    - Do you have a fishpond? Why did you decide to have a fishpond?
    - Do you fish only for food or also for recreation? Do you attach cultural value to fishing?

PHYSICAL CAPITAL

- Would you plant (more) oil palm if you have the opportunity? If so, where? Which land would you convert to do it?
- If they don't have land → Would you want to plant oil palm anytime in the future? If so, where?
- Do you know who would own the NCR land?

- If you have land, would you lease it to the JVC?
- Those who have leased out the land to the JVC → What is your experience and challenges? Would you do it again?
- Are you concerned about land rights and ownership? That the government can just take over the land and give it to another JVC?
- Are you concerned whether you are planting oil palm on your own land or NCR land?
- To households with small scale plantations → What are the encountered or anticipated problems and why?

HUMAN CAPITAL

- Do you work on the field (e.g., paddy, oil palm, pepper, etc.) yourself or do you have someone doing it for you?
- If you have workers, do you have issues to get them or other associated challenges?
- Do you employ local or foreign workers? Why?
- Is there any contract with the workers or any informal agreement?
- Do you practice "berduruk"?

FINANCIAL CAPITAL

Input costs (e.g., fertilizers/pesticides for oil palm):
- How much do you use? Has the used quantity changed over time?
- How much has the prices changed for fertilizers and pesticides?
- Are the costs an obstacle for you?
- Would you rather get some financing support from bank loans or from your family members?

CLOSING

- What are your hopes for the future concerning your livelihood?
- Any comments? Questions? Something to add?

Focus groups: give scenarios and ask them to discuss things we already know. Each focus group should focus on 1-2 scenarios or major themes.

1. Target: all longhouse inhabitants.
    a. Focus: pros and cons bubble map. What are the advantages and disadvantages of cultivating oil palm (small-scale and large-scale) for the longhouse?
2. Target: elderly people.
    a. Focus: resource mapping. How was the area before the JVC arrived, 30 years ago?

Appendix 5: Questionnaire

LIVELIHOOD QUESTIONNAIRE OF HOUSEHOLDS

Hi,
We are 9 students from UNIMAS and University of Copenhagen, Denmark. We are here because we are conducting field work as part of our course about land use and natural resource management. We are interested in learning about your agricultural practices and livelihood strategies. We would like to research what impact agricultural practices have on the environment and on the socioeconomic status of the longhouse's inhabitants. We would like to ask you some questions through a short survey, if that is okay. We will use the data for our school project. If you have questions, comments, or would like to withdraw your participation to the study, please let us know.

Household

Name :

Age :

Job :

Marital Status :

1. What is the highest level of education you have completed?

I have no formal education		
Preschool		
Primary School		Which primary did you complete? 1 2 3 4 5 6
Secondary School		Which form did you complete? 1 2 3 4 5
Tertiary Education		Remark

2. List of family members

No.	Relationship	Age	Present in longhouse?	Job	Education

3. Have any family members migrated within the last 20 years?

Yes	
No	
If yes, how many members?	

4. Is this longhouse your primary residence (more than 6 months of the year)?

Yes, everyday	
Yes, commute on weekends	
No, seasonal	

5. How long have you been living in the longhouse?

_____

6. What is your household's monthly income?

0-1000 RM	
1000-2000 RM	
2000-3000 RM	
3000-4000 RM	
4000-5000 RM	
>5000 RM	

7. What are the sources of your monthly income?

Cash crops	
Wages	
Remittances	
Lease of land	
Pension	

Others (Please specify)

8. Do you receive any welfare assistance from the government or an NGO?

Yes	
No	
If yes, please specify	

9. Which of the following categories do you spend most of your income on? Please give percentages for the top 3.

	Ranking	%
Food		
Clothes		
Medicine/Health		
Education		
Luxury items (i.e. mobile devices or gadgets)		
Household items/Repairs		
Agricultural inputs		
Bills		
Petrol (vehicle)		
Other		

10. Where do you get medical treatment?

Rural Clinic	
Government Hospital	
Private Clinic	
Medicinal Plants	

11. Do you own a vehicle? If yes, how many?

Car	

Van	
Lorry	
Motorcycle	
Others	

12. In your opinion, what public service needs to improve in Sungai Bawan? Please rank from 1 to 8 with 8 being the most needed and 1 being the least needed.

