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LAND USE CHANGE AND LIVELIHOODS

A case study of Sebangkoi Undop, Sarawak, Malaysia

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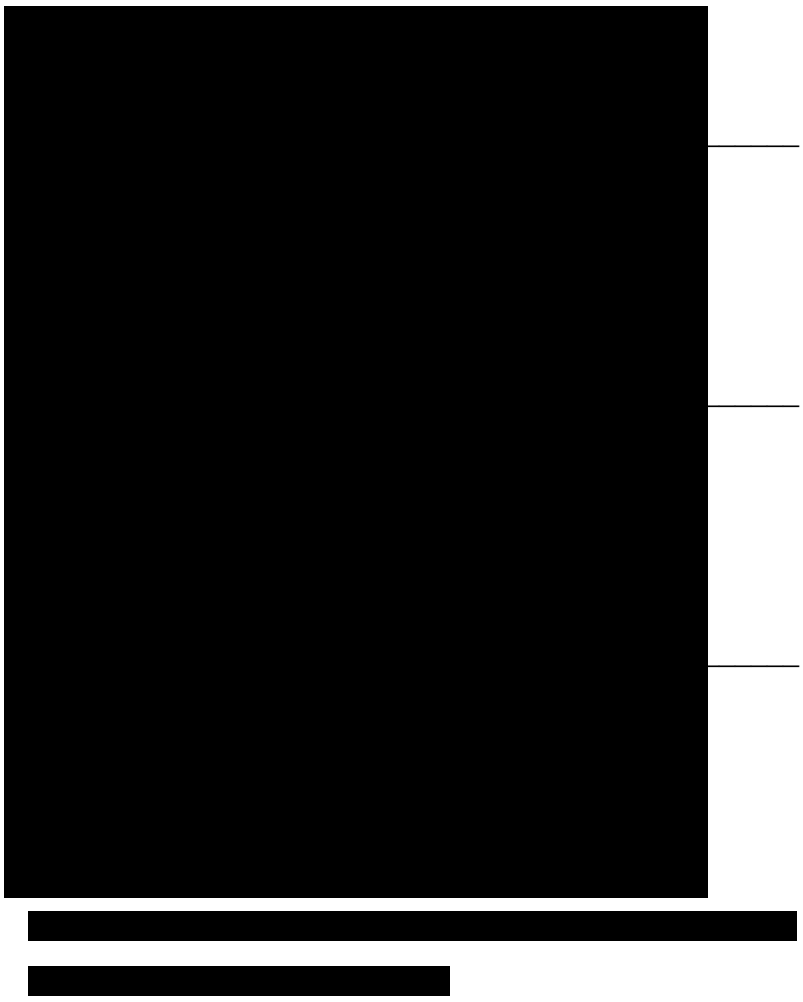

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Abstract

This study is mainly based on data, which was collected during a two week fieldwork at the longhouse Sebangkoi Undop, Sarawak, Malaysia, with 23 household units in total. The aim of the report is to show how and to what extent livelihood strategies of the households and other factors are driving and causing land use changes (LUC) but also how these LUCs can create opportunities for new livelihood strategies. Specifically, we found that the major LUCs are the transition from forest to crop land and the other way around, the decrease in rice cultivation area, the change in pepper cultivation area and the opening up of small-scale oil palm plots. The predominant underlying causes for LUCs in Sebangkoi Undop are the better access due to moving to the new longhouse, the lack of labour force, the increased monetization and the change in cultivation strategies, i.e. more use of fertilizer and pesticides. These factors are all interlinked and tightly connected to other livelihood strategies and environmental factors, i.e. out-migration, focus on cash crops, Government intervention, soil and water quality. In general, the findings in our study site coincide to a large extent with the general trend in Sarawak, described by the literature, but additional data would be needed to make any significant conclusions.

Acknowledgements

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Our deepest gratitude goes to the people of Sebangkoi Undop, especially to Tuai Rumah Bandi Layeh, the people in bilek number 12, 14 and 15 for hosting us and the women cooking for us. We want to thank the whole community for their great willingness to engage in our study, spending hours on answering our questions, guiding us through the surrounding areas and teaching us about more about the beautiful nature around. We really appreciate that they let us celebrate their customs, by sharing their wine, food and traditions. Thank you for being so welcoming and joyful, and for making our fieldwork as smooth as we ever could have wished for.

Contents

List of Abbreviations

JVC - Joint Venture Company

LUC – Land use change

MPB - Malaysian Pepper Board (Lembaga Lada Malaysia)

MRB - Malaysian Rubber Board (Lembaga Getah Malaysia)

NCR - Native Customary Rights

SOP - Sarawak Oil Palm

SSI - Semi-structured interview

TR - Tuai Rumah (Headman)

1. Introduction

Cramb (2007) claims that over the past century and a half the agricultural practices in the Southeast-Asian uplands have undergone a transformation. The transformation is driven by the introduction of new agricultural crops and technologies, impacting the livelihood of small-scale societies. This takes place in a context of population growth, migration and extension of global markets into rural hinterlands that were once secluded, leading to intensification and agricultural commercialization.

