Interdisciplinary Land Use and Natural Resource Management
February 2023 - April 2023

KØBENHAVNS UNIVERSITET

LAND USE CHANGES IN NANGA BAT

A STUDY ON THE SOCIOECONOMIC, CULTURAL AND ENVIRONMENTAL CAUSES AND IMPACTS OF LAND USE CHANGES RELATED TO RICE CULTIVATION IN NANGA BAT

Signe Schakenda Kaldahl, Sofie Banke Poulsen, Mariana Sarmiento, Flavie Ancelin and Toke Due Sjøgren

Interdisciplinary Land Use and Natural Resource Management 2023

ABSTRACT

Land use changes in relation to agricultural practices in Sarawak have occurred significantly due to several reasons including agricultural policy change and urban migration happening at a national level. Those tendencies have greatly impacted the level of rice cultivation among Iban communities, in particular. The aim of this research is to assess how and why rice cultivation in the selected study site Nanga Bat has changed since 2011 and the associated socioeconomic, cultural, and environmental impacts. The main land use change in Nanga Bat has been the drastic cessation of rice cultivation, which led to a number of diversified agricultural practices and land abandonment. The direct and indirect causes include changes in occupations and sources of income, urban migration, daily struggles with pests and weeds, increasing prices of life and new expenses, health issues, aging population, and lack of generational replacement. The end of rice cultivation as a result has impacted life in Nanga Bat in various cultural, socioeconomic, and environmental aspects. The environmental impacts include agricultural soil degradation and loss of biodiversity. The end of rice cultivation has led to an increase in income dependency, and expense sharing and shift in rice consumption. Finally, examples of cultural impacts are the loss of knowledge, change of relevant cultural practices around rice, and the loss of Iban identity. The discussion on the causes and impacts of the ending of rice cultivation in the field site can be related to regional agricultural tendencies. Overall, the gradual decline in rice cultivation, and traditional knowledge is a relevant and still developing discussion in academia.

ACKNOWLEDGEMENTS

This research is part of the SLUSE 2023 Joint Field Course in Sarawak, Malaysia, in cooperation between the University of Copenhagen in Denmark and UNIMAS in Sarawak, Malaysia.

Firstly, we would like to express our overall sincere gratitude for being a part of this course. Thank you to all the Malaysian and Danish teachers who have made the trip possible and made it a unique and memorable experience. Special appreciation to our supervisors Dorette Sophie Müller-Stöver and Sinne Borby Ørtenblad, whose dedicated guidance and valuable support have allowed us to carry out this research project from the very beginning to this report, as the final outcome. Special thanks to our Malaysian research persons for facilitating our stay in Sarawak and supporting us in all aspects of this course.

Last but not least, we would like to thank all the inhabitants of the longhouse for allowing us to stay in Nanga Bat, for hospitality at a noticeable level regarding both food, accommodation, and a very friendly, welcoming, and warm-hearted vibe. Special thanks go out to the Headman (Appai) whose kindness and commitment made us all feel very much at home during the entire stay.

We would also like to thank all our Malaysian counterparts and interpreters for cooperating with us and making this such an amazing experience! Thank you for an unforgettable experience and we sincerely hope to meet you all again soon.

Thank you

TABLE OF CONTENTS

1. INTRODUCTION

In recent decades, Malaysia has been home to significant land use changes, relating both to changes in agricultural land and practices as well as an increase in industrialization (Azari et alt, 2022). One significant land use change, which is both influenced by and affects socio-economic, cultural, and environmental aspects, are the changes in rice cultivation (Yasar & Chamhuri, 2016; Mertz et al, 2013). Being not only the main staple food for the Malaysian population but also the center of a number of well-established and strong social and cultural traditions as well as playing an important role in the local economy, this crop is of particular importance for the country (King & Knudsen, 2021; Sarther, 1980). In 2021, rice was grown in a land area of 322.000 hectares, resulting in Malaysia reaching 80% self-sufficiency in rice production (Houma et al, 2021). Rice production, especially traditional hill rice cultivation, has faced various problems and challenges leading to drastic changes in land use (Echoh et al, 2017).

Looking closer at the Malaysian state Sarawak, located in the south-western part of Borneo,prominent land use changes have been taking place in relation to agricultural land use practices in particular. According to Mertz et al (2013), the shift is particularly characterized by moving away from small-scale practices such as rice cultivation to large-scale production of cash crops. Hansen &Mertz (2006) defines a number of reasons to explain this phenomenon, including economic growth, an increase in off-farm job opportunities, labor migration, and interventions regarding shifting cultivation among other things.

A study carried out by Hollaus et al (2022) examining two villages in Baram, Sarawak, and their development of traditional rice production, found environmentally driven challenges, such as pests and invasive vegetation, socially, related to lack of labor and poor capability, and agriculturally in relation to poor soil quality and synthetic fertilizer. It appears that although rice cultivation is confronting a number of difficulties, rice cultivation is still to some extent taking place in local communities as an important part of local farming strategies, but also due to the long-established tradition of cultivating rice (Mertz et al, 2005; Sarther, 1980). On another note, studies have identified linkages between the current land use change and larger tendencies related to urbanization and modernization (Lambin & Meyfroidt, 2011; Yonda 2016).

It seems relevant to examine to which extent the local communities are undergoing land use changes related to rice and, in this regard, the actual causes behind this phenomenon as well as the directly associated impacts on both people and nature. These objectives of the research will be carried out through a case study in the longhouse community of Nanga Bat, located outside of Kanowit in the state of Sarawak (section 3). Names of longhouses and headmen as well as all research participants have been anonymized.

1.2 OBJECTIVE AND RESEARCH QUESTIONS

The overall objective of this research is to assess *how and why the rice cultivation in Nanga Bat has changed since 2011 and the associated socioeconomic, cultural, and environmental impacts*. In order to answer this objective, the following research questions have been developed:

1. What is the main land use changes in Nanga Bat?
2. What are the causes of the land use changes in relation to rice cultivation?
3. How has the shift in land use affected soil properties and biodiversity?
4. How does land use changes impact socioeconomic and cultural aspects relate to the people of the community?

1.3 ABBREVIATIONS & CLARIFICATION OF TERMS

LUC = LAND USE CHANGE(S)

1.3.1 The end of rice cultivation

In this report, “the end of rice cultivation” refers to the main LUC in Nanga Bat. LUC is often defined as an interaction between humans and land through processes that operate with a high degree of complexity, with a number of different variables at different scales and at different times influencing the changes that occur (Hansen, 2005). Following this definition, it is possible to identify changes in rice cultivation as a LUC.

1.3.2 The environmental, socioeconomic, and cultural aspects

When environmental, socioeconomic, and cultural aspects are written, there are multiple perspectives and meanings behind them. All three are associated with the impacts of LUC in rice cultivation. The environmental aspect concerns biodiversity and the conditions of the soil at the four sites. In regard

to the socioeconomic aspects, reference is made to people's income and occupation, their rice consumption, and remittances. In terms of cultural aspects, the focus is mainly on the Iban traditions and rituals related to rice and rice cultivation, as well as knowledge and perceptions of rice.

1.3.3 The younger and the older generation

In order to systemize the findings, two different terms have been developed, characterized by a generational gap in differences in mentality and actions related to rice cultivation. First, the term "the older generation" represents the older part (50-80 years old) of the respondents. "The younger generation" includes the youngest part (25-50 years old) of the respondents. These two age groups will be applied throughout the report for data analysis, and the discussion related to a broader context.

1.4 CAUSAL ANALYSIS

This section presents the causal analysis framework that is applied to analyzing and discussing the causes of changes in rice cultivation.

The terminology of land use transitions developed by Meyfroidt (2016) as a conceptual framework will be applied to identify a causal analysis of rice cultivation as a LUC. This framework supports the discussion of the findings in relation to establishing a causal analysis between causes and effects (section 6.2).

Meyfroidt (2016) presents a number of key concepts that are often used in relation to examining different aspects of causality when analyzing land system transitions. In this report, selected concepts that are relevant to the identification of the causes of the LUC change are used. A cause can be defined as an explanation of a certain outcome which can be events, facts, or variables. Whereas an underlying cause is often characterized as the factors involved in the first steps of the causal chain, the proximate cause is the action itself that directly leads to the outcome. Identifying the effects of the causes is referred to as a causal explanation. The causal mechanism then provides an explanation of the processes by which a certain cause produces its effect, examining how a cause leads to an outcome. Finally, the outcome can be seen as the occurrence of any variable where the associated explanation of the "why" and "how" (the causes) has been addressed. Thereby it is possible to outline the causal chain, as the series of causal mechanisms linking the identified causes to the outcome (Meyfroidt, 2016).

2. METHODOLOGY

This section presents the different methods used for the study.

In order to obtain adequate data collection and answer the research objective, both quantitative and qualitative methods have been used. The two research methods will complement each other through a number of methods selected on the basis of relevance as well as the possibility of achieving triangulation and complementarity. How the methods complement each other will be described in the course of this section and discussed later (Section 5.3).

Surveys

Considering that this research is a case study, it was expected that the data collected through the survey method contributes, with the help of the literature, to generalizing findings from the respondents to the regional and national levels. Also, the survey allowed information that is not easily accessible in the literature to be obtained (Parker & Rea, 2005). The survey will cover demographic matters, understanding of overall land use activity, the presence of rice cultivation, and the related causes and impacts, addressing both environmental and socioeconomic aspects. The survey provides data for especially two aspects of the research. Firsty, the findings can be used to lay out the background of the research and support the characteristics of the study area. Secondly, the survey is a relevant method to either support or nuance the findings from the other methods in the three analysis sections (section 4). During the research process, there were 41 surveys collected in all five longhouses through opportunity sampling. All data analysis is performed in Excel 2016.

Interviews

The purpose of semi-structured interviews is to obtain detailed information and perceptions about the research objective in order to elaborate and nuance the obtained findings from the remaining methods. This method, and the data that it collects, is relevant because it allows the research team to access what is not ordinarily viewed, it gives the research close access to information, meanings, and experience that is only accessible throughout an interview (Skinner, 2012). The respondents have been collected through purposeful sampling aiming to turn attention towards the most relevant respondents and collect in-depth exploration. During the fieldwork, a total of six individual interviews and three group interviews were done. While the individual interviews allow for a conversation of deep character, with the opportunity to get the full benefit of the respondent's knowledge, the group

interview allows for a safer environment for the expression and the generation of diverse perspectives. In total 9 interviews have been conducted.

Transect walks

The purpose of transect walks is to obtain relevant data and gain better insight into the current rice farmers perceptions through participatory learning. Being engaged in the rice fields as researchers allowed a better identification and understanding of the cause-effect relationship with associated challenges and realities related to the research objective (Okoko & Prempeh, 2023). The transect walks consisted of two walks with rice farmers in their respective rice fields. The transect walks have provided data on a general overview of the daily life patterns of the farmers in the rice fields and changes in their agricultural activities.

Photo I: Transect walk in active paddy field.

Community mapping

Through community mapping people can draw how they see and experience their territory through a graphic representation of the actors, the relation between them, and properties of the area (Sweet & Ortiz Escalante, 2017). Community mapping provides a visual overview and understanding of the LUC and the associated perceptions of the longhouse community while emphasizing knowledge about the particularities of the study site. This was conducted in the common area in the longhouse with the participation of people from the community, resulting in a diverse representation. The participants were asked to draw a map of Nanga Bat and discuss associated changes, current activities, and general characteristics. The method provided detailed information about the community and territorial changes which supported and nuanced the findings from the interviews aswell as data from the survey.

GPS

The purpose of the GPS has been to obtain updated coordinates of the whole area of research with the aim to create a satellite photo framing the study site (section 3).

Biodiversity assessment

The purpose of the biodiversity assessment was to find potential changes in vegetative biodiversity, related to LUC. Biodiversity assessments are useful to monitor the effects of management practices or different environmental impacts (Hill et al, 2005). Four sites were studied and compared at varying levels of succession, which provided a temporal gradient with an active rice field as the baseline. The study sites were selected based on the year of the end of rice cultivation, with similar characteristics in terms of previous land use and slope. The sampling methods conducted were two replicates of 1m^2 squares at each site, measuring species abundance of non-woody vegetation and one large strip transect at each site. Vegetation was chosen as the focus due to the fact that plants are easier to sample and generally act as decent indicators of the overall biodiversity of an area. The biodiversity is quantified with species richness, rank abundance, and calculating the biodiversity index Shannon-Wiener.

Photo II: Biodiversity assessment

Soil sampling

The purpose of soil sampling is to examine the changes and impacts in the characteristics of the soil due to LUC. As agricultural practices are changing it becomes pertinent to investigate the changes in soil properties as small changes can have large impacts on the community (Shepherd et al, 2008). Four sites were selected, with the active cultivation site acting as the baseline and then three different sites where rice cultivation ended in 2020, 2016, and 2011, respectively. Four replicates were collected at each site and mixed in a plastic bag for composite mixing at the long house. The samples were then dried indoors, and examined in a lab, where pH, nitrate, ammonium, phosphate, and soil organic matter were measured.

3. STUDY SITE

The research is conducted in the rural longhouse community of Nanga Bat (satellite image 1), located about 40 km east of Kanowit town in the state of Sarawak, Malaysia. Nanga Bat consists of three individual houses and five longhouses maintained under the surnames of the respective headman. It is inhabited by about 400 Ibans (interview 1). As described and illustrated by the participants of the community mapping (section 4.1), the rural area ischaracterized by hilly terrain, covered by mainly rainforests and a large river system connecting the landscape. Formerly, hill and wet rice fields were also a major part of the landscape, but have declineddramatically over the years (section 4.1). The community subsists primarily on their own agriculture and wild forest resources, both fruit, vegetables, and grains, and fishing and hunting (interview 5, 8 & transect walk 1). However, as revealed in the survey, several community members also have wagework, such as construction (9% of the survey respondents) or service jobs (4% of the survey respondents).

Satellite image 1. Overview of Nanga Bat (N01°57’37.57”, E112° 22’40.39”)

Satellite image 1 presents the five longhouses and the four sites as the focus of the data collection. The survey and interviews have been carried out in all five longhouses, while the soil and biodiversity assessments have taken place in four different areas - one active hill rice field, and three former hills rice areas abandoned in 2011, 2016, and 2020, respectively.

4. FINDINGS

4.1 LAND USE CHANGES IN NANGA BAT

This section outlines the land use changes that have been taking place in aiming to answer the first research question.

The district officials of Kanowit roughly estimate that the land use of the region is 50% agriculture, 40% secondary and primary forest, and 10% human settlements and infrastructure (interview 9). Specifically, for Nanga Bat, the findings of the survey reveal that 75,6% of the respondents previously cultivated rice, and only 7,3% are still actively cultivating. The same change appears when examining the findings of the community mapping exercise which reveal that of the 24 documented rice fields, 22 have been left and only two are actively in use (Figure 1).