Public Services	**Rank**
Education	
Health Facilities	
Resource Centre	
Road network	
Market Access	
Water supply	
Recreational Activities	
Internet Access	

13. Are you involved in any committees in this longhouse?

Yes	
No	

14. If yes, which committee are you a part of? (select all that apply)

Sports and youth	
Development	
Agriculture	
Culture	
Welfare	
Religion	
Education	
Safety	
Health	

“Keceriaan”	

15. How much time do you spend on the committee activities per month?

0-5 hours a month	
6-10 hours a month	
11-15 hours a month	
16-20 hours a month	
20+ hours a month	

16. How much land do you own?

_____ ha

17. How is the land being used? What is the most important? And what is the economic value?

	Score of 1 to 7 (7 is the most important)	Size of crop area (ha)	Monthly or annual revenue (specify)
Swamp rice			
Oil Palm			
Rubber			
Pepper			
Backyard garden			
Forest Product			

18. Do you perceive any change due to palm oil plantations? Explain why.

Yes	
No	

_____

_____

IF NO AGRICULTURAL INVOLVEMENT, STOP HERE.

Thank you very much for your time. We might be interested in conducting a longer interview with you for our project. Would it be okay if we contacted you about this at a later time?

Yes	
No	

If you have any questions, now or later, do not hesitate to contact us.

19. Do you receive any agricultural subsidies from the government?

Yes	
No	
If yes, which types of crops and in what form are the subsidies in?	

20. Are you a member of an agricultural organization?

Yes	
No	
If yes, please specify.	

21. Where do you market your crop yields?

Swamp rice	Market
	Middleman
	Others (specify)
	I don't
Oil Palm	Market
	Middleman
	Others (specify)
	I don't
Rubber	Market
	Middleman
	Others (specify)
	I don't
Pepper	Market
	Middleman
	Others (specify)
	I don't
Backyard garden	Market
	Middleman
	Others (specify)
	I don't
Forest Product	Market
	Middleman
	Others (specify)
	I don't

22. Has the area to grow crops changed in the past 10 years?

Change\Crop	**Swamp Rice**	**Rubber**	**Pepper**	**Oil Palm**
Increase				
Decrease				
Equal				

Focus on palm oil – from now on our questions will focus on land use for oil palm.

23. Do you cultivate oil palm?

Yes	
No	

24. If yes, do you cultivate on your own land?

Yes	
No	

25. Do you lease some of your land for oil palm, if yes how much (in %) of the total land area you own?

Yes, to a Joint Venture	%
Other (please specify)	
No	

26. Do you face any challenges with oil palm cultivation?

Yes	
No	

27. If yes, what are the top 3 main challenges you face with oil palm cultivation?

1.
2.
3.

Thank you very much for your time. We might be interested in conducting a longer interview with you for our project. Would it be okay if we contacted you about this at a later time?

Yes	
No	

If you have any questions, now or later, do not hesitate to contact us.

Appendix 6: Synopsis

Synopsis Sungai Bawan

Environmental and Social Impacts of Oil Palm Plantations in Sarawak's Kanowit District, Malaysia

(Palm oil alliance, n.d.)

Date: February 24, 2023

Names: Marie Eenens, Eva Leeman, Thea Bjornson, Lavinia Svae

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Introduction

Oil palm, a tree-crop indigenous to Africa, was first introduced to Malaysia in 1875 and planted for commercial purposes in 1917 (Cramb & Curry, 2012). Since then, it has become a major part of Malaysia's exports. In January 2023, Malaysia exported ~1.9 million tonnes of oil palm products (Malaysian Palm Oil Board, 2023). If you take a look around your house, you will almost certainly find some product with palm oil listed in the ingredients, whether it be chocolate or laundry detergent. Being the most produced, consumed, and traded form of vegetable oil in the world (WWF, n.d.), palm oil comes with a host of different challenges as well as benefits. Over the course of a decade, publications related to palm oil increased dramatically from 355 in 2004 to 1796 in 2013. Specifically, there was an increase in publications regarding the sustainability of palm oil with 95 articles being published during the ten year period. Of those 95 publications, 63% came from Malaysian Universities (Hansen et al., 2015).