Tanaka et al. (2009), like Cramb (2007), connect the transformation from traditional shifting cultivation towards a more permanent cultivation to an increased commercialization, claiming that the rising need for cash income in a monetary economy has enhanced the importance of cash crop farming.

Cramb and Sujang (2013) furthermore argue that agricultural commercialisation has been widely advocated in Sarawak, especially focusing on tree crops and other perennials in smallholder production. The World Bank, amongst others, sees this as a pathway out of poverty for a large number of rural households, especially in the upland areas. However, at the same time Cramb and Sujang (2013) argue that the government of Sarawak has pursued a policy favouring large-scale estates over smallholder agriculture. Sarawak's agricultural sector has therefore been transformed during the last four decades from being almost exclusively in the hand of smallholders to being dominated by private estates, involved especially with oil palm plantations (Cramb and Sujang, 2013). They do however argue, that there has been a rapid growth of oil palm smallholders since the year 2000, a trend that could become even more predominant if these smallholders are getting support in terms of financial inputs and infrastructure (Cramb and Sujang, 2016).

Hansen (2005), who has studied large-scale land use change (LUC) in the Niah catchment, Sarawak, Malaysia, adds to the arguments presented above that the land tenure system is a key factor for understanding LUCs in Sarawak. The land tenure system is rooted in the 1958 Land Code, established by the colonial government under Brooke Rajah which categorised the land into: 1) Mixed Zone land - with no restrictions on who can acquire land titles; 2) Native Area Land - only native people of Sarawak can hold land titles; 3) Native Customary Land - land not held under titles, but under native customary rights; 4) Reserved Land - land held by the State Government; 5) Interior Area Land - residual land, accounting also for some of the State land (Cramb, 2007, pp. 222). Most large-scale oil palm plantations were first established on State land by private companies, who hold the land through long

term leases. However, as suitable State land has been used up, the attention has shifted to Native Customary Land, where small-scale land holders make their land and labour available to private plantation companies through joint ventures (Cramb and Sujang, 2013).

Hansen & Mertz (2006) claim that the agricultural transition in Sarawak has been pushed by various policies, including a ban on open burning; by promoting joint venture agreements between private companies, small-scale land holders and the Government; and by the extension of services such as road infrastructures. Hansen (2005) also argues that the development policies have an effect on the land use in Sarawak. She points out that areas around road networks are predominantly kept by small-scale land holders, practising shifting-cultivation and small-scale permanent cultivation, whereas the surrounding areas are held by large-scale commercial enterprises. However, she claims that shifting-cultivation and small-scale permanent cultivation have been intensified during the last 30 years as these practices have been increasingly replaced by perennial cash crops on permanent fields and by off-farm activities.

This report is mainly based on data which has been collected during our fieldwork from 26th February 2020 to 8th March 2020 in Kampung Sebangkoi Undop, Sarawak, Malaysia. With our analysis and discussion we wish to contribute to the existing literature of LUCs in Sarawak, Malaysia. Our aim is to understand how livelihood strategies of the households and other factors are driving and causing LUCs, and how LUCs can give opportunities for new livelihood strategies. Therefore we seek to answer the following research questions:

How and to what extent are LUCs in Sebangkoi Undop linked to livelihood strategies?

1) What are the major LUCs in the area surrounding Sebangkoi Undop over the last approximately 20 years?

2) Which factors are interacting with the LUCs?
   a) What are the livelihood strategies in Sebangkoi Undop?
   b) What are other factors (i.e. institutions, technology) interacting with the LUCs?
   c) How are environmental factors (i.e. water and soil quality, crop diseases) interacting with the LUCs?

3) What are the proximate causes and underlying drivers of LUCs?

We will start our report by presenting the study site and the theory and conceptual frameworks. Then we will describe the methods, which we applied in the field and afterwards we will illustrate and analyse the data. In the last chapter, we will discuss the findings in relation to our conceptual framework and the theory.

1.1 Site description

The Sebangkoi Undop longhouse (North 01° 2' 28" East 111° 37' 16") is part of Sri Aman administrative district in Sarawak, Malaysia. The community consists of 23 households, with 20 *bileks* (appartments) within the longhouse and 3 individual houses next door. The land area is characterized by hilly areas and rivers in the lowlands. As expected for its geographical location, Sebangkoi experiences heavy rainfall and high relative humidity, a climatic requirement for pepper (Ravindran 2000). The average relative humidity in Sarawak in 2012 was between 82.0% and 85.5% (Ashraf et al 2018). It rains all year in Sarawak, and the total annual rainfall is approximately 3300 mm (forecast.water.gov.my). The rainfall pattern is suitable for the crops that are grown in this region. The main crops cultivated by households in the longhouse are rice (*Oryza sativa*), pepper (*Piper nigrum*), oil palm (*Elaeis guineensis*) and rubber (*Hevea brasiliensis*). Fruit orchards are common as well.

Drone picture taken above the longhouse showing the surrounding area

2. Theory and Conceptual Frameworks

This chapter describes the theoretical background and defines the concepts, which we are going to use when analysing the LUCs in the area surrounding Sebangkoi Undop.