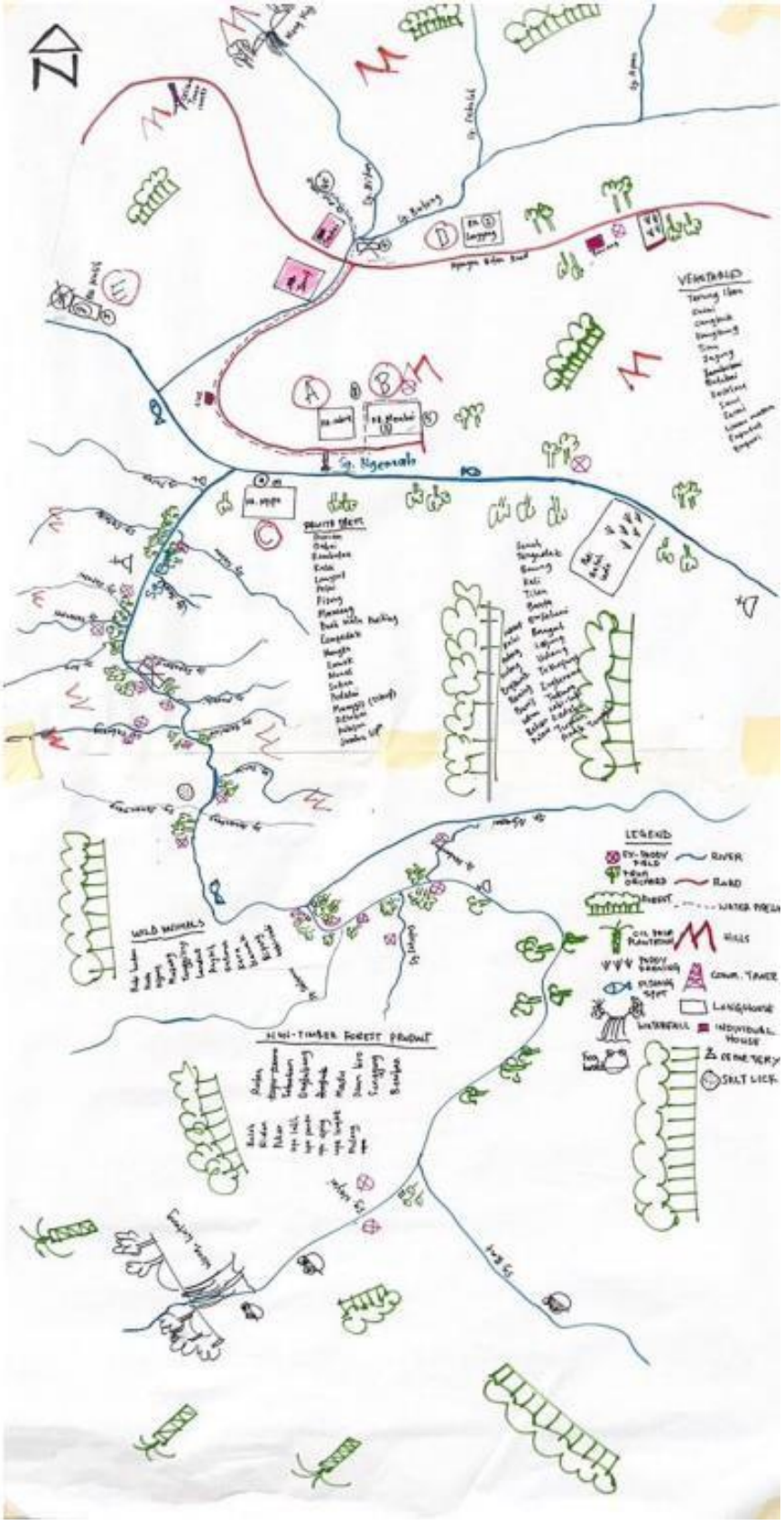


Figure 1: Community mapping.

This is also expressed in the community as at least one woman estimates that rice cultivation will be completely ended in Nanga Bat within 2-3 years (interview 4). All survey respondents who had cultivated rice in the past indicated that their rice cultivation was primarily for self-consumption and that other interests such as selling the products were less important. This is corroborated by the headmen in the group interview (interview 6).

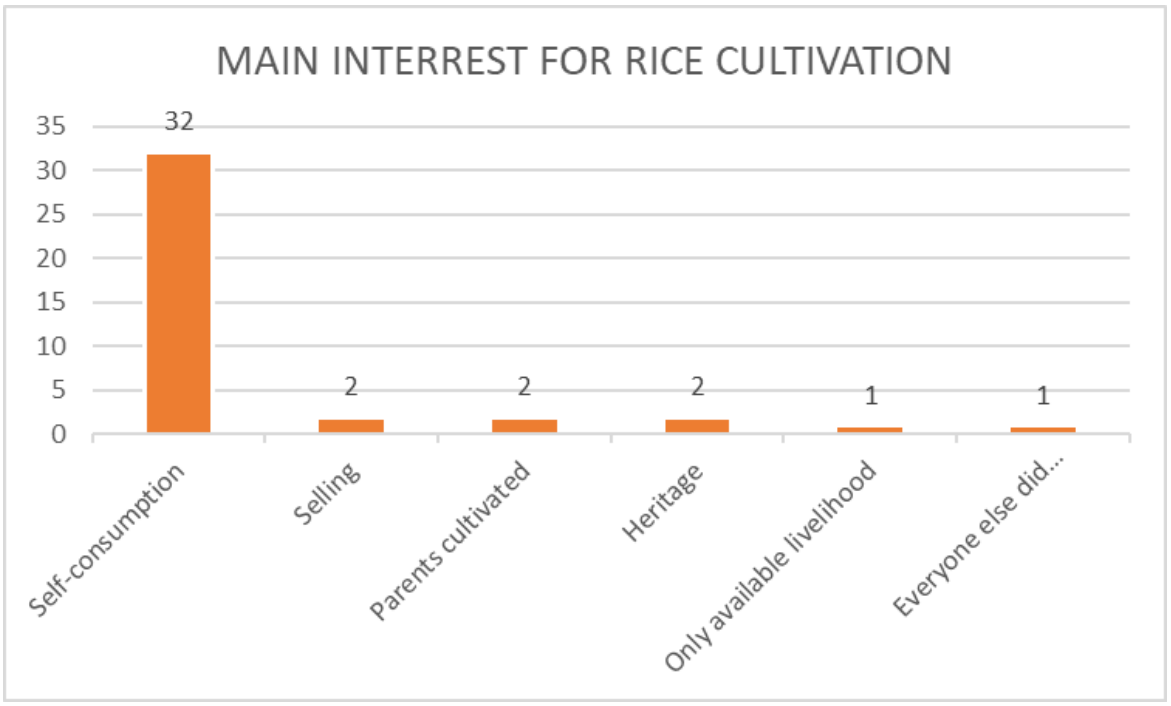


Figure 2. Bar plot of the reasons given for cultivating rice.

After ending rice cultivation, only 7.5% of respondents have left their land completely uncultivated, whereas the rest have diversified their agricultural practices. Whereas the majority of the respondents grew fruit trees alongside rice cultivation, 54% have expanded this practice, while 8% have started cultivating vegetables. Both the headman and the farmers clarify that most fields are not entirely abandoned but fruits are still harvested (interview 1 and 8). Vegetables are grown to a lesser degree due to the soil not being favorable without fertilizers (interview 6) but the market price of vegetables is higher than rice still making it profitable on some occasions (transect walk 1). Cash crops such as pepper, rubber, and small and large-scale oil palm constitute 30 % of the LUC related to the end of rice cultivation. The findings are summarized in Figure 2.

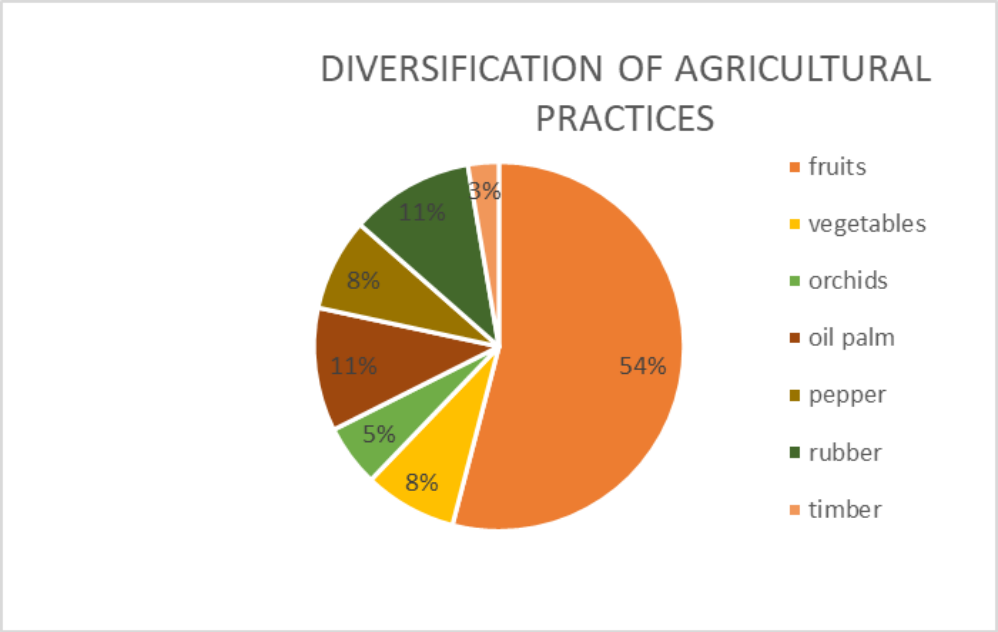


Figure 3. Survey findings of land use changes related to the end of rice cultivation.

The dominance of fruit orchards as the main LUC can likely be attributed to the ease of cultivation, as no fertilizers are needed as with vegetables, and the soil in Nanga Bat is well suited for fruit trees (interview 6). Additionally, fruit production is mostly for self-consumption but extra produce can be sold at the market (interview 6).

Findings from the survey show that of those who own land, 73 % are cultivating it themselves, while only 12% are renting out their land. The farmers state that they are primarily renting out to oil palm plantations with renewable 30-year contracts in areas that are far from the longhouse (interview 8). The headman is one example as he started renting 170 hectares of Nanga Bat land to oil palm companies after he stopped rice cultivation and now receives 7.000 MYR from the company for his rented land. However, it is recognized, that the people in Nanga Bat are interested in palm oil, but due to logistical challenges, especially related to road conditions and disagreements between the farmers regarding renting out, it is difficult to realize these wishes as the oil palm companies need a certain amount of land area, if it should make sense (interview 1).

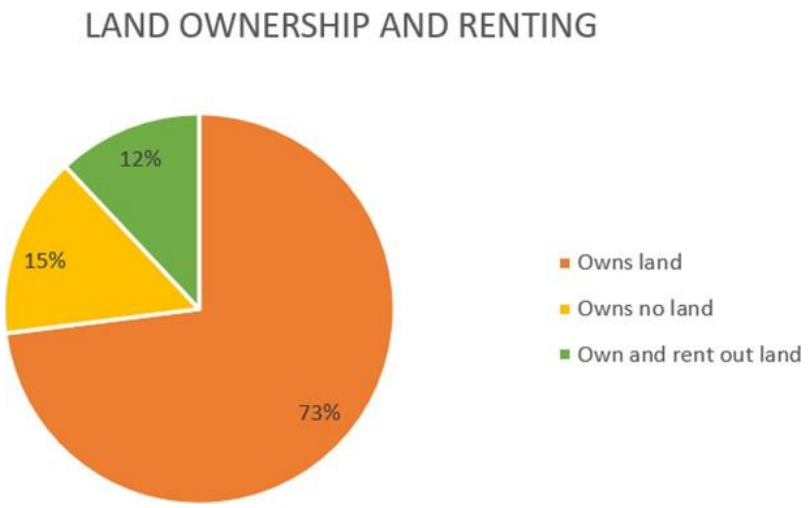


Figure 4. Survey findings regarding the ownership and renting of land.

4.2 CAUSES OF LAND USE CHANGES

This section addresses the causes behind the end of rice cultivation. The aim is to answer the second research question.

4.2.1 Change in everyday activities and interests

One cause that has been recurring in several interviews as well as in the survey, is the decrease in both the activities and the interest in relation to rice cultivation (interview 6, 8). 20% of the respondents see this cause as being a part of the explanation whereas the vast majority (80%) of these define it as being the main reason leading to a decision of ending rice cultivation. In particular, the younger generation is less interested in rice cultivation, and agricultural activities in general. A t-test revealed a 14-year age gap between the means of people involved in activities related to land use (farming, fishing, hunting) and people not involved in such activities (mostly wage workers and housewives). The statistical relevance is very high as it is 0.001. In all interviews, it is emphasized that the younger generation is more interested in getting an education and finding better-paid jobs (interview 2, 3).

There are a few reasons presented for this, but the most prominent one is that there are far more opportunities to choose from nowadays (interview 1, 4, transect walk 1). And as the cities offer many other possibilities in terms of work, career, and education, the majority of the younger generation has

migrated from Nanga Bat to the cities. This is also in line with the findings from the survey, where 14% of the respondents explain the lack of labor as a cause behind the cessation of rice cultivation. It is explained by several of the elders and parents from Nanga Bat that only a few young people stay and live in a longhouse, and the few who remain are not involved in rice cultivation (interview 1, 5). Most of the young people remaining in Nanga Bat are either working as contractors or are employed in oil palm plantations or at construction sites. The headman hopes that if cultivation of oil palm increases in the area, it will create job opportunities and thereby attract a part of the younger generation to stay in Nanga Bat and work in the plantations (interview 1). Figure 5 shows an overview of the distribution of the many occupations in Nanga Bat today. It highlights the diversification of occupations and daily activities in the community, linked to both income generation and change of interests.

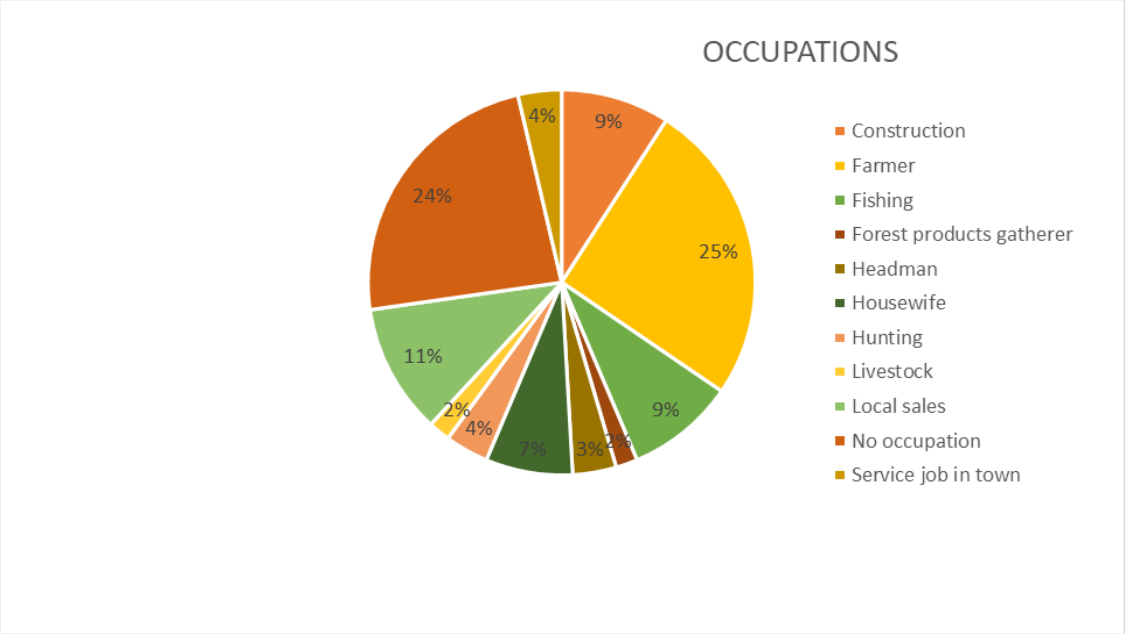


Figure 5: The distribution of occupation

This trend of an increasing interest in choosing other activities and pathways of living, has meant that only a few people are left in Nanga Bat to cultivate rice (transect walk 1). As a result, the few people still cultivating rice express that they often feel overwhelmed by the amount of work in the field and are unable to manage the rice cultivation themselves.