While it has become increasingly stigmatized for the deforestation and subsequent biodiversity loss associated with its production (Koh & Wilcove, 2008), oil palm has also contributed to economic development in Southeast Asia and lifted people in rural areas out of poverty (Hasan & Nur Hidayat, 2018). In addition, oil palm is a highly productive crop with an exceptionally low land footprint compared to annual oilseed crops (Murphy, Goggin, & Paterson, 2021), yielding 5 tonnes palm oil/ha/yr in perfect conditions. One empirical study found that oil palm crops globally produce 81 million tonnes of oil over about 19 million hectares which boils down to about 4 tonnes/ha/yr. Comparatively, soybean and rapeseed combined yield 84 million tonnes over 163 million hectares (~0.5 tonnes/ha/yr) (Murphy et al. 2021). Presumably as a result of this efficiency, there has been a drastic increase in palm oil production globally compared to other vegetable oils over the last 30-40 years (Figure 1). In 2020, the oil palm matured area in Malaysia was 5.23 million hectares, with Sarawak being the state with the largest oil palm cultivated area, owing 1.58 million hectares (Ghulam Kadir, 2021).

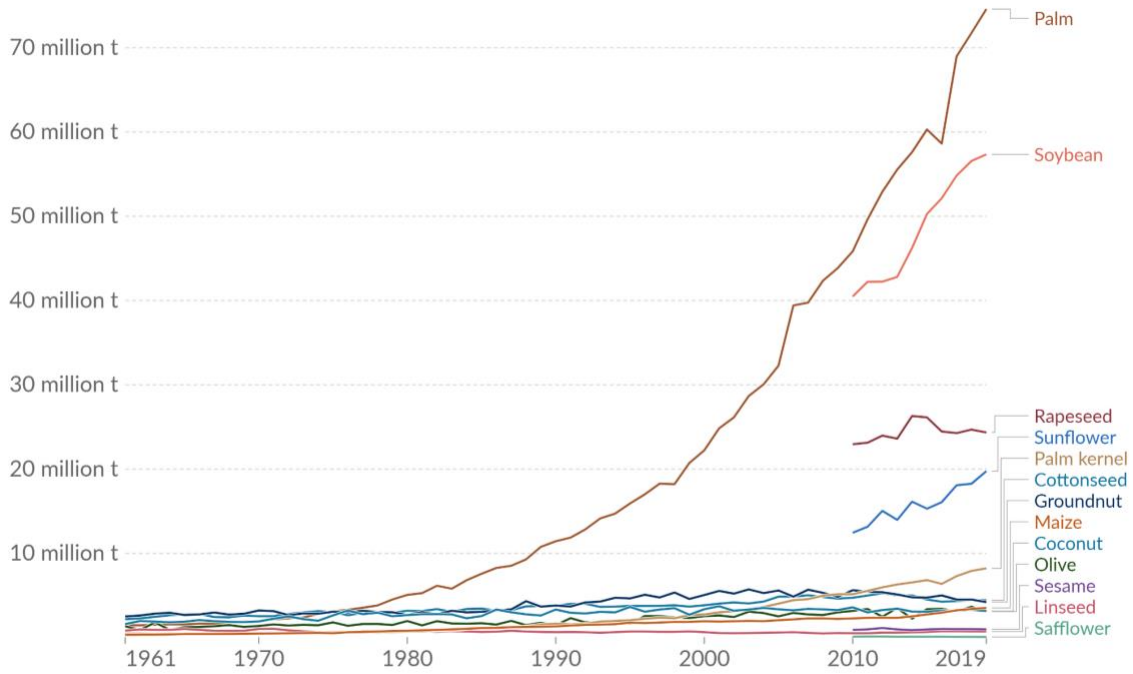

Figure 1: Vegetable Oil Production, World (Ritchie & Roser, 2020)