2.1 Proximate and underlying factors of LUC

LUC is part of the interdisciplinary study on Land Use and Land Cover Change (LUCC), focused on studying the social-ecological systems of land use (Turner et al. 2007; Meyfroidt 2016). The Intergovernmental Panel on Climate Change (IPCC) defines 'land use' the following way: "Land use is defined through its purpose and is characterized by management practices such as logging, ranching, and cropping." (IPCC 2001, 155). Ostwald (2009) adds that 'LUC' is defined by the change of one usage to another – for example from forest to cropland, from subsistence to cash crops or the addition of technical innovations such as pesticides.

Understanding the causes of LUCs is challenging, as they consist of multiple factors operating through "non-linear and complex linkages between processes" (Ostwald 2009, 157). This can lead to issues with establishing causality, which we will deal with by using the conceptual framework of proximate and underlying factors explained by Turner et al. (2007) and Geist & Lambin (2002). Figure 1 shows how this framework has been used to describe the proximate and underlying factors of deforestation:

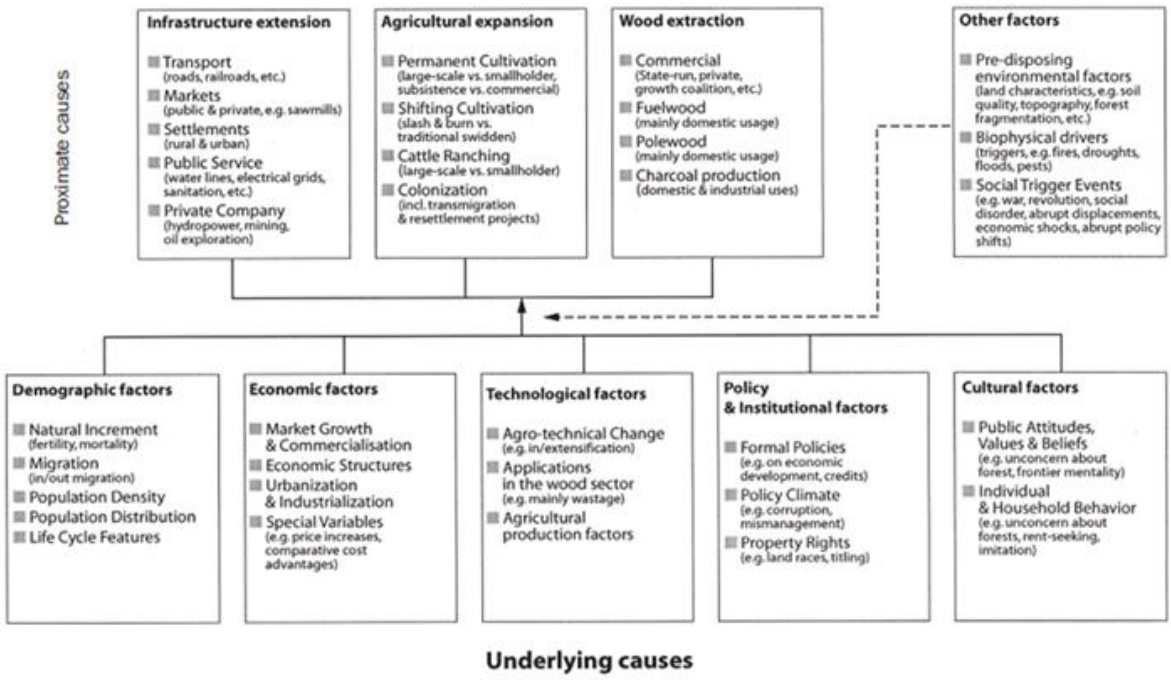

Figure 1 (Geist & Lambin 2002, 144)

Although Geist & Lambin deal with deforestation, we find their analysis strategy as a good inspiration for our project. A similar chart has been made to explain the causes of LUCs in our study area.

A cause is a "factor that produces a causal effect on an outcome through a chain of mechanisms" (Meyfroidt 2016, 506). Accordingly, LUC is not attributed to just one factor, but rather to a chain of factors (Ostwald et al. 2009). A proximate cause has a direct effect on land use and will be placed as the last step of a casual chain. An underlying driver has an effect on the proximate cause and will therefore be the earliest step in a causal chain (Meyfroidt 2016).

Through the analysis of our findings we aim to cluster causal linkages and divide the factors into proximate causes and underlying drivers according to Geist and Lambin's (2002) framework presented above. This framework is very efficient in establishing straight forward causal chains of explanations, however we do acknowledge that sometimes causal chains are more complex, than what is shown in this framework, e.g. there can be feedback loops where a factor is both a cause and an outcome at the same time (Meyfroidt 2016).

2.2 Livelihood framework

In our report we have chosen to use parts of the livelihood framework presented by Scoones (2015).