4.2.2 Pests

Concerning the identification of pests as a cause for ending rice cultivation, two of the 31 former rice farmers pointed out monkeys as being the main reason for ending the cultivation of rice, whereas one-fifth of the respondents state it as part of the reasons. In addition, almost all respondents in the interviews mention pests as a major and serious problem for the work in the rice fields as well as the yield of the harvest. This accounts for monkeys, birds, worms, bugs, pigs, grasshoppers, and rats. The monkeys especially destroy the rice fields as they dig up the small rice crops from the ground and peel out the rice corn (transect walk 1, interview 5). Even though the farmers have tried traps and poison, there is no effective solution to this challenge. Instead, it has increased significantly due to labor shortages, lack of help, and the fact that the few rice fields that are left are thus a victim of increased attacks than previously (interview 5).

Photo III: Broken banana tree by monkeys.

4.2.3 Economy

Five of the respondents to the survey (10%) define economic reasons as the cause for ending rice cultivation. The economy is equally divided between being the main reason or part of the explanation. Increased expenses of herbicides and fertilizers are identified as the main explanation in relation to economic matters. In a few of the interviews, farmers explained that they could not afford pesticides and/or herbicides (interview 5, 6, transect walk 1). They were, therefore, unable to control weeds, and increased the risk of pests and diseases, resulting in poor rice cultivation. In addition, the farmers who are currently engaged in rice cultivation, state that the government does not provide any financial support for rice cultivation (transect walk 1, interview 5).

However, they do, for example, subsidize the cultivation of peppers, which has also led to more farmers being incentivized to grow pepper instead of rice (transect walk 1). The officials address the situation regarding subsidies and funding from the government for rice cultivation, explaining that subsidies have been provided in previous years but have been removed due to insufficient funding (interview 9). A change, they explain, has had an impact on the incentives for cultivating rice. Another

economic factor frequently mentioned is the greater desire and need to earn money nowadays. Both the headman and the women express that their money has become less valuable and further that living expenses have increased over time, and therefore need to increase their income. The younger generation also shows concern that cultivating rice could affect their ability to generate a sufficient income (interview 1, 7). For three-quarters of the survey respondents rice was solely cultivated for self-consumption and did not generate income (section 4.1).

4.2.4 Health

The findings show that health and well-being are mentioned several times as major causes of the decline of rice cultivation. In the survey, 34% of the respondents explain health conditions as the main cause of ending rice cultivation. More than a quarter of the respondents (26%) who have cultivated rice, explain the hard work and health conditions, especially age, as being the main explanation for ending rice cultivation, whereas an additional 8% define it as being a part of the reason. Thus, health is the primary reason for ending the cultivation of rice. Several of the women in the interviews identify especially high blood pressure and other problems related to aging as explanations for stopping cultivating rice, which also accounts for their relatives (interview 3, 4, 7). Additionally, some of the farmers explain that working in the rice fields only aggravated their health problems, as rice farming is physically demanding (interview 8). The exhausting and tiring work is further mentioned in the survey, with three respondents identifying this as the main reason why they have stopped cultivating rice.

Photo IV: Group interview with farmers from the older generation

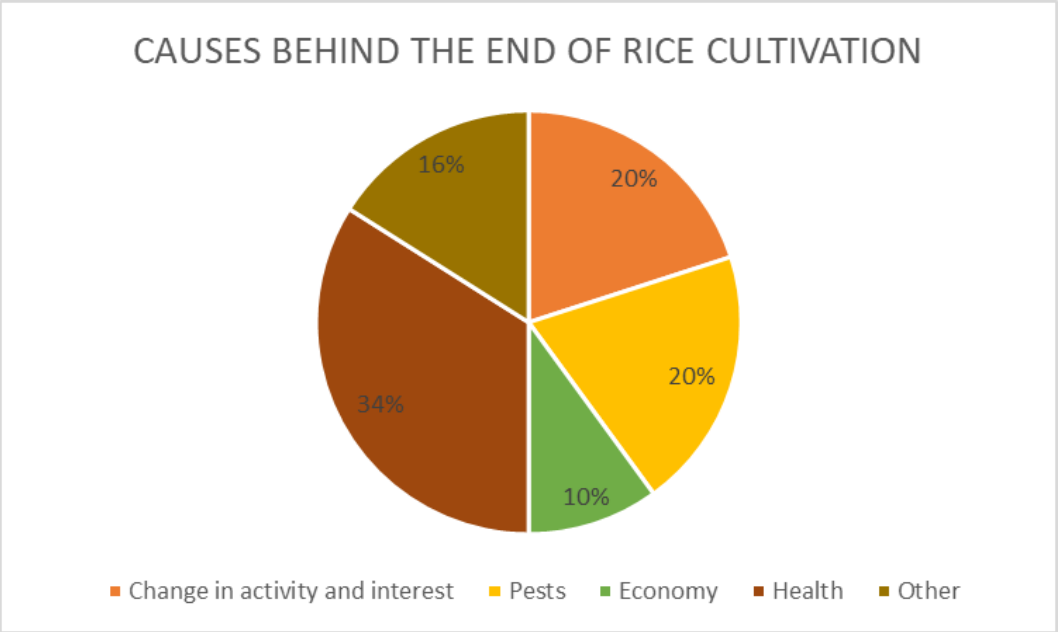


Figure 6: percentage distribution from the survey of the five major causes behind the end of rice cultivation identified

4.3. IMPACTS OF LAND USE CHANGES

This section presents the socioeconomic, cultural, and environmental impacts related to the end of rice cultivation aiming to answer the third and fourth research questions.

4.3.1 Environmental impacts of the land use change

This section addresses the environmental impacts of the end of rice cultivation.

4.3.1.1 Biodiversity

When asked about the experience of the amount of plants and trees after the end of rice cultivation, 65,5% of respondents answered that they experienced a change in the amount of plants and trees, while only 20,7% stated that there was no difference. Overall, 12 respondents stated that they experienced a larger diversity (figure 7).

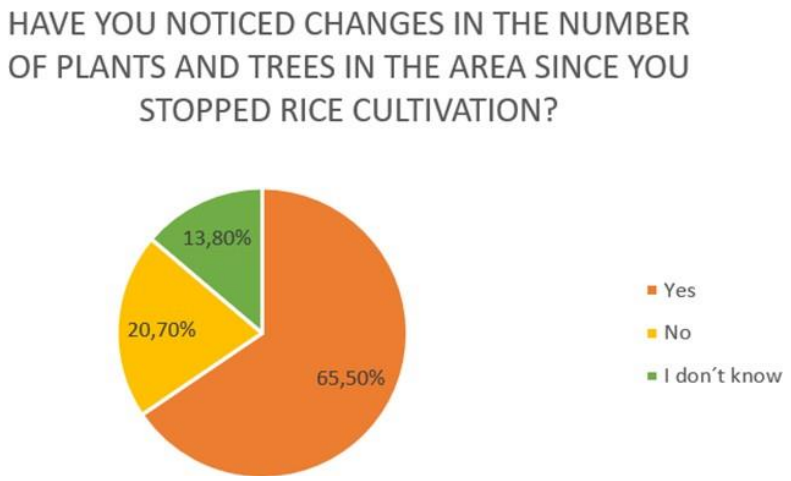


Figure 7. Circle diagram of survey data. Experience of changes in plants and biodiversity.

As displayed by the barplot in figure 8, the 2016 site is less diverse than the other sites with a Shannon wiener value of 1,791 while the other sites are >2. The species richness of the 2016 site is much higher than the other sites however as 21 species were found at the 2016 site while ≤16 species werefound at the other sites (appendix 2). The discrepancy between the lower biodiversity and the higherspecies richness can be explained by Pilou's evenness (appendix 3), which is 0,58 for the 2016 site and >0,75 for the other sites. Additionally, rank abundance graphs (appendix 4) reveal that two species at the 2016 site make up a disproportionately large part of the observations.

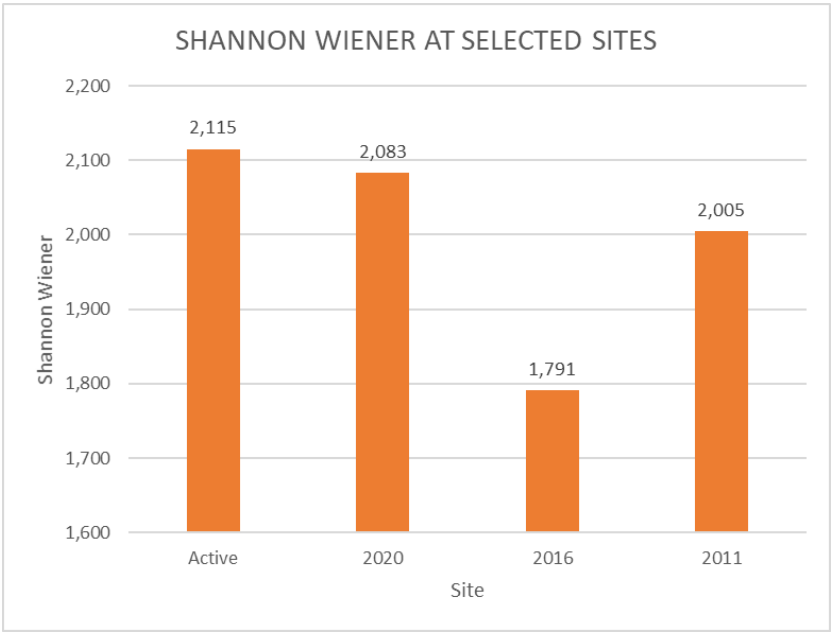


Figure 8: Shannon wiener diversity index of the 4 selected sites.

In relation to the Iban people's perception of biodiversity, the headman reveals that Iban people have developed well-defined terms for different stages of biodiversity based on vegetation. The speed at which an area is restored depends on the duration of previous cultivation and thereby the state of the soil after cultivation. If land has only been cultivated for a few years, the area moves more quickly to a new stage (interview 1).

4.3.1.2 Soil

In relation to the impacts on the soil after ending rice cultivation, 57,1% of the survey respondents answered that they noticed a change in soil quality, while 32,1% did not notice any difference. By examining the underlying perceptions of these changes 22% stated that they had experienced an improvement, while 20% reported a perceived deterioration. Additionally, the headman states that the soil in Nanga Bat is generally not very fertile and is mostly suited for rice and fruit trees (interview 6). It is relevant to test this perception by analyzing the nutrients, pH, and soil organic C of the soil.

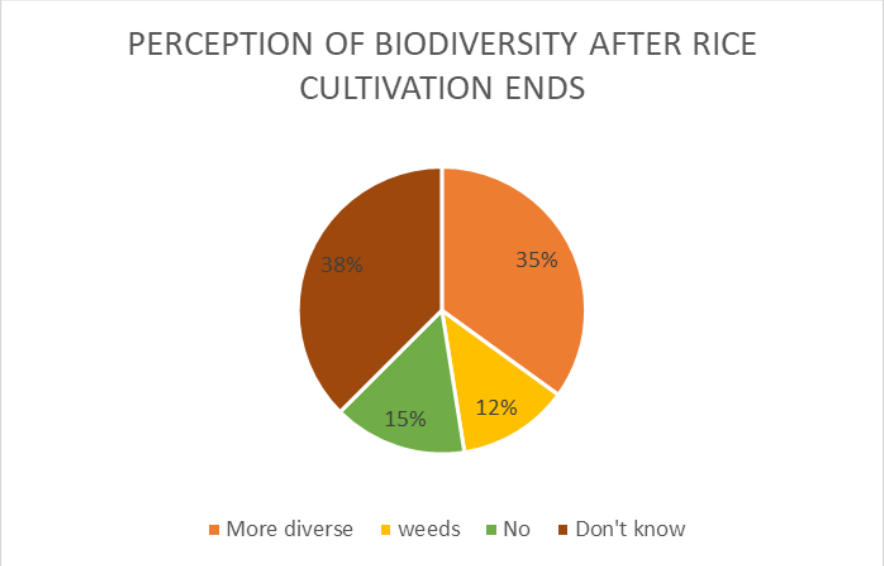


Figure 9: Circle diagram of survey data. Perception of biodiversity after end of rice cultivation.

Soil analysis reveals that the amount of ammonium at the active and 2016 sites is significantly higher than other sites with ammonium amounts at <6 mg/kg (Fig 10). Additionally, phosphorus analysis was inconclusive except for the active site which measured 2,328 mg/kg P available in the soil. The amount of phosphorus at the other sites was under the detection limit of the phosphorus test (<0,05 ppm). According to a farmer, they use fertilizer at the highest elevation of the selected active rice field hoping that the leaching will fertilize the lower part of the field (interview 5).

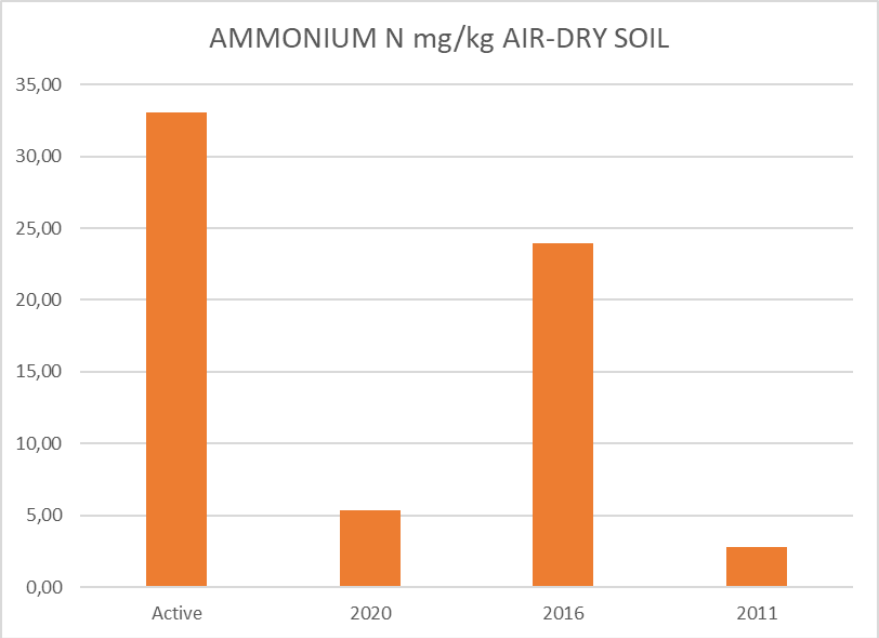


Figure 10. Ammonium content of each site in mg/kg air-dry soil.

The differences in soil organic C appear to follow a negative trend after rice cultivation ends, until sometime after 7 years when SOC increases (Figure 11. a). Differences in soil pH are small between the active site, 2020 site, and 2016 site but are significantly lower for the 2011 site, indicating acidification sometime 7 years after rice cultivation ends (Figure 11. b).

According to both the headmen and the farmers, the longer a rice field is left fallow the more suitable the soil becomes for agriculture but shifting cultivation has been replaced with continuous cultivation (transect walk 1, interview 1, 8).

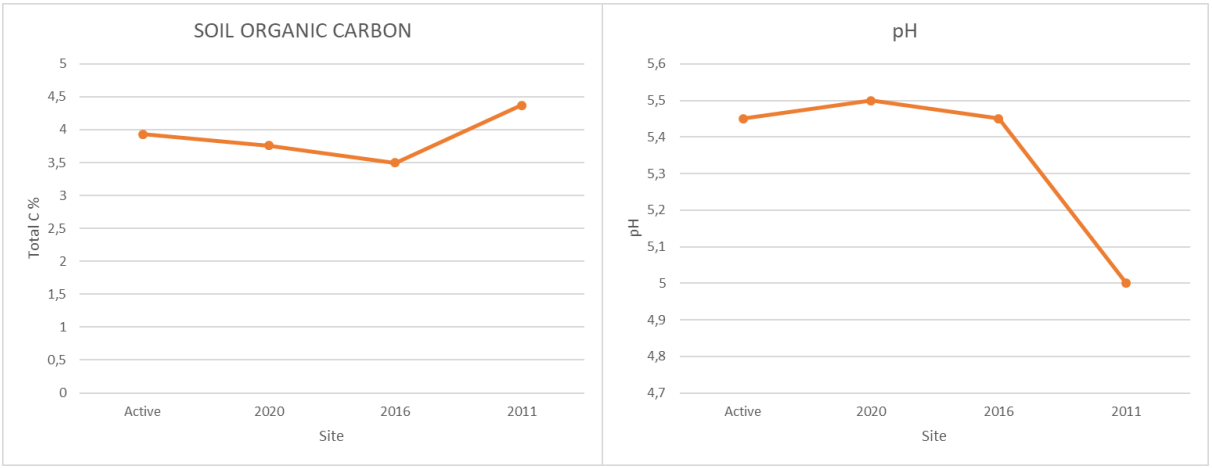


Figure. 11. (a) Soil organic carbon (SOC) at the 4 sites and (b) graph of the pH measurements.