Economic development of oil palm plantations in Sarawak

Traditionally, the indigenous population of Sarawak, namely the Iban peoples, were engaged in shifting cultivation which was successful due to the incorporation of smallholder cash crops, mostly rubber and pepper (Cramb & McCarthy, 2016). In 1981, the chief minister of Sarawak introduced the 'Politics of Development' policy which focused on the development of agricultural and manufacturing industries (Jomo & Hui, 2003). After the 1980s, the practice of small-scale agriculture in Sarawak decreased due to agricultural development and an increasing global demand for palm-oil. The expansion of large-scale palm oil plantations transformed Sarawak from a mostly small-scale agricultural producer to a large-scale palm oil producer. These large plantations were primarily managed by private estates or government schemes (Cramb & McCarthy, 2016). Critics argue that socioeconomic development has not reached all groups equally, especially excluding the indigenous peoples (Osman, 2000).

Since the mid-1990s when Konsep Baru (New Concept) was introduced (Cooke, 2002), an oil palm development model of joint-venture companies (JVCs) on customary lands has been heavily pushed by the government (Cramb, 2013). Despite this, independent smallholder plantations increased at a similar rate to the joint-venture schemes from 2001-2009 (Cramb &

Sujang, 2013). At this point in time, small-scale and large-scale oil palm plantations are spread across Sarawak. Independent smallholder oil plantations are generally less than 40ha. Instead, large-scale private commercial plantations in Sarawak can range from 40ha to more than 100,000ha, and state-mediated private company plantations require a minimum size of 5,000ha (*ibid*). Based on information from our partner university, UNIMAS, we expect to find 9 households (*pintu*) that are independent smallholders and 7 which lease their land to large-scale JVCs. According to Cramb et Sujang (2013), the average plantation size for independent smallholders was just over 5ha, a bit more than those leasing their land to government-supported JVCs which averaged 5ha. These plantations have changed the way of life in the rural areas of Sarawak and its environment.

Background on the field site

The field site of this research is along the Sungai Bawan river, a tributary of the Rajang River which flows through the district of Kanowit, Sarawak. The district is characterized by this major river and a tropical climate ("Introduction Kanowit", n.d). The main ethnic group that lives in this district is the Iban (*Sea Dayak)* and the main religious practice is Christianity ("Kanowit District", n.d). Iban people traditionally live in longhouses which are houses linked together in a single row (Ngidang, 1995). The field work of the project will happen in and around a longhouse which we will refer to simply as "Sungai Bawan" in Kanowit, Sarawak. In this longhouse the social structure comprises the headman and the so-called JKKK which refers to several committees. These committees include welfare, education, development, agriculture, sports & youth and religion.

The aim of this research is to provide an understanding of the differences between large-scale and small-scale oil palm plantations. As mentioned, oil palm is an important agricultural commodity in Sarawak, Malaysia. There has been research done on the environmental and social effects of these plantations separately (Cramb & Curry, 2012). However, there is to date very little research focusing on the different impacts of large-scale and small-scale oil palm plantations in a comparative analysis. To fill in this knowledge gap, this research tries to answer the following question: 'How do the environmental and social impacts of oil palm cultivation differ between large- and small-scale plantations in Kanowit District, Malaysia?'.

The subquestion, specifically on the environmental side, is 'What are the environmental impacts of the large scale vs small scale oil palm plantations in Kanowit district?'. This question

will look at the impact of the plantations on the quality of the soil and on biodiversity. The subquestion in terms of social impacts is 'What are the social impacts of the large scale vs small scale oil palm plantations in Kanowit district?'. The answer to this question will produce knowledge of the socioeconomic differences between smallholders who cultivate oil palm on their own small-scale plantations and those who lease their land to JVCs. The socioeconomic differences will be explained using assets, education, occupation and the involvement of people in the longhouse committees. This question will also try to explain the attitude towards palm oil of the people living in the longhouse.