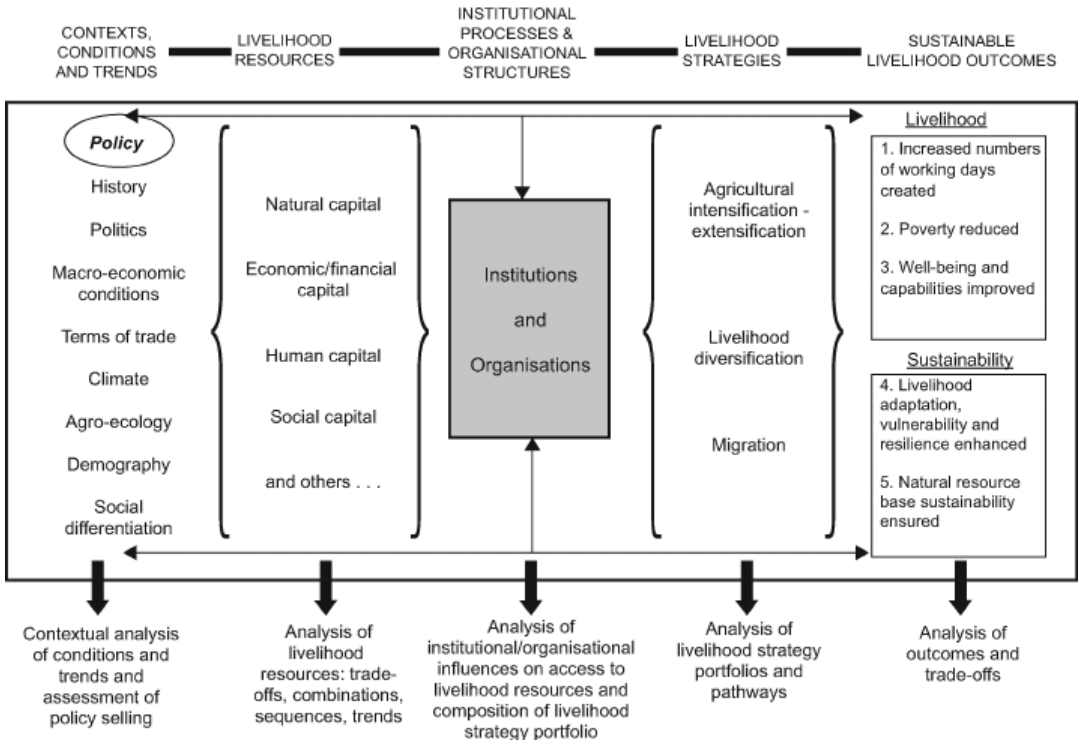

Figure 2 (Scoones 2015, 36)

Regarding this framework, we will especially focus on the ‘livelihood strategies’, which include ‘agricultural intensification and extensification’, ‘livelihood diversification’ and ‘migration’. This part of the framework is especially useful to capture the change and diversity of livelihoods over time, as it is “an assessment of livelihood dynamics, showing how different people are forging a variety of alternative trajectories” (Scoones 2015, 41).
From this framework, we will furthermore include the part of ‘Institutions’ in the form of the interactions between the Government and the longhouse. Also some points under ‘contexts, conditions and trends’ will be included in our analysis, accessed from of secondary literature.

3. Methodology

3.1 Participatory observation

We chose to do participatory observation (Martin 2004), which allowed us to gather information in a casual way. We assumed this could lead to other insights than for example the more formal interviews could and therefore support the triangulation of our data.

When walking to a field with a guide and an interpreter, we would ask questions about the field - what has been planted before, how long it has been cultivated etc. This led to important insights about the land use and to some other unexpected insights. A small-scale oil palm farmer for example told us his opinion about the EU-ban on palm oil and about the SOP's impact on his small-scale production. This was great information that we had not thought of asking before.

As participatory observation often took place at random times and places, the interpreters were not always able to be present, which may have caused to miss some important pieces of information. However, as observation is not only about conversation, we did get some information even when interpreters where not there. For example we observed that the women used forest products in everyday cooking, e.g. bamboo shoots and ferns.

3.2 Participatory Rural Appraisal (PRA): Resource mapping and resource ranking

We used participatory resource mapping (Narayanasamy, 2008) in order to get an insight into the community's own perception of the area surrounding the longhouse. It quickly gave us an overview of the agricultural activities, rivers and roads in the area and the maps were very useful for us to choose the locations for water and soil sampling (the final maps can be seen in the appendix).

Resource mapping with the female group

We did participatory resource ranking (Martin, 2004) to get an understanding of the importance of each type of crop, the livestock and the secondary forest for the people in Sebangkoi Undop.

As both methods are visual tools, the language barrier was in some ways a smaller challenge. We could understand when they were drawing oil palms, rivers etc. and we could point to an empty part of the map to ask them if something is there. Our interventions, may have had the effect that they ended up drawing what we thought was important, not what they thought was important, which was not our intention. However it was hard for us to follow some points, as the mappings and rankings were group activities. This meant that the interpreters sometimes had a hard time keeping up with the conversation.

For both, the mapping and the ranking, we sampled according to gender. We asked a group of women sitting in the community kitchen and a group of men sitting in the hall of the longhouse. Our hypothesis was that there were differences in how men and women perceive the area, and how they would rank different products. Besides the gender selection the sampling was based on who was randomly available at the time. This has the disadvantage that some voices may be unheard – for example the older people, who tended to stay inside or very close to their *bilek*.

The advantage was that we were able to start the mappings and rankings in a more casual way. Our selection bias also plays a smaller role, since we did not choose specific people to get involved in these activities. However we did already know the women in the kitchen, which might have made us more likely to choose them for the group activities.