The amount of nutrients in the soil decreases with time after rice cultivation ends for both nitrogen and phosphorus and there appears to be an inverse relationship between SOC and pH. Additionally, the 7th year after rice cultivation ends appears to hold some importance as the development of SOC and pH reverts after this period.

4.3.2 Socioeconomic impacts

This section addresses the socioeconomic impacts of the end of rice cultivation.

4.3.2.1 Impact on income and occupation

Due to the cessation of rice cultivation, the majority have changed their occupation (interview 4, 6, 8). The farmers have more time on their hands to start diversifying their agricultural practices (interview 8). Farming, fishing, and hunting are part of the main occupations of 34% of the respondents in the survey, and side occupations for the 25% that are retired. The type of farming is changing as it now focuses on vegetables, fruit, and timber farming instead of rice. This is confirmed by the interviewed farmers. They explain that the change in occupation is also related to an increased income generation to be able to pay for the rice. They also state that they have increased the number of fruit trees on their land, and vegetables both for self-consumption, but also to sell to other members of the longhouses (interview 4, 7, 9). Both one woman and the headman explain that the future of agriculture for Nanga Bat is oil palm plantations, and states that most households might be involved in oil palm production in the future, either at a small scale or by renting out the land (interview 3).

Although the majority of people in Nanga Bat highlight the need to increase income after ending the cultivation of rice (interview 1, 2, 3, 4, transect walk 1), the survey shows that there is a general feeling that income levels have not increased, as 92.5% of the respondents have not seen any change in their income since they stopped cultivating rice.

4.3.2.2 Rice consumption, quality and expenses

Rice consumption is changing alongside the end of rice cultivation. Whether it is due to income, decreased quality or taste, or an increase in the price of rice, all respondents of the survey are impacted by the cessation of rice cultivation. Overall, 25% of the community estimated that the quantity of rice consumed has changed, and 20% have decreased their consumption.

As explained by the women, the price of rice increased from 30 MYR for 10kg to 50 MYR for 10kg (interview 7). This is confirmed by the survey findings where 60% of the respondents estimated that the price of rice increased in the last 10 years. Moreover, all respondents from the interview complained about the taste and quality of the bought rice. The rice that the majority of households are able to afford is imported which is acknowledged by a lower quality than ban or Sarawakian rice. Iban rice is perceived by the community as softer, more fragrant, and with a better taste. The cooking process also differs between the different types of rice in relation to the quantity of water and the cooking time (interview 7). An overview of the reasons for the decrease in rice cultivation is in figure 12. As a solution, most households mix better-quality rice with lower-quality rice, in order to feel less of the decrease in taste and fragrance. This is especially the case for people that still cultivate Iban rice or those who get Iban rice from relatives (interview 5, transect walk 1).

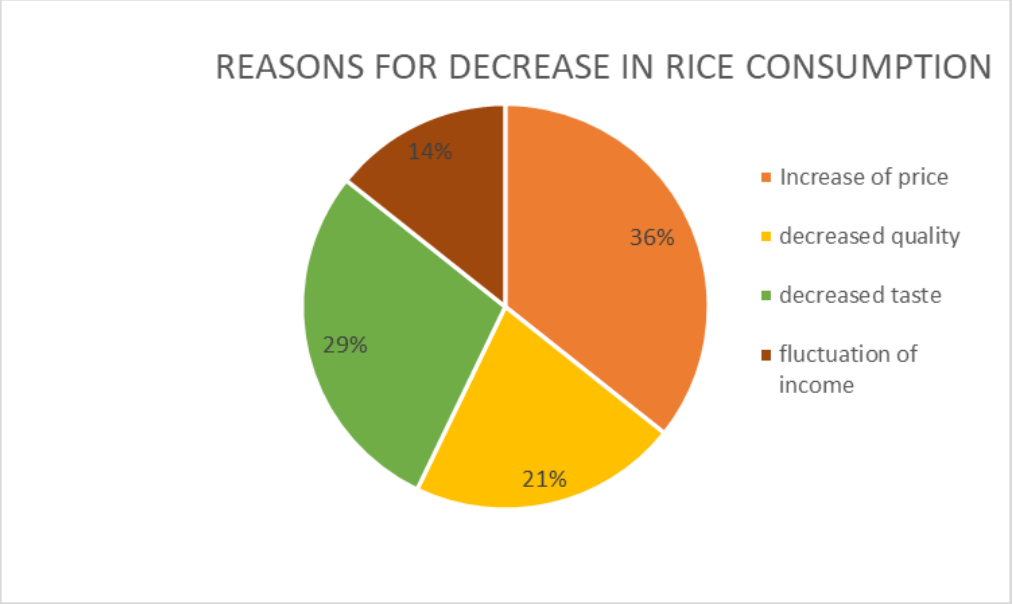


Figure 12. Survey findings of reasons to decrease rice consumption.

3.2.4 Remittances and expense sharing

Remittances and expense sharing are phenomenon that started recently and have been rapidly increasing. Since income, occupation diversification, and urban migration increased, siblings and children have started to get new sources of income. They were able to send money back to the longhouse and their relatives (interview 2, 3, 5). As explained by the women, expense sharing was not happening before the increase in urban migration (interview 7). As soon as their children have an

income-generating job, they start sending her money to participate in household expenses (interviews 3, 4). It is also explained that in Iban tradition, at least one of the children has to take care of their parents when all the children leave the house (interview 3). This is confirmed by the son of the headman, as he participates in household expenses by providing money for clothes and food for his parents. As a result of this recent phenomenon, households have been able to afford new foods and new expenses that they could not afford previously, such as new clothing, or better coffee (interview 2, 5).

4.3.3 Cultural impacts

This section addresses the cultural impacts of the end of rice cultivation.

4.3.3.1 The Iban rice culture

The tradition of rice cultivation in Nanga Bat has led to a strong presence of associated cultural practices. This is manifested through celebrations, and the emotional bond between the individuals who are or have been part of rice cultivation. (Interview 1, 7, 8).

Photo VI: Traditional utensils for iban rice cultivation.

Today, rice is still deeply cultural for Iban people, and the older generation refers to rice as the main source of energy and food for Iban communities following the seasonal rhythms of rice cultivation where rituals at the different farming stages, traditions, and celebrations are important time markers for activities and gatherings during the year. However, this tradition is changing rapidly due to LUC in rice cultivation (Interview 1, 7, 8). The relationship that the younger generations have with rice is almost strictly practical, meaning that the cultural significance is getting relegated to an aspect of what for them is old Iban customs and culture. Rice is no longer the center of Iban life and culture for the younger generation. As rice has a less cultural impact on the younger generation the interest in cultivating and the associated culture diminishes. They simply do not sense the same pride, affection, or identity in the cultivation of rice (interview 2).

3.3.2 Beduruk

One of the cultural aspects that are affected by ending rice cultivation is the tradition of Beduruk, which is an important cultural concept and an example of how important a factor rice cultivation is in weaving social bonds in the community. Beduruk evokes a strong sense of community because the practice requires collaboration across the longhouse, merging everyone's efforts around the same task, leading to strong collaborative dynamics where knowledge of rice cultivation is produced and reproduced between generations (interview 4). However, due to the end of rice cultivation, Beduruk is drastically changing, and has in some aspects disappeared along with the associated knowledge. One group that to a certain extent has managed to continue some of the cultural aspects related to rice cultivation are thewomen who by cooking and collecting NTFP´s continue some of the traditions and knowledge. (Interview 7, 8).

Photo VII: Harvesting rice in an active paddy field.

3.3.3 Connection to rice

The farmers representing the old generation have several times expressed the importance that rice plays for them and the associated sentiments that rice evokes (interview 8). The availability of rice gives people security, the seasonality has been something they could count on, and the availability of rice is their main source of energy. Thus, the younger generations' emotions regarding rice are drastically different from their elders. If a young person does rice cultivation as their main activity, the community perceives this as a failure, whereas education and other occupations are more recognized and appealing (section 4.3.2.3).

The older generation is emotionally affected by the end of rice cultivation and the changed way the younger generation views rice (interview 1, 8). Especially the question of their feelings regarding the end of rice cultivation, the respondents reacted with sadness. The reason being difficulty accepting and adapting because the lost practices are what gives sense and meaning as a significant part of the Iban culture (interview 8).

4.3.3.4 Loss of knowledge

The older generation express concern about the loss of knowledge and the value of rice cultivation for the younger generation (interview 8). It is the overall experience among the older generation that celebrations, rituals, and knowledge related to rice are disappearing, connected to the identity of being an Iban. This is also related to the understanding of owning land, which for the older generation implies more than just the title, requiring active cultivation and management of the land particularly the cultivation of rice, which have been the main reason for Iban people to own land (interview 4, 8).

Photo VIII: rice cultivation.

Although the younger generation acknowledges that the stop of rice cultivation will affect Iban culture, they state that it is unlikely that their children will be involved with the associated cultural aspects (interview 2). Even though the vast majority of the younger generation cultivated rice with their parents during their childhood, they never obtained the required skills either because of other interests or because their parents stopped cultivating before they were at an age of learning (interview 1, 2, 3, 4, 7).

5. REFLECTION ON METHODOLOGY

This section addresses aspects of methodology and limitations.

5.1 Language barrier

Although the language barrier was an anticipated obstacle, it was highly challenging throughout the data collection process, due to a lack of experience in conducting research in a foreign language. Most of the interviews were conducted by a team of both Malaysian and English-speaking students and subsequently translated. However, the translators did not have the needed experience to fulfill the requirements, which impacted the collection of data.

Another issue that arose from the language barrier was the concepts that could not be translated from English to Iban. An example of this is the term "biodiversity" which does not exist in Iban. To ask about the change in biodiversity as perceived by the survey respondents, the translators had to replace it with "number of trees and plants". As a result, the answers that were given did not correspond to the question asked, leading to findings that cannot be analyzed without caution.

5.2 Representation and cultural divide

The surveys, interviews, and community mapping are characterized by a low representation of the younger generation of people, especially young women. Three different explanations were identified. The first was the cultural divide. Due to the cultural differences, the experience was often that women were too shy to participate. The second one was the low representation of younger people. As many of the younger people have migrated to cities and do not live in the longhouses, they were not available. The third one, was the limited time in the field, resulting in a lack of time and engagement to interview multiple representatives of the younger generations. Thereby, the representation of the younger generation is very low, which creates a bias in the findings as most of the participants are the older generation. However, this bias and lack of representation have been taken into considerationwhen analyzing the findings.

5.3 Methodology and experiences

With limited previous experience with some of the methods, some challenges and modifications have been current throughout the data collection. For instance, the group interviews were initially planned as focus groups, but due to challenges with the language barrier, it was changed to group interviews,

as the translations made it difficult to capture all reactions, emotions, and discussions necessary for a focus group (Caillaud et al, 2022). Regarding the survey, it is important to mention the underrepresentation of the younger generation, and the small sample size, means that a generalization of the findings to a regional level would be inaccurate. However, by using the survey, the interviews, and the community map for the data collection, the findings were more nuanced, as the survey made it possible to have a bigger sample size and get a broader overview of the context in Nanga Bat, while the interviews allowed for a deeper understanding of people's perceptions. Soil sampling, as well as biodiversity assessment, compliments the research as it has enabled more nuanced findings in terms of the environmental impacts. However, in some cases, the environmental findings contradict the perceptions of the survey respondents and the interviews with the farmers and headmen.

5.4 Sampling and sites

The limited time-line of the research reduced the amount of possible sites to only four, which is not sufficient to accurately determine changes in biodiversity and soil properties. Additionally, sampling should ideally be conducted by one single person but was performed by multiple researchers. Specifically, the biodiversity assessment was conducted by different people with varying levels of thoroughness and the sampling method itself was not consistent across sites. For example, the 2020 site was sampled in one 1x2 plot and all other sites were sampled with two 1x1 squares and one 50x10 plot. Furthermore, dried soil samples were transported from Malaysia to Denmark over the course of a few days which allowed microorganisms to potentially affect the soil properties and as composite samples were collected, variations of the replicates are unable to be identified.

5.5 Group process

Designing a research project, and conducting it in a group of eleven students, from different countries proved difficult at times. The ways of understanding and conducting academic research were different, and the approach to translations and the difference in cultures differed largely within the group. With perseverance and extensive discussions, the group has managed to turn this into a strength rather than a weakness. The group process between the students from UNIMAS and the students from the University of Copenhagen has made this research more extensive and thought- through, which has allowed the addition of more methods and increased the amount of data collected.Moreover, it contributed to understanding the culture and the language more than would have been possible without the Malaysian students.

6. DISCUSSION

6.1 GENERATIONAL GAP

This section discusses the generational gap as a recurring factor throughout the findings. It will provide an elaborated understanding of the two terms applied (section 1.3) as a recurrent analysis tool.

The generational gap observed in this research is an unexpected result. Indeed, such a significant difference between the two generations, in both economic, ambitions, interests and cultural aspects, was never expected. Most of the themes explored are tainted with the generational gap factor (section 1.3).

The gap between generations is primarily a cause of the cessation of rice cultivation, as it relates both to health and to the change of interests and income. This aspect is linked to social and cultural transformations discussed by Yonda (2016), as she states that changes in the Iban society are due to modernization. Indeed, she states that "national economic improvement, industrial development gives new work-field alternatives for traditional society" (p.1). Modernization, as a concept, increased the job opportunities and income prospects for youngpeople, who, encouraged by their parents, leave to get a job in the cities, accentuating the generational gap. The social transformation is also mentioned by Anggo and Laja (2018) and Echoh et al (2017), as they explain that the younger generation is not being taught by the older generation in the same way, and they often migrate or are only part-time members of longhouses, lose the social, traditional and cultural aspects of the community and social ranking. Thereby, the findings of this research might be aligned with a more general trend that is unfolding in the whole of Borneo island.

Photo IX: Survey.

However, it is also associated with the impacts of the end of rice cultivation. The generational gap plays a role in the increase of remittances and shared expenses. This is supported by Soda (2000) who states that 82.5% of respondents share expenses with their families, and 15.9% send remittances (p. 157-158). It shows that the generational gap regarding income directly links to the increase in expense sharing and parents relying on their children for monetary help. As the findings also indicate, this trend is rapidly increasing with the cessation of rice cultivation.

The generational gap is impacting the decline of labor and loss of knowledge. The decline in the labor force and the lack of generational replacement are direct causes of the loss of local knowledge concerning rice cultivation is a noticeable trend in many Iban villages (Echoh et al, 2017). The duality of the attachment from the Iban community to rice cultivation, as their identity and heritage, and the increasing need for money are highlighted in this generational change of ambition. Indeed, the older generation is sad to see their children turning away from rice cultivation, but they also push them to get an education and an income. The importance of rice to the Iban community is confirmed by Echoh et al (2017) “Paddy farming is very much associated with the Iban community in the rural areas in Sarawak" (p.3). Soda (2001) mentions the sacred rice succession tradition that has been carried out through generations by Iban women, which is slowly going extinct alongside rice cultivation. Thus, the recent increase in the abandonment of rice cultivation and the lack of interest of the younger generation creates a deep social divide between generations. The generational gap can therefore be perceived as a main theme present in most parts of the research.