Hypotheses

For the environmental impacts, we assume that large-scale plantations rely on a more intensive use of fertilizers in comparison to small-scale plantations. We therefore expect to find more nutrients in the soil on the large-scale plantations (Zhu, Qi, & Wang, 2022). However, due to the increased use of Nitrogen fertilizers, we expect the pH to be lower on the large-scale plantations. The soil will become more acidic because of leeching of excess nitrate (Nelson et al., 2011). The small-scale plantations are expected to be more biodiverse than the large-scale plantations, as evidence shows that the integration of biodiversity conservation is more successful in smallholdings compared to large-scale plantations, due to a variety of factors, such as diversity and density of trees, the presence of native plant species in the understory, and the lack of use of pesticides (Azhar, Saadun, Prideaux, & Lindenmayer, 2017). Also, small holdings often engage in polyculture, which increases floristic diversity (*ibid*).

For the social impacts we expect the attitude of the people living in the longhouse and government officials to be positive towards the oil palm plantations. Additionally, from a socio-economic perspective, we expect the farmers involved with large-scale plantations to be better off than those involved in small-scale plantations. As mentioned in Mohd Idris and Siwar (2015), off-farm strategies are important to reduce poverty. They also mention a disparity between, low-income, rural work and, high income, urban work (Mohd Idris & Siwar, 2015). Those involved with large-scale plantations are known to rent out their land and work off-farm somewhere else.

Lastly, we do expect there to be a difference between the social status of those involved in small-scale plantations versus those involved in large-scale plantations. A study in Indonesia found that living standards and nutrition were positively affected by the adoption of oil palm and that

benefits would vary based on education and access to land and capital (Euler, Krishna, Schwarze, Siregar, & Qaim, 2017). Thus, we expect that rural people will feel generally positive about oil palm and that the scale of their plantation and the profits generated from their cultivation will be correlated with their socioeconomic standing. Lastly, we expect membership in committees and education level of inhabitants of the pintu to correlate with social status.

Methodology

Social sciences:

The research aims to be interdisciplinary. Data collection stemming from both the disciplines of social sciences and natural sciences will complement each other (Krishnan, 2009). Concerning the social sciences, the use of questionnaires, interviews, participant observations, transect walks, and mapping will be the means of data collection. This triangulation of methods strategy will ensure a broader scope of collected data (Thurmond, 2001).

A short questionnaire created with the aim to collect introductory information about the longhouse community members will be created. It will inform the researchers about the locals' identity, assets, oil palm and other crops cultivation, non-agricultural work, and committees involvement. It will allow the researchers to gain an understanding of who lives in the longhouse, the position of its inhabitants, and directions for sampling interview participants. Indeed, the questionnaire will help the researchers identify key informants for the following semi-structured interviews from the information gathered about their occupation and their willingness to participate in a longer interview. A target of thirty answers has been set. This quantitative data will also lead to correlation analysis and pattern identification to determine whether the involvement in large or small-scale oil palm plantations impact their socioeconomic status in different ways (Bryman, 2012). The socioeconomic status will be determined using the involvement of people in the longhouse committees, education level, occupation and their assets. The determination of assets will be done using the livelihoods framework introduced by Ellis. This framework differentiates between 5 types of capital which together give an understanding of assets as part of people's livelihoods. These types of capital include: natural, physical, social, financial and human (Allison & Ellis, 2001). Two team members accompanied by one translator will carry out this work in the beginning of the stay.

Deriving from the questionnaire, semi-structured interviews will help answer both research questions (Bryman, 2012). The sampling strategy is a mix between stratified and snowball sampling. Three groups are targeted: small and large-scale oil palm cultivators, and government officials. A preliminary target of fifteen interviews has been set. Twelve interviews will be conducted with the Sungai Bawan's longhouse inhabitants, equally targeting both small-scale and large-scale individual farmers. The remaining three interviews will be conducted with government officials. This stratified sampling is not random as the participants will be selected based on the information given by the headman, the questionnaire, and other participants in a snowball sampling process (Gill, 2020). The interview guide explores the following topics: identifying questions, position in the longhouse, oil palm, and JVC. Small-scale and large-scale farmers will help answer the questions concerning the influence of oil palm plantations on the socioeconomic differences within community members, as well as the reason behind their choice to remain small-scale or switch to JVC. In addition, the interviews will focus on questions related to the attitude of people towards oil palm plantations. Government officials will provide more specific information on the role of the government in JVC and its functioning. The interviews will be done by two team members, one asking questions and one taking notes, accompanied by one translator. With the consent of the participants, they will be recorded, transcribed, and analyzed through thematic coding in NVivo. This will permit the classification of the data in categories to facilitate the answers' analysis (Bryman & Burgess, 1994).