Preference ranking with the male group

3.3 Timeline

We did a timeline (Mikkelsen 2005) with the TR (Tuai Rumah) of Sebangkoi Undop, as we assumed, that he has knowledge about the history and decision making. The purpose was to get an overview of the history of land use and other important events over the last approximately 20 years. We decided that the timeline would start at the point when they were still living in their old village and would end at present time, in order for us to ask relevant and coherent questions.

We did the timeline on one of the first days of our stay, allowing us to quickly get an overview of important events in the recent years. However it had the disadvantage that we did not know very much about Sebangkoi Undop yet, which made it hard for us to ask more details about specific LUCs.

3.4 Transect walks

We did several transect walks (Mikkelsen 2005) to map the LUCs over the past approximately 20 years in the area surrounding Sebangkoi Undop. When choosing our guides for the transect walks, we asked who would be able to tell us something about the development of the area. We chose to focus on two facts when doing the transect walks – what is the land used for currently, and what was it used for in the past. While walking we could observe what is cultivated in the field and we would specifically ask the guides about the history of each field. We saved the waypoints of each field in the GPS, with a description of the land use of the past and the present. This resulted in a map of the LUCs in the area. The participatory mappings were useful for us to choose our routes for the transect walks.

Transect walk in the surrounding areas of the longhouse with local guides

3.5 Questionnaire

We created a questionnaire to gather information about various aspects related to land use and livelihood strategies. The longhouse only has 23 bileks so we aimed to talk to one respondent from each bilek to get information at household level. In the end 22 questionnaires could be completed, one man living alone was never present during our fieldwork.

In one of the first days, we conducted one pilot test questionnaire. That trial was extremely valuable to see which questions did not make sense to ask or which could not be understood easily: for example the man could not tell us the age of his children. Since we also shifted the focus of our study after the trial questionnaire, we spent a lot of time in editing the questions according to that. Our interpreters have been included in this process, so that they had a clear idea of what is meant by each question and in what way they should ask. In general, when we did the questionnaires there was always one interviewer, one interpreter and one or two note takers present. Taking additional notes turned out to be crucial, since some of our questions were quite close and some respondents wanted to elaborate more on the topic. Once we started conducting the actual questionnaire we could identify different issues and limitations:

When asking about cash income sources, unfortunately we did not specifically ask for income from off-farm activities, such as employment in a plantation or a construction company etc. Thanks to the additional notes we were still able to categorise some cash income more specifically.

The question about change in plot size and yield per plot, caused confusion for some respondents. The wording was not clear enough and it was probably too complex to capture everything in one single table (see question 8 of the questionnaire in the appendix).

Sometimes even the interpreters/interviewers got confused about the questions and answers. For example, one household stated that they did not grow rice, but in the question about applying fertilizer and pesticides, the same household stated that they applied fertilizer and pesticides on the rice fields. This discrepancies in the answers, show that the communication between the interviewer, the interpreter and the respondent was not always optimal.

3.6 Semi-structured interviews

We chose to do semi-structured interviews (Casley & Kumar 1988) to get more in-depth answers about some parts of the questionnaire to triangulate our data. We conducted four semi-structured interviews.

SSI1 was with a woman who works in the SOP. We noticed that this was quite typical for women in the longhouse and we therefore wanted to learn more about it. SSI2 was with a young man to understand the youth's perception of growing up in a longhouse and the dreams for the future. SSI3 was with an older man to get a better understanding of the land use and the LUCs over time. In SSI4 we interviewed the counsellor of the longhouse to understand his role, the land tenure system and other socio-economics of the longhouse.

We chose to interview one person at a time, to make it easier for us and the interpreters to keep up. However we did notice that some information was lost between the interpreter and us, since they did not have a chance to translate or note down everything. Choosing to do one to one interviews was an advantage, as sometimes it took several follow-up questions before we got to understand the respondent's point of view. For example when interviewing the young guy, we first understood that he wanted to be a small-scale farmer, but after some follow-up questions he clarified that he would more like to be an agricultural entrepreneur.

When constructing the interview guides and when conducting the interviews, our strategy was to ask open questions, for example when we asked in SSI2: "How is it for you being a young person growing up in the longhouse?" However looking back we did ask some leading questions unintentionally - for example in SSI4 we asked: "Will it [outmigration] be a problem in the future?" and "Is there an effort to reduce outmigration?" This is a limitation for our data collection, as we might have influences the results by asking in this way.

3.7 Soil sampling

We took soil samples from a pepper plot that is close to the Undop river, a rice plot in the hilly area, a fruit orchard, an oil palm plot and a rubber plot. All of the sampling sites were areas undergoing LUCs. The secondary forest was also sampled as we assumed that the soil here would be representative of the soil quality before cultivation. In this way we used the secondary forest as a control plot for determining the effects of agricultural activities on the soil quality. We took samples at soil depths of 0-0.8 inches and 8-16 inches. We used an auger to collect the samples.