6.2 DISCUSSION OF CAUSES BEHIND THE LAND USE CHANGES

In this section, the findings are discussed with the use of the causal analysis framework (section 4.2) in relation to the causes and mechanisms of the land use change.

With inspiration from Meyfroidt (2016), figure 13 is developed in order to illustrate the causal chain presenting the interlinkages between the different proximate and underlying causes behind the decrease in rice cultivation in Nanga Bat as the outcome.

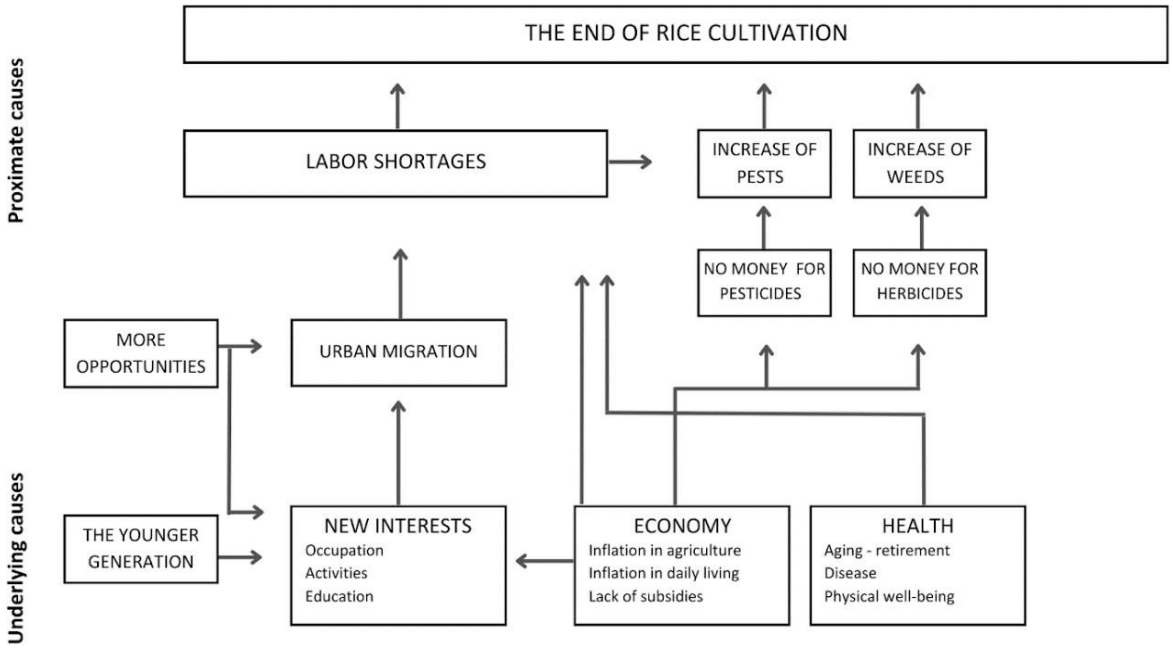


Figure 13. Causal chain of the underlying and proximate causes to the end of rice cultivation.

When identifying the proximate and underlying causes of the decrease in rice cultivation, it is obvious that while some of them can be perceived as a causal explanation itself, it is important to highlight that the majority are interlinked and associated as a causal chain.

According to Mertz et al (2013), the observed significant decline in rice cultivation in Sarawak is largely due to the increasing interest in the large-scale production of cash crops to improve income. This research supports this claim to some extent as several farmers in Nanga Bat have either replaced rice cultivation with other crops or abandoned the rice fields to find sources of income. This is due to the economy, namely lack of subsidies, and inflation in both agricultural expenses and daily living costs, forcing people to find income-generating activities, and thus, have less time and labor for rice cultivation. Thereby, inflation and lack of subsidies can be argued as underlying causes responsible for labor shortages, and the cessation of rice cultivation.

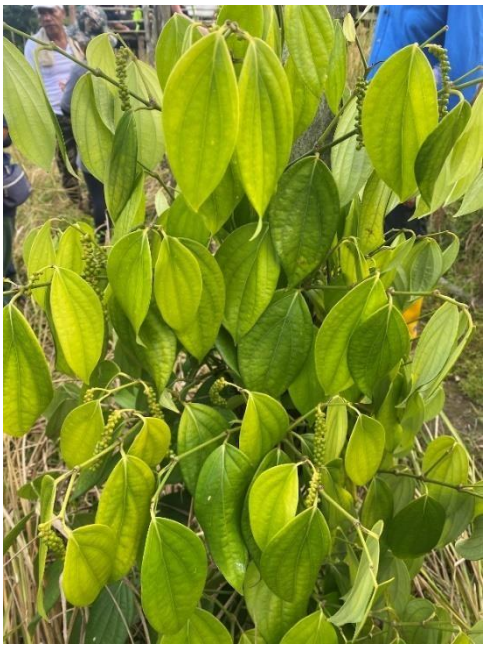


Photo IX: Pepper plant as cash crop within the active rice field.

The younger generation in Nanga Bat as a mechanism in the causal chain, are not particularly interested in rice cultivation. Instead, they seek other activities such as education and wage work, resulting in numerous people migrating to the cities. Similar trends have been noted in other areas of Sarawak where rural land use areas are reduced as a result of urban migration, not only by the younger generation (Hansen & Mertz, 2005; Lambin & Meyfroidt, 2011). According to Hansen, and Mertz (2005), and also emphasized in the findings, urban migration plays an obvious role in the decrease of rice cultivation, because the absence of people in rural areas implies a shortage of labor, forcing farmers to either reduce or cease the cultivation. Thereby urban migration and new interests in careers can be identified as underlying causes.

Health conditions are an underlying cause for the end of rice cultivation, with both diseases and aging being responsible for the farmers' reduced ability to cultivate the land. The causal mechanism associated with health as a cause is the fact that labor shortages mean that there is an absence of people to take over the rice fields. Nor is this a unique case in Nanga Bat. A study of problems related to rice cultivation in the upper Baram, Sarawak, mentions that an aging population is a part of the reason for a decline in rice cultivation, as the older generation struggles with their ability to carry out the cultivation, and it is not always certain whether their children can take over the responsibility of the rice fields (Hollaus et al, 2022).

A significant factor emerges as a result of most of the causes identified, namely labor shortages. It can be argued that this is the main proximate cause in the causal chain addressing the outcome, due to the traditional Iban practices of rice cultivation relying on a high degree of mutual support, workforce and cooperation (section 3.3.2). This importance of help and labor is confirmed by studies showing that working collectively is highly required to manage rice cultivation successfully (Teegalapalli & Datta, 2016; Soda & Kato, 2020). As rice cultivation largely requires several laborers, the harvest suffers from both the retirement of the older generation and the shift to other occupations and activities with the subsequent migration.

Other proximate causes emphasized in the findings are the increased issue with both pests and weeds. While these causes appear to be widespread problems, the increase in pests and weeds seems rather a symptom of the greater challenges namely the decline in labor and the scarcity of subsidies and money. Indeed, it is almost impossible for farmers to control pest and weed challenges when

necessary help and labor are not available. Other areas in Sarawak have also experienced problems with an increase in pests, however, in this research, the increase is due to neighboring oil palm plantations causing monkeys to move from oil palm areas to the rice fields (Echoh et al, 2017).

6.3 DISCUSSION OF IMPACTS DUE TO LAND USE CHANGES

In this section, a discussion of the findings related to the land use changes and the associated environmental, cultural and socioeconomic impacts, is carried out.

6.3.1 Environmental influences

In line with the causes behind the LUC, it is possible to draw parallels to the amount of land left abandoned and the environmental effects (section 4.1). Here it is possible to identify linkages between farmland abandonment and socioeconomic factors as being the underlying drivers. In particular, urbanization and industrialization are perceived as being fundamental factors resulting in large rural-urban migrations and thereby reductions in the agricultural labor force as a result. These factors are connected to aspects relating to new ways of living and perception of quality of life. (Li & Li, 2017). This is in line with the articulated labor shortage from the findings, as well as the importance of the gap between generations. When a land is abandonment it has unavoidable impact on both biodiversity and soil (Koshida and Katayama, 2018)

However, when discussing the environmental impacts on the LUC, it is first and foremost relevant to address the differences in the very meaning and perceptions of the environmental aspects before assessing the findings in relation to general tendencies.

The survey respondents experienced an increase in biodiversity, which can be explained by the appearance of the term "*biodiversity*" and thereby differing understandings (section 5.1). Where the terms in biology is based upon the variability and heterogeneity of the entire ecosystem including minor or less "interesting" plants (Swingland, 2001), the Iban understanding is stemming from the assessment of fallow periods of shifting cultivation. The Iban assessment of successional stages is also based on the soil properties, where early colonization of weeds indicates poor soil for cultivation, whereas a higher number of trees indicate a greater soil property for cultivation. (Tanaka, 2007).

There is a differentiation between how the biodiversity of the area is assessed, whether the aim is to investigate all plants or whether a few plants of relevance are selected related to soil quality. As with biodiversity, it is also relevant to shine a light on the differentiated understandings when it comes to soil. In Iban language the words for soil and land are the same. Therefore, according to Tanaka (2007) "the term *land fertility* or *soil fertility* is almost equivalent to the suitability of land for shifting cultivation" (p.360). Therefore, the perception of good soil would be related to a composition that favors agricultural practice, where a decrease of SOC would be seen as a deterioration and whereas an increased SOC would be viewed as improved (section 4.3.1.2).

The fact that only small changes in biodiversity between the different sites have been identified (section 4.3.1.1) can be explained by factors such as the intensity and duration of agriculture, as well as the level of habitat degradation and fragmentation (Ladouceur, 2023). As indicated in the findings (section 4.3.1.1), it was possible to determine an overall decline in biodiversity after the end of rice cultivation. The diversified cropping system found in hill rice cultivation including crops as vegetables and fruit trees, supports a wider range of biodiversity (Emran et al, 2022), which has also been the case in the findings where most of the farmers grew fruit trees alongside rice (section 4.1). This complies with a study by Koshida and Katayama (2018) who examined the effects of rice-field abandonment on biodiversity, where the decline in biodiversity is caused by degradation and loss of management as rice fields are associated with a diverse array of adapted flora and fauna.

When looking at soil, a possible explanation of the differentiated perceptions of the observed changes in soil quality (section 4.3.1.2.) could be the inherent difficulty of assessing soil properties strictly from observation (Anderson & Ingram, 1994). Clearer are the headman stating that the longer a field is left fallow, the more the soil improves (section 4.3.1.2). This finding is in line with a study by Temjen et al (2022), who examine the effects of shifting cultivation and fallow on soil quality. They found that an increase in fallow period affected both values of soil organic carbon, available nitrogen, available phosphorus, positively. However, when looking at the findings from the soil assessment, it was only possible to detect phosphorus at one site, which would indicate that the level was too low to measure on the remaining sites. The study also noticed a decline in soil pH (Temjen et al, 2022) which is also compliant with the findings, demonstrating a drop after 12 years, in particular (section 4.3.1.2).

As the headmen say the fallow period improves soil (interview 6) it is interesting that farmers have stopped this agricultural practice (transect walk 1). One explanation could be that Acidic tropical soils require amendments and fertilizers to be productive and maintain yield (Halim & Abdullah, 2018) and the fallow period is being replaced with fertilizers. This is supported by the findings of section (3.3.1.2.) which show the highest amount of phosphorus and ammonium at the fertilized active site (interview 4) and a general decrease after rice cultivation ends. Another study by Choudhury & Kennedy (2007) concludes that the differences are most likely due to leaching, denitrification and/or volatilization of ammonium caused by geophysical differences between the sites. Additionally, the findings show surprisingly low levels of ammonium at the 2020 site, which could possibly be due to different agricultural practices as the 2020 site might not have been fertilized.

6.3.2 The culture around rice

"Rice farming is our way of life" (interview 8) is a common Iban saying, which clearly indicates the importance rice has for the Iban societies. Rice represents far more than just food, being a center for both strong traditions, rituals, and values (Sarther, 1980). As Sarther (1980) highlights, an Iban family, through the cultivation of rice, is able to "demonstrate its social worth, and its fields continue to represent, not only a major form of heritable wealth and a source of economic security but are a place of worship, sanctified by myth, and blessed by continuing ritual contact with the gods and spirits" (Sarther, 1980, p.70). This description of the importance of rice is very much in line with the findings, highlighting the different traditions, rituals, and practices around this crop in particular (section 4.3). However, as the findings indicate, the LUC related to rice cultivation have to a high extent been affecting these cultural aspects and dimensions of rice farming. Already back in 1950, the trend towards shining a light on the importance of education and the extended varieties in occupation as well as increased cultivation of cash crops has led to a drastic shift in the cultural practices which went along with rice cultivation, resulting in a great loss of knowledge (King & Knudsen, 2021). This is in line with the findings addressing the shift in everyday activities and

Photo X: Interview with one of the farmers that owns an active rice field.

interests among the younger generation, as being the reason why traditions are not carried on. Another important aspect that the findings highlight as being essential for understanding the importance of rice play for social bonds, is the long-established concept of Beduruk. This tradition has suffered from the cessation of rice cultivation and the lack of an available workforce (section 4.3). This also counts as a general tendency especially when it comes to the principles and the practices of gathering across longhouses in the different stages of the rice cultivation cycle of preparing, planting, and harvesting (King & Knudsen, 2021). However, the fact that it is still to some extent present in some occasions in Nanga Bat (section 4.3) is consistent with the fact that Beduruk in many other connections is still relevant. Whereas it was associated with farming practices in the past, it is nowadays an equally important concept in many other contexts such as weddings, festivals, and other gardening events (King & Knudsen, 2021).

However, despite the fact that some concepts and traditions around rice cultivation still live on in other ways, it is clear from the findings that with the LUC, important knowledge about rice cultivation and its cultural aspects is lost. In relation to the changes in Beduruk, which is no longer as much associated with farming, it is a well-known aspect that the knowledge that the older generation possesses about rice cultivation is gradually disappearing among the younger generation (Kendawang et al, 2005). This is to a large extent also where the findings emphasize this as an essential aspect when it comes to cultural impacts of ending rice cultivation.

6.3.3 Economic tendencies

As the end of rice cultivation, the expenses spent on rice have been increasing for both people cultivating and buying their rice, which has affected the way they consume rice. Rice, whether imported or local, is still present and important in the everyday lives of Iban people and is prioritized, even though it is becoming an increasing struggle to get good rice. It is confirmed by King & Knudsen (2021) that the increase in rice importation and the loss of rice cultivation causes a “dramatic shift in local Iban economies” (p.27). However, it appears that the total disappearance of rice cultivation for self-consumption is not yet universal across Borneo, as there are still an overbearing amount of testimonies indicating that rice cultivation still occurs (King & Knudsen, 2021; Mertz et al, 2013. Lyndon et al, 2020).

As everyday life expenses increase, and in order to afford acceptable quality rice, the Iban people look for jobs or other income-generating strategies. As mentioned previously, remittances are an increasing economic activity caused by the end of rice cultivation. In line with the findings, Soda (2000) highlights that younger generations contribute to the household expenses of their older family members, as they nowadays are more involved in income-generating jobs. Thus, the economic status quo in the Iban community is slowly changing towards a more cash-income-oriented one, to meet their needs.

However, the population of Nanga Bat does not seem to perceive an increase in their income, even though numerous people have got income-generating jobs and share household expenses with their families. Indeed, the overall income of Iban communities has increased, and for the richest individuals, it has doubled (Mertz et al, 2013). These discrepancies in our findings can be explained by the fact that investment in oil palm production is not common among the population of Nanga Bat. Mertz et al. (2013), for instance, highlight many testimonies of successful oil palm plantations in Iban communities that have increased income and social status. Indeed, it is explained that social status is now correlated with the economic gains linked to oil palm and that rice cultivation is not the most prominent social status anymore (Mertz et al, 2013). The change in social status is also perceived in Nanga Bat, as interviews from the younger generations testified that growing rice as a young person is now a synonym for having a failed career.