Participant observations will complement these methods throughout the field work (DeWalt & DeWalt, 2011). Some observations will take place in the village, around and inside the longhouse and during committee meetings. They will provide the researchers with a better understanding of the environment around the village and the community members' activities. Additional participant observations will happen on the small and large-scale plantations sites, accompanied by one or more inhabitants. Here the aim is for the researchers to gain a better understanding of the position of oil palm in the daily lives of those involved with oil palm plantations. If possible some participants' observations will also be conducted later on in the oil palm production chain, mainly the process of weighing the oil palm. Some observations will also be conducted later in the same places once the researchers have more knowledge about the situation and thus a new perspective with potential new insights.

Finally, at least one transect walk will happen in and around the longhouse, at a small-scale, at a large-scale oil palm plantation, and at the marketplace where the weighting of harvest takes place. This will provide additional information from the locals through discussions and visualizations (Mikkelsen, 2012). A GPS will be used to record each place of relevance, with the objective to develop a map after the field work localizing the different plantations, markets, meeting rooms, and other potential interesting areas for the research in and around the longhouse. One transect walk will happen on the first day with the headman. The others will ideally happen in conjunction with some interviews for efficiency reasons.

Natural sciences:

Reviews of the on-site environmental impacts of oil palm plantations show that the major impacts are found on soil quality, soil erosion, water quality, and biodiversity (Hartemink, 2003, 2005; Nelson et al., 2010; Comte, Colin, Whalen, Grünberger, & Caliman, 2012). Due to time constraints, in the present study, we will focus on the impact of oil palm plantations on soil quality and biodiversity.

We aim at assessing soil quality by collecting soil samples from cultivated areas, both small- and large-scale. Soils will be sampled with a cylindrical corer from beneath weeded circles surrounding individual palms (i.e. at a distance of one meter from the base of the oil palm) and from the frond pile at two depth intervals, 0-20 cm and 20-40 cm, as the literature suggests (Pauli et al., 2014, Rüegg et al., 2019). We will collect five replicates per area and will sample them on a systematic grid that will be developed once we know the plantations' structure. We will subsequently test soils for a range of soil properties, including soil texture, using the Feel method (Ritchey, McGrath, & Gehring, 2015), soil organic carbon (% SOC), total nitrogen (N), available phosphorus (P), and acidity (pH).

Concerning biodiversity, only a few studies look at plant biodiversity in oil palm plantations. Thus, we believe it would be relevant to further investigate this aspect of biodiversity. In fact, one study found 298 plant species in the oil palm undergrowth (Germer, 2003), while a meta-analysis of plant diversity identified between one and fifteen associated plant species (Letourneau et al., 2011). In our study, we will assess plant biodiversity by random sampling five 1-m^2-quadrats in each field.

A preliminary schedule of the field work can be found below (Figure 2).

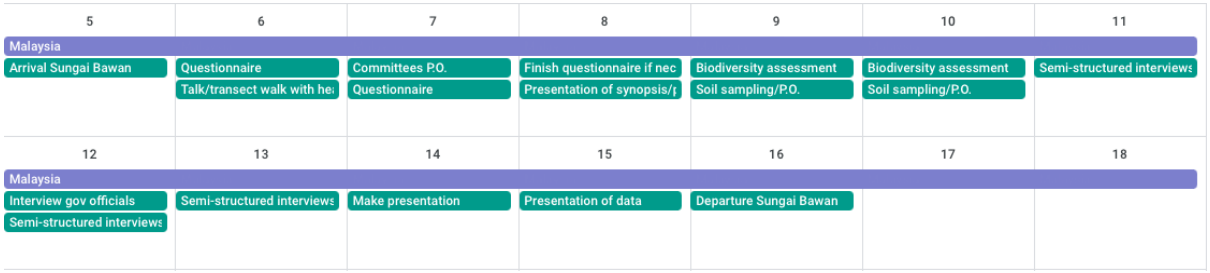

Figure 2: Schedule of the field work

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