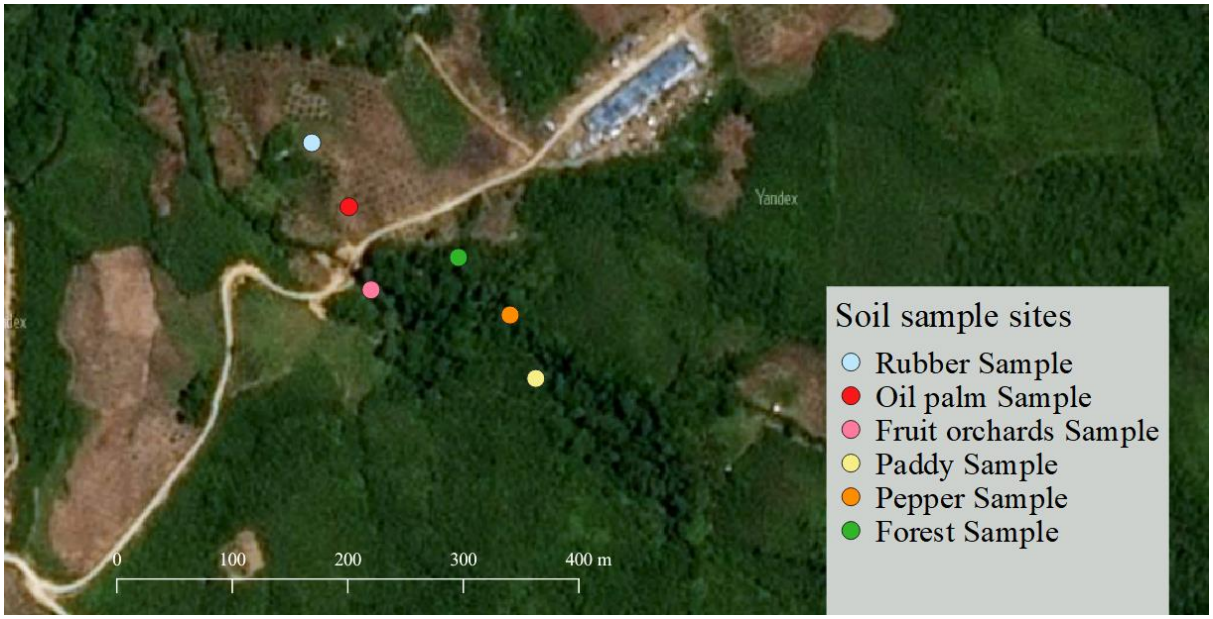

Figure 3: Soil sampling stations (NB. it has not been possible to get the date on the satellite images of the area, therefore it is not possible to detect the land use from that)

3.8 Water sampling

We included water sampling in our study, as a way to assess the environmental impact of the LUCs in the area surrounding Sebangkoi Undop. These measurements can be compared to the statements about environmental impact, which we gathered during participatory observation and interviews. For example, two men told us that the river was muddier because of the erosion from the SOP plantations.

We chose the sampling stations for the water sampling by using the participatory maps and the information we got through participatory observation and the questionnaires. The first station was in the gravity feed water system reservoir, leading water down to the longhouse. We chose this station because people from the longhouse had expressed their interest in wanting to know the quality of water for their household consumption. We are aware that we cannot use this sample to analyse the impact of LUC on water quality, however we thought it would be a good way to include the community's interests. The second station was downstream from the SOP plantation, in order to examine the oil palm plantations' effect on water quality. The third station was from a fishpond near to the longhouse to examine the effects of fish and fish food on water quality. The last sample site was downstream of a small-scale mixed field with pepper, rice, oil palm and fruit trees, in order to determine the effect of small-scale cultivation on the water quality.