6.3.4 Future perspectives

As touched upon in the latter section, it is recognized that oil palm is a factor that determines future perspectives on LUC in Borneo. It is likely that the perception the people in Nanga Bat have regarding the expected increase of oil palm plantations will be realized, especially considering the ongoing tendencies in this direction. Sarawak has in the past two decades achieved the highest area of oil palm since 2002 with an average increase rate of more than 10% yearly, dominating land cover classes and agricultural practices (Hon & Shibata, 2013). When examining studies of the overall changes in shifting cultivation, it is clear that oil palm for long has been perceived as being the most important cash crop (Hansen & Mertz, 2006).

However, it seems like the transition in Nanga Bat is slightly slow compared to the above tendencies described in the region, where other communities have engaged heavily in oil palm plantations,

especially as smallholders, reaching 82% in some communities (Mertz et al, 2013). This number is slightly lower for Nanga Bat, both in relation to land rented to oil companies and smallholder oil palm production into account (section 4.1).

However, it is crucial to note that not everyone is as certain that the era of rice cultivation is over. As one official said, in relation to the future of rice cultivation; “The government is not giving up. We will continue the struggle to produce rice and become rice’s production region soon.” (interview 9).

7. CONCLUSION

In examining the occurring LUC related to rice cultivation within Nanga Bat as a case study, this report has encountered social, economic, cultural and environmental aspects of interests which in many ways draw lines to overall patterns and tendencies present at both regional and national level. Ongoing LUC, either caused by or resulting in an increasing popularity of oil palm plantations, urban migrations processes and cultural changes, among other aspects, are findings that are currently present in Sarawak and in Malaysia. Although there is a discovered differentiation between the explanatory power of the mentioned tendencies, it has been possible to establish linkages between the findings and compare it with other existing studies.

The end of rice cultivation has been leading to a number of new lands uses such as land abandonment, fruit orchards, and cash crops, which is consistent with and supported by existing studies. This considerable change is a result of several tendencies and challenges that abound within the community. The causes include changes in everyday activities and interests, challenges with pests, health issues, labor shortages, urban migration and economic incentives, ranging from the inflation of everyday life and agricultural practices to the lack of governmental support for rice cultivation.

The end of rice cultivation impacts people in social, economic and cultural ways, and is also affecting levels of biodiversity and soil at the former rice fields. Particularly, the generational gap that has been identified both in relation to the causes, as the occurrence of increasing urban migration, and in the impacts related to the loss of cultural knowledge, is in line with the general tendencies. One example is the decline in the labor force, generational replacement and knowledge transmission regarding rice cultivation which can be identified as a general tendency in many Iban villages.

The cultural identity of the Iban has been affected with the end of rice production, mostly experienced by the older generation whereas the younger generation seems much more unaffected. The importance of rice for Iban culture, and the associated traditions are well explained in other studies, where the coherence between the end of rice cultivation and loss of knowledge are also identified. From a socioeconomic perspective, the end of rice cultivation has resulted in increased costs as the community now has to purchase their rice. This new expense is proving increasingly high, as good quality rice is often not affordable. To improve their incomes, a lot of individuals change their occupations and increase their income sources to afford rice and household products. Studies also discuss the tendencies of new economic practices, such as the way in which younger generations contribute to household expenses, which is a phenomenon that also supports the findings.

The end of rice cultivation has further impacted environmental aspects, leading to changes in both vegetation, and soil quality. The measured biodiversity shows minor differences between sites but indicates an overall decreasing trend determined by the fallow period. This it confirmed by similar studies highlighting a decline in biodiversity due to degradation and loss of management. Measured soil properties show differences in nutrient levels with a decreasing trend over time, likely to indicate leaching of fertilizers. However, the perception of soil does not match with the measured soil properties, which can be explained by the local definition of soil, affecting the examination and perception of SOC and pH.

Looking at the findings in relation to future expectations, Nanga Bat might turn into a community expanding its oil palm plantation. These expectations are consistent with general tendencies identifying an increase in oil palm plantations as a major current tendency.

REFERENCES

- Anderson, J. & Ingram, J. (1994). Tropical Soil Biology and Fertility: A Handbook of Methods. *Soil Science.* 157. 265. 10.2307/2261129.
- Anggo, F. A., & Laja, L. (2018). The Function and Role in the IBAN Social Rank in their Communities. *International Journal of Engineering & Technology*, 639-641.
- Azari, M., Billa, L. & Chan, A. (2022). Multi-temporal analysis of past and future land cover change in the highly urbanized state of Selangor, Malaysia. Ecol Process 11, 2. https://doi.org/10.1186/s13717-021-00350-0
- Caillaud, S., Kalampalikis, N., & Doumergue, M. (2022). Designing Focus Group. Chapter 40. In Flick, U. (2022). Handbook of Qualitative Research Design. The SAGE.
- Choudhury, A., Kennedy, I., (2007), Nitrogen Fertilizer Losses from Rice Soils and Control of Environmental Pollution Problems https://www.tandfonline.com/doi/abs/10.1081/CSS-200059104
- Echoh, D. U., Nor, N. M., Gapor, S. A., & Masron, T. (2017). Issues and Problems Faced by Rural Farmers in Paddy Cultivation: A Case Study of the Iban Paddy Cultivation in Kuala Tatau, Sarawak. *Journal of Regional and Rural Development Planning*, 174-182.
- Emran, SA., Krupnik, T.J., Aravindakshan, S. et al. (2022). Impact of cropping system diversification on productivity and resource use efficiencies of smallholder farmers in south-central Bangladesh: a multi-criteria analysis. *Agron. Sustain. Dev.* 42, 78. https://doi.org/10.1007/s13593-022-00795-3
- Shepherd, Stagnari, F., Pisante, M., & Benites, J. (2008). Annual Crops. Rome: Food and Agriculture Organization of the United Nations.
- Halim, A., Abdullah R., (2018), Influence of Soil Amendments on the Growth and Yield of Rice in Acidic Soil https://www.mdpi.com/2073-4395/8/9/165#B22-agronomy-08-00165
- Hansen, T. S. (2005). Spatio-Temporal aspects of land use and land cover changes in the Niah Catchment, Sarawak, Malaysia. *Singapore Journal of Tropical Geography*, 26(2), s. 170-190.
- Hansen, T., & Mertz, O. (2006). Extinction or Adaptation? Three Decades of Change in Shifting Cultivation in Sarawak, Malaysia. *Land Degradation and Development*, 135-148.
- Hill, D., Fasham, M., Tucker, G., Shewry, M., & Shaw, P. (2005). Surveying and monitoring management or environmental impacts. In D. Hill , M. Fasham, G. Tucker, M. Shewry, & P. Shaw, Handbook of Biodiversity Methods (pp. 237-244). Cambridge University Press.

- Hollaus, A., Schunko, C., Weisshaidinger, R., Bala, P., & Vogl, C. (2022). Indigenous farmers' perceptions of problems in the rice field agroecosystems in the upper Baram, Malaysia. *Jounal of Ethnobiology and Ethnomedicine.* 18,26 https://doi.org/10.1186/s13002-022-00511-1
- Hon, J., & Shibata, S. (2013). A Review on Land Use in the Malaysian State of Sarawak, Borneo and Recommendations for Wildlife Conservation Inside Production Forest Environment. *Borneo Journal of Resource Science and Technology*, *3*(2), 22-35. https://doi.org/10.33736/bjrst.244.2013
- Houma, Abdusslam A. et al. (2021). Climate Change Impacts on Rice Yield of a Large-Scale Irrigation Scheme in Malaysia. *Agricultural water management*: 106908–. Web.
- Ismail, A. et al. (2022). Labour Requirement in the Oil Palm Independent Smallholder Sector in Sabah and Sarawak, Malaysia.
- Kendawang, J., Tanaka, S., Soda, R., Seman, L., Wasli, M. E., Sakurai, K. (2005). Difference of rice farming practices of the Iban in a national boundary area in Borneo and its socio-economic background. Tropics. 14. 295-307. 10.3759/tropics.14.295.
- King , V., & Knudsen, M. (2021). The Iban of Temburong: Migration, Adaptation and Identity in Brunei Darussalam. *Gadong: Institute of Asian Studies, Universiti Brunei Darussalam.*
- Koshida, C., Katayama, N. (2018). Meta-analysis of the effects of rice-field abandonment on biodiversity in Japan https://pubmed.ncbi.nlm.nih.gov/29943862/
- Ladouceur, Emma & Isbell, Forest & Clark, Adam & Harpole, William & Reich, Peter & Tilman, G. & Chase, Jonathan. (2023). The recovery of plant community composition following passive restoration across spatial scales. *Journal of Ecology*. 111. 10.1111/1365-2745.14063.
- Lambin, E. & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. PNAS. 108.9: 3465-3472
- Li, S., Li, X. (2017). Global Understanding of Farmland Abandonment: A Review and Prospects. *Journal of geographical sciences* 27.9: 1123–1150. Web.
- Lyndon, N., Jali, M. F., & Rose, R. A. (2020). Indigenous Knowledge and Socio-Economic Development of a Malaysian Rural Indigenous Community. *Journal of Southeast Asian Studies*, 109-129.

- Mertz, O., Egay, K., & Bruun, T. B. (2013). The Last Swiddens of Sarawak, Malaysia. *Human Ecology*, 109-118.
- Mertz, O., Wadley, R. L., & Egelund Christensen, A. (2005). Local land use strategies in a globalizing world: subsistence farming, cash crops and income diversification. *Agricultural Systems*, *85*(3), 209-215.
- Meyfroidt, P. (2016). Approaches and terminology for causal analysis in land systems science. *Journal of Land Use Science* 11(5): 501-522. 22p. https://doi.org/10.1080/1747423X.2015.1117530
- Okoko, S., & Walker, K. D. (2023). Critical Ethnography. In *Varieties of Qualitative Research Methods*. Springer International Publishing AG. https://doi.org/10.1007/978-3-031-04394-9_15
- Parker , R. A., & Rea, L. M. (2005). Chapter 1. In R. A. Parker, & L. M. Rea, Designing and Conducting Survey Research (pp. 21-19). Jossey-Bass.
- Sather, C. (1980). Symbolic Elements in Saribas Iban Rites of Padi Storage. *Journal of the Malaysian Branch of the Royal Asiatic Society*, 67-95.
- Skinner, J. (2012). A Four-part Introduction to the Interview: Introducing the Interview; Society, Sociology and the Interview; Anthropology and the Interview; Anthropology and the Interview. In J. Skinner, The Interview: An Ethnographic Approach (pp. 1-52). Taylor & Francis Group.
- Soda, R. (2000). Living Strategies of the Urban Poor in a Local Town in Sarawak, Malaysia: Population Mobility of the Iban between Urban and Rural Areas. *Geographical Review of Japan, 73* (2), 139-164.
- Soda, R. (2001). Rural-Urban Migration of the Iban of Sarawak and Changes in Long-houde Communities. Geographical Review of Japan, 92-112.
- Soda, R & Kato, Y. (2020). The Autonomy and Sustainability of Small-Scale Oil Palm Farming in Sarawak. In *Anthropogenic Tropical Forests*. 357–374. Springer Singapore. https://doi.org/10.1007/978-981-13-7513-2_17
- Sweet, E. L., & Ortiz Escalante, S. (2017). Engaging territorio cuerpo-tierra through body and community mapping: a methodology for making communities safer. Gender, Place & culture, , 594–606.
- Swingland, I. R. (2001). BIODIVERSITY, DEFINITION OF. *Encyclopedia of Biodiversity*, *1*, 377–391.

- Tanaka, S., (2007). Ecological study on site selection for shifting cultivation by the Iban of Sarawak, Malaysia. A case study in the Mujong River area https://www.jstage.jst.go.jp/article/tropics/16/4/16_4_357/_pdf
- Temjen, W., Singh, M.R. & Ajungla, T. (2022). Effect of shifting cultivation and fallow on soil quality index in Mokokchung district, Nagaland, India. *Ecol Process* 11, 42. https://doi.org/10.1186/s13717-022-00386-w
- Teegalapalli, & Datta, A. (2016). Shifting to settled cultivation: Changing practices among the Adis in Central Arunachal Pradesh, north-east India. *Ambio*, *45*.5, 602–612. https://doi.org/10.1007/s13280-016-0765-x
- Yasar, M., Chamhuri, S. (2016). Paddy Field Conversion in Malaysia: Issues and Challenges. *Rona teknik pertanian* (Online) 9.2: 168–177. Web.
- Yonda, D. R. (2016). Social Transformation on Traditional Society (Case Study on Dayak Iban Society of Kapuas Hulu, Kalimantan Barat). *International Conference on Ethics of Business, Economics, and Social Science*, 452-460.

APPENDICES

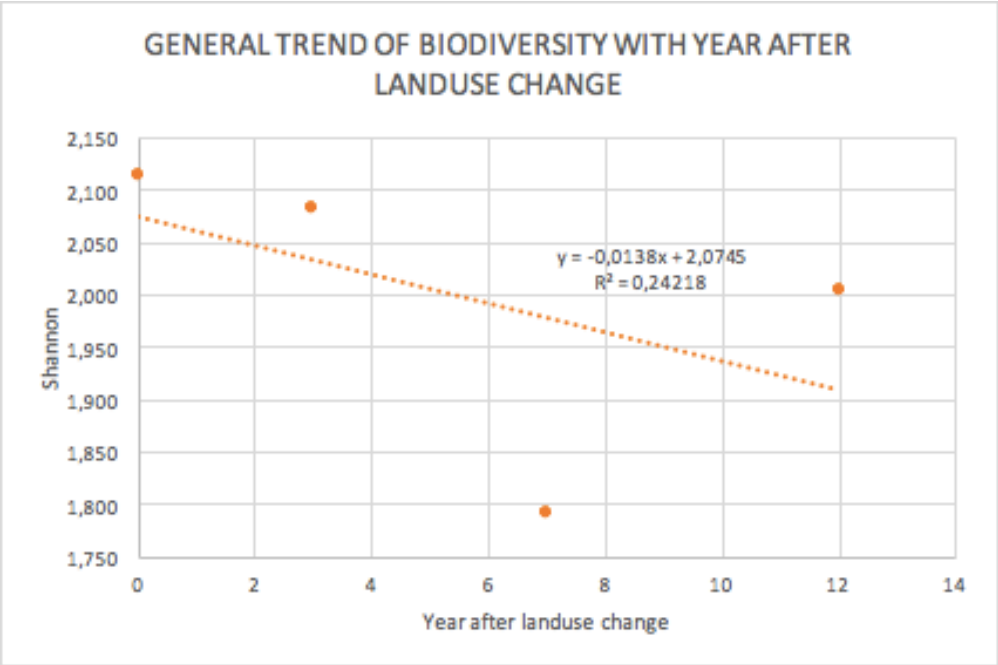
APPENDIX 1: OVERVIEW OF APPLIED METHODS

METHOD	QUANTITY
Surveys	41
Individual Interviews	6
Group Interviews	3
Transect Walk	1
Community Mapping	1
Soil Profile	Sites 2011 & Active: one replicate per site
Soil Samples	4 replicates at 4 sites
Biodiversity Assessment	Sites: 2011,2016, Active Two 1xm quadrat squares & One 50x10m plot Site: 20202: One 2x1m plot

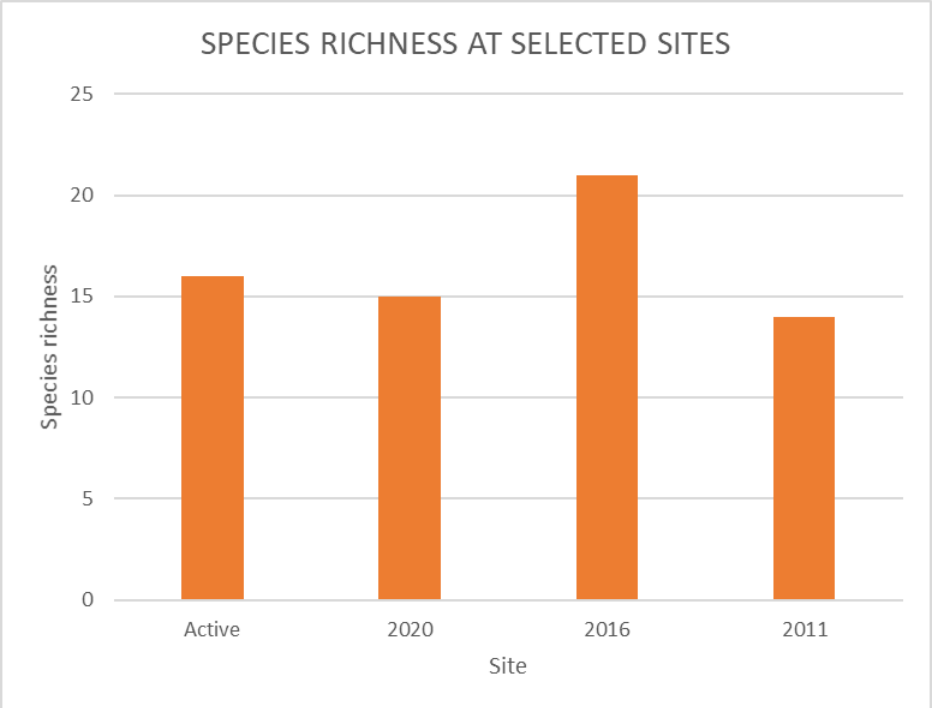
APPENDIX 2: TABLE OF INTERVIEWS

Citation used	Description
Interview 1	Interview headman
Interview 2	Interview youth - son of headman
Interview 3	Interview woman 1
Interview 4	Interview woman 2
Interview 5	Interview active rice farmer 1
Interview 6	Group Interview Headmen
Interview 7	Group Interview Women
Interview 8	Group Interview Farmers
Interview 9	Interview with District Officer
Transect Walk 1	Transect Walk with active rice farmer 2

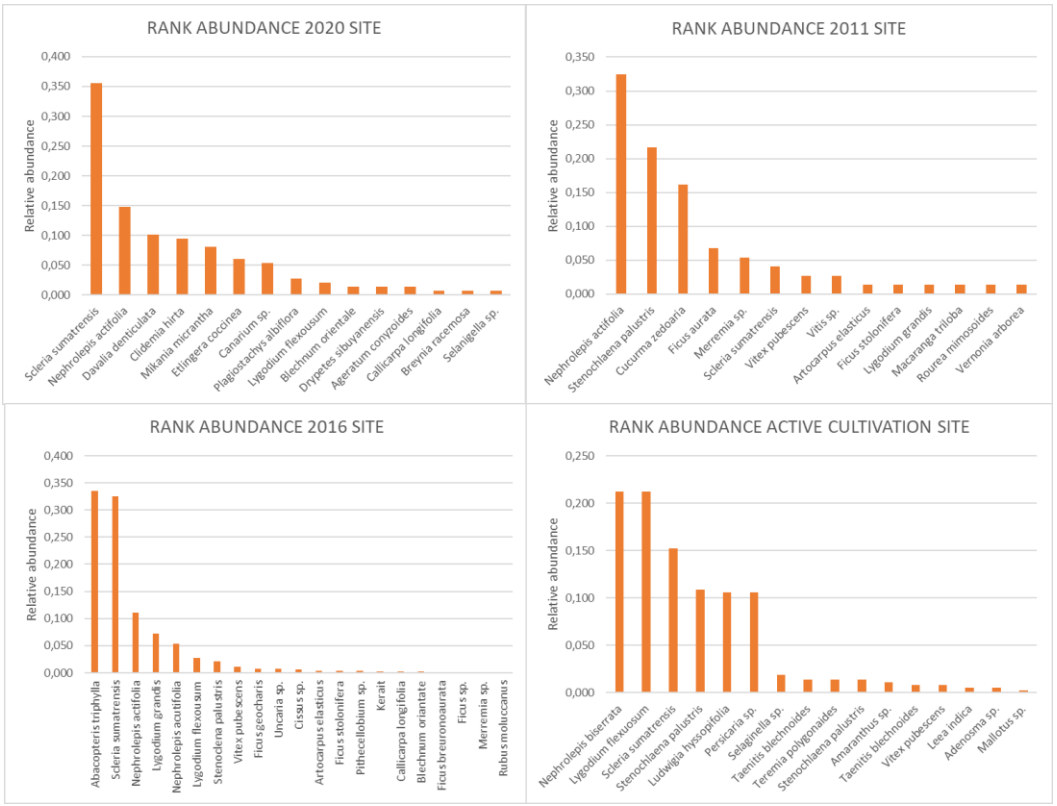
APPENDIX 3: TRENDLINE OF BIODIVERSITY RELATED TO YEARS AFTER LUC



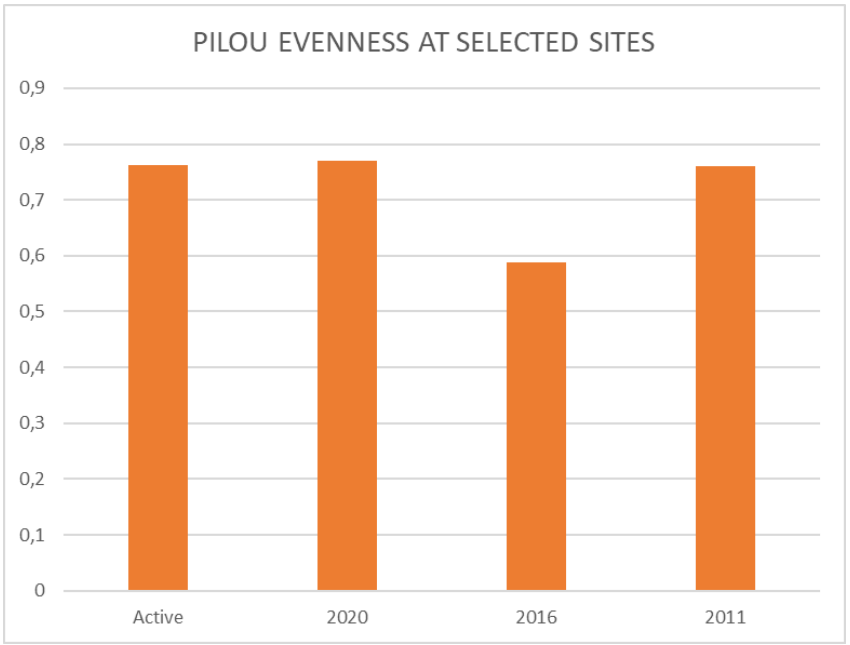
APPENDIX 4: SPECIES RICHNESS AT 4 SELECTED SITES



APPENDIX 5: RANK ABUNDANCE DIAGRAM OF 4 SELECTED SITES



APPENDIX 6: PILOU EVENESS AT 4 SELECTED SITES



APPENDIX 7: SYNOPSIS

KØBENHAVNS UNIVERSITET

LAND USE CHANGE IN NANGA BAT

A STUDY OF THE SOCIAL AND ENVIRONMENTAL IMPACTS RESULTING FROM CHANGES IN LAND USE DUE TO THE END OF RICE CULTIVATION IN NANGA BAT

Signe Schakenda Kaldahl, Sofie Banke Poulsen, Mariana Sarmiento,
Flavie Ancelin and Toke Due Sjøgren

Interdisciplinary Land Use and Natural Resource Management 2023
Keywords: Land use change,intensity, soil quality, biodiversity, rice cultivation, livelihoods

INTRODUCTION

In recent years and over the past decades, the Malaysian state Sarawak, located on the north-western part of Borneo, has undergone prominent changes in land use, especially when it comes to agricultural practices. Significant economic growth, increasing off-farm job opportunities, labor migration, intensification of farming systems due to population growth, and Government criticism and interventions regarding shifting cultivation are important drivers of the current changes in land use (Hansen & Mertz, 2006).

Shifting cultivation has been the primary change, together with timber extraction, permanent large-scale plantations and logging (Hansen, 2005). The disappearance of shifting cultivation from the early 2000s has particularly shifted away from rice cultivation and small scales practices to large-scale production of cash crops (Mertz et al, 2013). More specifically, state governmental policies have aimed to ban swidden cultivation, which is a form of shifting cultivation, as shifting cultivation is perceived as "an obstacle to resource utilization (...) and not contributing to local development" (Mertz et al, 2013, p.2). Those policies banned the use of open fire, thus banning swiddens. However, it has been assessed by Mertz et al that shifting rice cultivations produced higher cash returns than working in oil palm and that there is no evidence of land degradation as an impact of shifting cultivation. Thus, the governmental policies are not in line with the actual impacts and evidence produced by research concerning shifting cultivations. The state has experienced a decline in forest cover and the collection and management of forest products together due to an increase in LUC (Hansen, 2005).

Although shifting agriculture no longer is accountable as the main practice, studies suggest that this form of farming still remains an important part of local forming strategies, as it can act as a buffer in times of price fluctuations in relation to rubber (Mertz, O., Wadley, R. L., & Egelund Christensen,

A., 2005). This makes it particularly interesting to examine the extent to which shifting agriculture and rice cultivation is still practised, and what the social and environmental impacts have been of these district LUC.

This case study aims to investigate the environmental and social impacts of recent changes and transitions taking place in the longhouse community of Nanga Bat with an emphasis on the end of rice cultivation in the area. It is known that the community stopped its rice cultivation 1-3 years ago due to the increasing number of monkeys damaging the crops and lack of labor, but the actual extent to which the cultivation has decreased, and what is the substitution of agricultural practices still remains unclear. In addition, it is worth taking into account that Nanga Bat does not currently rely on any of their other crops, as the society stopped tapping rubber due to low prices and does not receive any money from the ongoing oil palm plantation located in the upper Bat river, and only fish at a self-sufficient level. Thereby it is unknown where the main sources of revenues in society come from. In addition, it is pertinent to address the environmental impacts of the changes in land use. If part or all of the area has remained uncultivated, it is likely that there have been changes in the state of biodiversity and the quality of soil in the community. Also, the challenge with monkeys is mainly due to the loss of habitat caused by the cash crop plantations.

Thereby, it is relevant to study the LUC in Nanga Bat, through relevant qualitative and quantitative methods to investigate the different impacts, and thus reach an understanding of the social and environmental characteristics that distinguish Nanga Bat.

This leads us to the overall objective of this study which is to assess *how the agricultural intensity of rice cultivation in Nanga Bat has changed in the past three years and the associated social and environmental impacts in this relation***.** In order to answer this objective, we have developed the following research questions:

RESEARCH QUESTIONS

- What have the main land use changes been in the last three years and what are the current agricultural characteristics and practices?
- How has the soil quality been affected by the shift in rice cultivation?
- How has vegetative biodiversity changed in the areas affected by the land use change?

- What is the longhouse community´s perception of the land use change and how has it impacted their income and rice consumption?

STUDY SITE

This study is taking place in the longhouse community Nanga Bat, located on the Ngemah River, about 40 km from the Kanowit town in the Malaysian state of Sarawak. Nanga Bat consists of three longhouses under three different headmen with a neighbouring longhouse under a fourth headman. On a general basis, the sourcesof livelihood come from the natural resources in the area, where the community are dependent on thecollection of non-timber forest products.

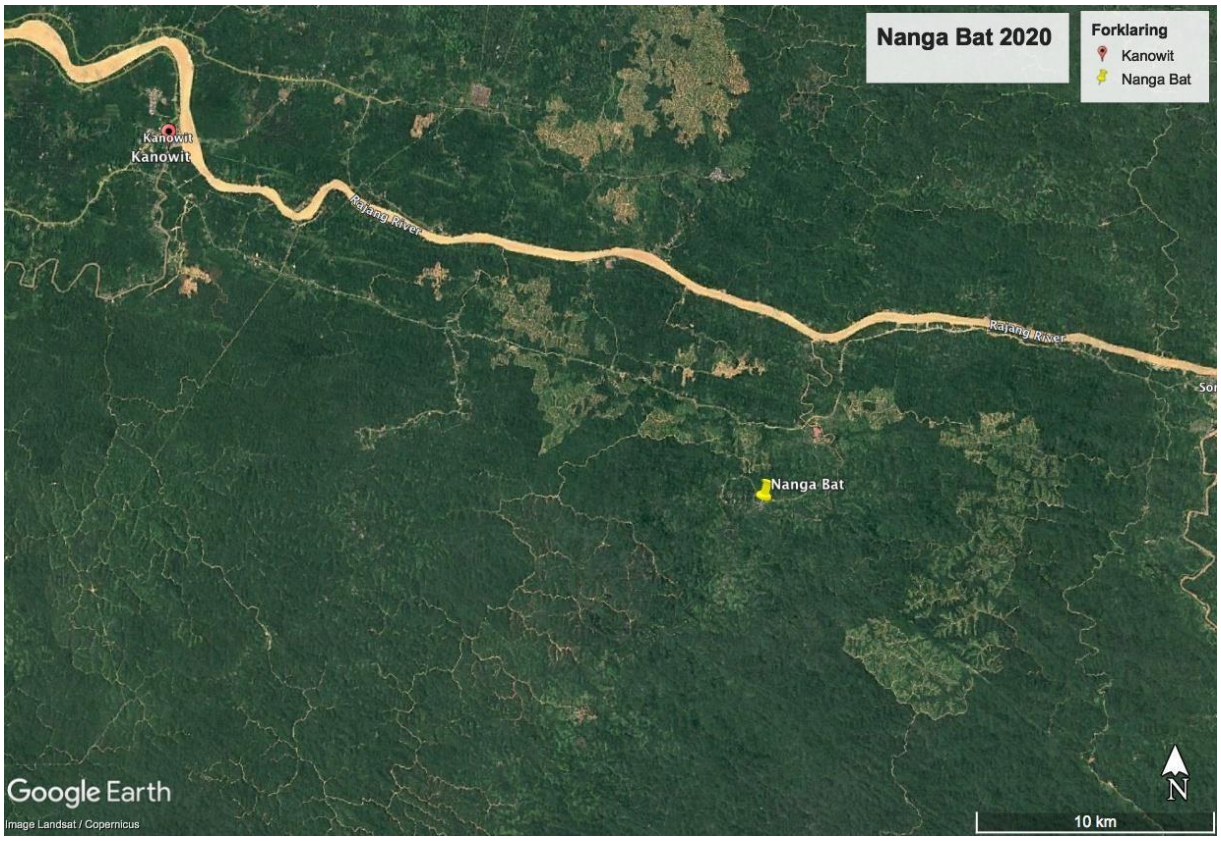


Fig 1. Satellite image of Nanga bat in the Kanowit District of Sarawak, Malaysia, 2020.

METHODOLOGY

In order to carry out our data collection we will make use of both quantitative and qualitative methods. These methods will be working in a complementary way and support each other in order to answer our overall research objective. Thereby, the implementation of data collection will be largely

interdisciplinary and interdependent with difficulties drawing a distinct line between the use of the different methods.