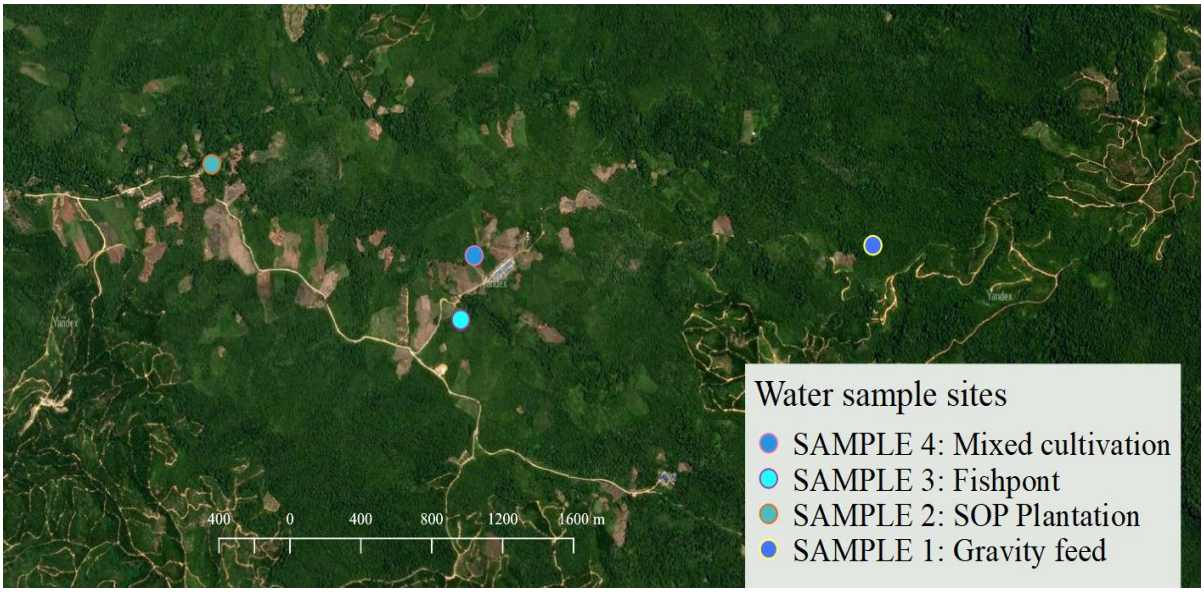

Figure 4: Water sampling stations (NB. it has not been possible to get the date on the satellite images of the area, therefore it is not possible to detect the land use from that)

In the field the procedure was as following:

1. Find a guide to take us to the desired sampling sites.
2. Water samples were gathered in plastic bottles with the help of a researcher.
3. Physical parameters of the water were measured on site by using an in-situ meter probe.
4. The samples were analysed in the longhouse afterwards.

Limitations: We were not able to collect data for the biochemical oxygen demand, because the equipment had suffered some water damage earlier in the field course.

Picture on the left - measuring the physical water parameters on sample site 3; picture on the right - collecting water samples on sample site 4

3.9 miniSASS (Stream Assessment Scoring System)

MiniSASS is a relatively simple method to assess the health of a river (www.minisass.org). It was carried out by collecting macro-invertebrates in the water column with a sieve. We furthermore used our hand to stir up the water and rocks so we were able catch some of the invertebrates, which normally would otherwise be holding on to rocks.

We did miniSASS in two stations, one in the Undop river and one in the gravity feed. For the latter location we are able to compare the results of the two different water assessment methods. At the river we were 10 people doing the sampling over a period of approximately 30 minutes and at the gravity feed we were only three students doing the sampling in a period of approximately 15 minutes, which may have influenced our results.

The gravity feed water system reservoir, leading water to the longhouse

3.10 Reflection on methodology

Throughout our study we have focused on triangulation of our data, which means that we have applied different quantitative and qualitative methods to acquire the knowledge needed to answer our research questions. However, further methods could have been helpful.

For example, we would have liked to include a land cover classification of satellite imagery. This would have helped us to answer sub-question one. We could have identified which plots have changed and calculate the extent of the land cover changes from the year 1999 up until now. Unfortunately, we were not able to find cloudless imagery of the area, which is probably due to the topographical and climatic characteristics of Sebangkoi Undop, and we did not have the time to do cloud removal.

Also conducting a crop-calendar could have been beneficial for our analysis. It could have clarified the climatic conditions throughout the year and given us an idea of the harvesting, fertilizing and planting season for the different crops. This would have given us a better ground to analyse our environmental data.

Overall we have found our choice of methods to be suitable for our study. We were able to get different perspectives and include many different views form the longhouse. We have been especially successful with the sequence of methods, initiating with the more participatory methods and finishing with the interviews. However it would have been good to have time for some follow up interviews with the counsellor and others, in order to clarify the final details.

4. Findings

In this chapter we analyse and discuss the data of our fieldwork in Sebangkoi Undop in order to answer our research questions, i.e. sub-question 1 and 2. Consequently the chapter will be structured as follows: first we describe the development of land use since the community moved away from the old longhouse; second we identify the livelihood strategies and other factors which are linked to LUCs; in the end we analyse the environmental factors interacting with LUCs.

4.1 LUCs over time

In this section we seek to answer our research sub-question 1 by giving an overview of LUCs in the area around Sebangkoi Undop.