Surveys

The purpose of this method is to obtain general and context-specific information about the local situation regarding agricultural practices and strategies, and the social aspects related to income, rice consumption and perception. The survey will cover demographic information, and questions related to LUC focusing on land tenure and land use practices and experiences of the LUC. The survey will focus on the shift in rice cultivation and the associated impacts. We will do a convenience sampling with an emphasis on both farmers and non-farmers. The limitations of carrying out a survey are the collection of unspecific and to a certain extent superficial answers without the possibility to elaborate. Nevertheless, with the aim to obtain a general understanding of the context, semi-structured interviews are incorporated in order to cover this limitation. Another practical thing is the limited internet access to Google Forms which can affect the access, thus, we have some printed copies of the survey as a backup option.

Semi-structured interviews

The purpose of interviews is to get further information, complementary to the surveys. The semi-structured interviews can provide insight into the perceptions of the longhouse community regarding the social impacts of the abandonment of rice cultivation. The interviews will work as a window to elaborate on findings from the survey and be supported by visualization of the social cartography method. These interviews are going to question local agricultural practices and the social and economic impacts of the recent land use changes in the community with an emphasis on income and rice consumption. The limitations of this method are the language barrier we have with respondents and the understanding that the translator has of what we are asking for. Finding the time for people to have long conversations with us can be an issue since they must interrupt their daily activities to be with us.

Social cartography

The purpose of this method is to obtain information about the LUC in the landscape and the perceptions in the longhouse community in relation to these changes together with the emphasis on knowledge about the particularities of the study site. The aim of social cartography is to provide visual

information that can support the explanations carried out in the semi-structured interviews as well as support the collection of waypoints from the GPS assessment. We are going to place our focus on the social relations between the land and the longhouse community. This is going to be done by two moderators from the research team with groups of max 5 persons, that are involved in the land use issues, with the purpose of going over satellite images and/or drawing new maps that allow them to go over the territorial changes. The limitations of this method are the language barrier between us and the participants and in this context potential linguistic misunderstandings between us, the researcher and the participants. Time can be a challenge as the method with associated discussions and drawing sessions can be time-consuming for the participants.

Transect Walks

The purpose of this method is to investigate how vegetative biodiversity has changed after the rice land use transition and the local perception of this transition. We aim to get an understanding of how the longhouse community of Nanga Bat perceive the state of vegetation biodiversity regarding species abundance and the correlation with the land use changes involving rice crops. The walks will provide a general overview of the area and land use in the area. This is going to be done by selecting relevant points throughout the area of Nanga Bat and for the purpose of selecting sites for soil and biodiversity analysis. The walks will be conducted by 2-3 researchers, translators and specialized people from the longhouse community to obtain information, explanations and viewpoints during the walks. The transect walk will be accompanied by GPS tracking to document the route and specific points of interest for later analysis. The limitation of this method is the language barrier between us and the people from the longhouse community. Moreover, this method can be time-consuming for the participants. The obtained data will only be reliant on the knowledge and view of the selected participants which can lead to biases and contradictions.

Soil sampling

The purpose of soil sampling is to examine the changes in the soil at different fields in Nanga Bat after abandonment 3 years ago. The changing biodiversity of the area and former changes in agricultural practices will have significant impacts on soil, making it relevant to answer our research question, especially to evaluate the environmental impacts of land use changes.. Soil samples were collected at the active cultivation site acting as the baseline/control and then at different sites where rice cultivation ended in respectively 2020, 2016 and 2011. Samples were We will evaluate the

carbon pool by noting the differences in weight, analyze the concentration of nitrate, ammonium and phosphorus in the soil and lastly measure pH. The limitations for sampling and analysis of soil include the homogeneity of soil and any eventual contaminants like stray feces or fertilizers. In addition, the selection of sites is important as the distance and elevation between sites can affect differences in biotic and abiotic factors.

Biodiversity assessment

The purpose of doing biodiversity assessments is to find relevant changes in vegetative biodiversity, related to the abandonment of rice cultivation by comparison of biodiversity indices. We will study several sites at varying levels of succession which provide a temporal gradient. Ideally, we will choose the same sites for both the soil samples and the biodiversity assessment to have coherence inour results. The biodiversity should be conducted with the guidance of local botanical experts. The selection of study sites will require the consultation of longhouse experts. The biodiversity will be calculated with indices such as Shannon-Wiener, Gini-Simpson, species richness, rank abundance and possibly Pilou-evenness. The limitations of this method are our limited knowledge and ability to correctly identify the local plants to a species level. Moreover, we are dealing with a biased perception by only focusing on flowering plants and trees where other taxonomic groups could be overlooked. Another limitation is the difficulty of collecting representative observations across sites with inter and intraspecific changes.

GPS satellite mapping

The purpose of this method is to get up-to-date coordinates of the whole study site and moreover waypoints of the most important and major land use changes that the longhouse community perceive. The marked GPS points will be used to carry out a comparison of land use changes in the selected study area over the last 3 years. GPS will also function as support for other methods such as transect walks and social cartography. It is also going to be helpful for soil sampling as it will allow us to mark the baseline of the analysis and the formerly traditionally cultivated area. The analysis will consist of the creation of a detailed map, highlighting all important aspects of the land use changes in the selected area. Moreover, this method will support the findings and analysis of other methods through a clear visualisation. The limitations of this method are the accuracy that the GPS equipment might have in the field site, inadequate management of the equipment, limitation of access to satellites in the site, and loss of information.

SCHEDULE OF FIELDWORK

DATE	METHODS
06/03	Surveys - choice of sample, conduct surveys
07/03	Surveys - conduct surveys, data cleaning
08/03	Choice of sites for soil sampling & biodiversity assessment
09/03	Biodiversity assessment - transect lines (transect walks) Soil sampling - choice of sites, collection, post-processing GPS - waypoint, target points, tracking
10/03	Biodiversity assessment - transect lines (transect walks) Soil sampling - choice of sites, collection, post-processing GPS - waypoint, target points, tracking
11/03	Overview of data collection, data cleaning / buffer day
12/03	Interviews - choice of sample, conduct interview
13/03	Interviews - conduct interviews
14/03	Social cartography Prepare for the presentations

PLANNED COLLABORATION WITH COUNTERPARTS

We have initiated first contact with our Malaysian counterparts and are excited to discuss our research questions and methods, in order to collaborate during fieldwork. However, we plan to have daily morning meetings to discuss each day's programme and distribute the key tasks of the day. Furthermore, we think having follow-up meetings at the end of the day to debrief the day would be beneficial. A detailed distribution of efforts in relation to the collection of data on the basis of

competencies needs to be done at the beginning of fieldwork to ensure everyone learns something new and can help others.

REFERENCES

- Hansen, T., & Mertz, O. (2006). Extinction or Adaptation? Three Decades of Change in Shifting Cultivation in Sarawak, Malaysia. Land Degradation and Development, 135-148.
- Hansen, T. S. (2005). Spatio-Temporal Aspects of Land Use and Land Cover Changes in the Niah Catchmebt, Sarawak, Malaysia. *Singapore Journal of Tropical Geography* 26(2): 170-190.
- Mertz, O., Wadley, R. L., & Egelund Christensen, A. (2005). Local land use strategies in a globalizing world: subsistence farming, cash crops and income diversification. *Agricultural Systems*, *85*(3), 209-215.
- Mertz, O., Egay, K., & Bruun, T. B. (2013). The Last Swiddens of Sarawak, Malaysia. *Human Ecology*, 109-118.

1. MATRIX

Research Questions	**Sub-questions**	**Required Data**	**Methods**	**Sampling**	**Techniques of analysis**	**Limitations**
1. What have the main land use changes been in the last three years and what are the current agricultura	1.1 What are the region's social, political and environmental context of agricultural	Information about laws, development policies, and historical events regarding Sarawak and	Literature Review	Relevant keywords	Thematic analysis for the context of research (Nvivo?)	L1. Data may not be up to date & we could build our context on outdated data, that may not include major drivers of change

l characteristics and practices?	land use change?	agricultural strategies. And look into if the policies had any impact, and whether other factors drive change or prevent change.				
	1.2 What are the agricultural practices and land use in Nanga Bat?	Agricultural practices and strategies	Survey Interviews	Stratified sampling of farmers	Descriptive statistics & correlation statistics	L3. Has unspecific answers and might lack depth and details. could shape the answer according to our question and possible answers
		Change in landscape	Satellite Imagery	Relevant areas according to	Mapping change over years/	L4. Technical problems with measurements - could limit

				discussions with farmers	change between local recollection and satellite imagery	accuracy + we could have a wrong estimation of boundaries
			Social Cartography	Intervention of satellite images and creation of newly drawn maps	Mapping changes over the years/getting to know particularities of the area that are not specified in the satellite images. social relations between land and community	L5. Language barrier & time issues
		Actual representation of	GPS		Mapping the	L6. Technical problems with measurements -

		practices & land uses			coordinates	could limit accuracy
2. How has the soil quality been affected by the shift in rice cultivation ?	2.1 How did the farmers change their agricultural practices regarding soil?	Change in strategies, pesticide use, tillage	Interview	stratified sampling of farmers	Descriptive statistics & thematic analysis with Nvivo	L7. Language barrier and time issues & might be hard to give your personal opinions to foreign people
	2.2 How has soil quality changed over the past 3 years?	Carbon levels, pH, nutrients. Changes in fields that have been abandoned at different times.	Core soil sampling in mineral soil agricultural lands & de-intensified land Different specific fields/ plots to compare and use as a baseline a piece of land that has not been a rice	Stratified random sampling	Field analysis of pH, lab analysis of carbon and nutrients	L8. Lack of time & space to bring back soil - limited lab analysis

			cultivation area			
3. How has vegetative biodiversity changed in the areas affected by the land use change?	3.1 How has vegetative biodiversity changed over the past 3 years?	Species abundance Species observations	Quadrat/strip line analysis Relevant areas according to the farmers, and the agricultural context. Control, land use and gradient between	3 replicates of quadrat with a focus on smaller vegetation and 100 m stripline transect with a focus on larger trees	biodiversity indices calculated; Shannon-Wiener, Gini-Simpson, Pilou evenness, species richness and rank abundance	L9. Poor knowledge of local species. Limited focus, lichens, mosses etc not identified. Overlooked species/observations. Getting representative measurements across sites could be difficult depending on interspecific changes.
					Mapping the coordinates	L10. (L6)
		Species location/ distribution of selected quadrats	GPS Waypoints at each quadrat	Purposeful	Mapping the walks	L11. Locals could be biased

	3.2 How do the locals perceive the potential change in vegetation biodiversity?	Perception of farmers and locals	Transect walks. Different specific plots to compare and use land that has not been a rice cultivation area	sampling of farmers or relevant locals	+ thematic analysis of the notes taken during the walk (discussion with the community)	
4.What is the longhouse community´s perception of the land use change and how has it impacted their income and rice consumption?	4.1 How have income-generating activities changed over the past 3 years?	Income source and change	Survey	Stratified sampling of farmers	Descriptive statistics & correlation statistics	L12. (L3)
	4.2 What are the changes in rice consumption?	Potential stop of rice production changed rice consumption	Survey & Semi-structured interview	Stratified sampling of farmers	Thematic analysis with NVivo & correlation statistics	L13 (L7)
	4.3 How has the community	Experiences perception	Semi-structured interviews	Stratified sampling	Thematic analysis	L14. (L12) + peer pressure of

	experienced the shift in rice cultivation?	s and views of the community		of farmers	with NVivo	the social setting
			Social cartography	Purposeful sampling	Notes during the session, using maps as data for local perceptions of land use changes	L15. (L5)

2. INTERVIEW GUIDE

Theme	**Question**	**Notes**
Personal information and context	What is your name, age, gender, and occupation?	
Residence (Nanga Bat and longhouse)	What is your relation to Nanga Bat?	Are they living in Nanga Bat, have they lived in Nanga Bat? Do they have family in Nanga Bat? Grew up in Nanga Bat?
	Do you live in a longhouse? If yes, which one?	

	How would you describe your social position in the longhouse?	
Occupation and income	What is your main occupation?	
	Is your occupation your main income-generating activity? If not, what is it?	
	Do you have other kinds of work as well?	
Land use change	Have there been any changes in your occupation? If yes, can you explain what changes occurred?	
	What motivated your change of occupation?	Economic? political? cultural - make them elaborate?
	For how long have you been working with x?	
	Are other people in the longhouse community relying on you in any way? If yes, in what way?	Be sure they are specific - maybe mention examples (income, food, housing)
Agricultural strategies and land	What do you use your land for?	If they own, rent or are renting out land Agricultural use or not

	Can you explain in as much in detail as possible what your agricultural practices are today?	Also if they grow a certain crop OBS - be ready to ask elaborating questions of special interest
	Who are the people involved in the maintenance and cultivation? What are their roles?	

3. QUESTIONNAIRE

Section I (Demographic)

Name	
Informant number	
Age	
Gender	Male:___Female:___Prefer not to say:___Other:___
Did you grow up in Nanga Bat?	Yes:___No:___
If no, where did you grow up?	
Marital Status	Single:___Married:___Divorced:___Other:___
Education Level Achieved	No formal education:___Primary school:___Secondary school:___ Highschool graduate:___University degree:___Other:___

Do you live in Nanga Bat?	Yes:___No:___
If yes, in which longhouse?	
If no, in which city/village do you live?	
If not, are you a member of a longhouse?	Yes:___No:___
How many live in your *pintu?*	
If you are living with other people in your *pintu*, who do you live with?	Family:___Friends:___Employees:___Other:_____
Current occupation(s)	
Does your occupation imply working with the land?	Yes:___No:___

Section II (Agricultural practices)

What is your relation to the land?	Owning:___Renting:___Renting out:___ Other:
If you are renting or owning - what type of activities do you use your land for?	Housing:____Agriculture:____ Other:
If you chose "Other" in the last question please specify here the activity	

How big is your land? (if possible)	
How many people are involved in this land?	
Who are the people involved in the cultivation of this land?	Family:___Friends:_____ Employees:___Volunteers:___
What crops are you cultivating?	Rice (swamp):___Rice (hills):___ Rubber:___Pepper:___Oil Palm:___ None:___ Other:
What crops have you cultivated but stopped?	Rice (swamp):___Rice (hills):___ Rubber:___Pepper:___Oil Palm:___ None:___ Other:
If you stopped, how long ago?	

Section III (Rice Cultivation)

Who are/were the owners of the rice?	Yourself:___Your family:___ Your employer:___ Other:
What has maintained your interest in cultivating rice?	Income:___Self-Comsumption:___ Tradition:___ Other:
What has maintained your interest in cultivating rice?	Money____Self-consumption____Other _____
How long have you had rice as your crop?	

Do you alternate rice cultivation with other crops?	Yes:___No:___
If yes please specify the reason	
What type of cultivation technique do/did you use?	Shifting cultivation:___ Paddies:____ Other:
If you stopped rice cultivation, what are you using the land for?	Housing:__Cultivation of another crop:__Renting:__Sold:___No use:___ Other:
What motivated you to change the rice crops?	Monkeys:_Other pests:___ Weather conditions:___ Low market prices:___ You buy your rice in the market:___ Law restrictions:___ Other:
Have you noticed changes in soil conditions since you stopped rice cultivation?	Yes____No_____ I don't know:
If yes, what are the perceived changes?	Improved:__ Deteriorated:__ Other:
Have you noticed changes in the amount of (insert plan or animal name) since you stopped rice cultivation?	Yes:___ No:___ I don't know:___
What challenges do/did you consider that rice cultivation is facing?	Monkeys:___ Weather conditions:___ Other pests:___ Low market prices:___

	Law restrictions:___ Other:
Has the source of your income(s) changed alongside the land use change?	Yes:___ No:___
How has it changed?	Diversification of income sources:___ Decreased amount of income sources:___ Other:
How stable is your income?	Unstable:___ Stable:_____ Other:___

Section IIII (Perceptions)

Are you going to buy rice at the market more often since the land use changes?	Yes:___ No:___
Have you changed your rice consumption?	Yes:___ No:___
If yes, how?	Stop of rice consumption:___ Decrease of rice consumption:___ Increase of rice consumption:___