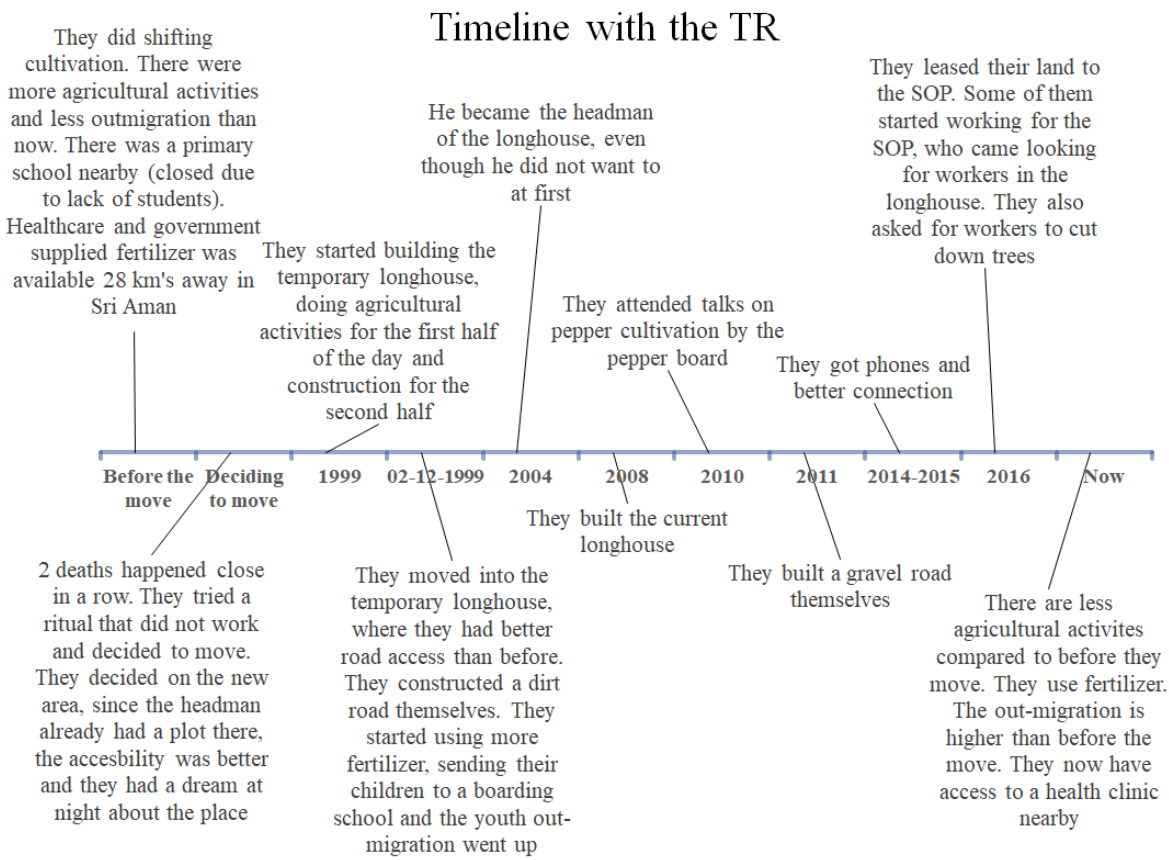

Figure 5, outcome of the timeline session with the TR

The timeline in figure 5 shows important events during the last approximately 20 years as described by the TR. Some of the information such as 'the out-migration is higher' was something that happened gradually, and the placement on the timeline should therefore not be taken too literally.

In relation to our research question, the timeline gives us important information about major LUCs and factors for that. Until 21 years ago, the longhouse community was practicing shifting cultivation, but this changed at a time when they moved to a location with better road access. According to Mertz et al. (2013), government policies in Sarawak have aimed towards eradicating swidden agriculture, which "has been perceived by the State Government as an obstacle to resource utilization – timber especially" (Mertz et al. 2013, 110). The decline of swidden agriculture has been associated with areas where joint-venture companies (JVC) are present (Mertz et al. 2013). These events also coincide in our timeline with the period when Sebangkoi Undop first got in contact with the JVC.

Besides the timeline, the transect walks in the surrounding areas of the longhouse gave us a good overview of the historical development of land use and crop cultivation in Sebangkoi Undop (see figure 6).

Figure 6: Map of the transect walks, showing the actual land use with a note on the past land use of the relative plot

Most notably many plots towards the old longhouse, north-east of the current longhouse, have been left and grow back to secondary forest, presumably because the plots are too far away now. Some pepper, rubber and rice plots in that area have been converted to oil palm plots. On the other side of the current longhouse, towards the road, many plots have been

opened newly after the community moved to this location. These new fields are mainly used for pepper and rice, which are the typical crops planted on newly opened land area. Especially rice grows better on previously uncultivated soil, according to the local farmers. Also some oil palm plots, fruit orchards and fish ponds have been established in this area, since the access is much easier now thanks to the road.

4.1.1 Changes in crop cultivation

In the questionnaire, we asked the farmers if the size of their plots (i.e. pepper, rubber, oil palm, rice and fruit orchards) has changed since they moved away from the old longhouse. 'Size of plot' is understood as total cultivated area for the specific crop and not as the specific size of the single plot. Additionally, we tried to find out the change in yield per plot for the different crops and the reasons for these changes (it could be multiple reasons for the same type of crop).

Rice

All 19 farmers who cultivate rice have decreased their rice plots. The decrease of agricultural plots is a common trend among Iban households according to Soda (2001). The decrease can be seen as part of a bigger trend in Sarawak described by Mertz et al. (1999), where the Government incentivizes small-scale farmers to diversify out of cultivating rice by giving subsidies for other crops. The yield per plot decreased as well in most cases, but 35% of households state that their yield per rice plot increased. One respondent mentions, that he gets the same quantity of rice from cultivating 2 ha now, compared to 4 ha in the past.

Figure 7 shows different reasons, of why the farmers in Sebangkoi Undop decreased rice cultivation. The majority of farmers (14 out of 19 planting rice) indicate that the lack of labour force is one reason for them to have reduced rice cultivation. In general, many farmers in Sebangkoi Undop pointed out that they had to reduce certain crops and/or to specific activities because there is not enough labour force. This is primarily linked to the outmigration of young people and the work as employee outside the longhouse.

Eight farmers indicate 'access to fertilizer / pesticides' as a reason for them to decrease rice cultivation. Several respondents mentioned that the fertilizer for rice, which the farmers get from the Government is not enough and not of good quality, therefore they have to buy fertilizer from the market. This statement has been confirmed also during SSI3.

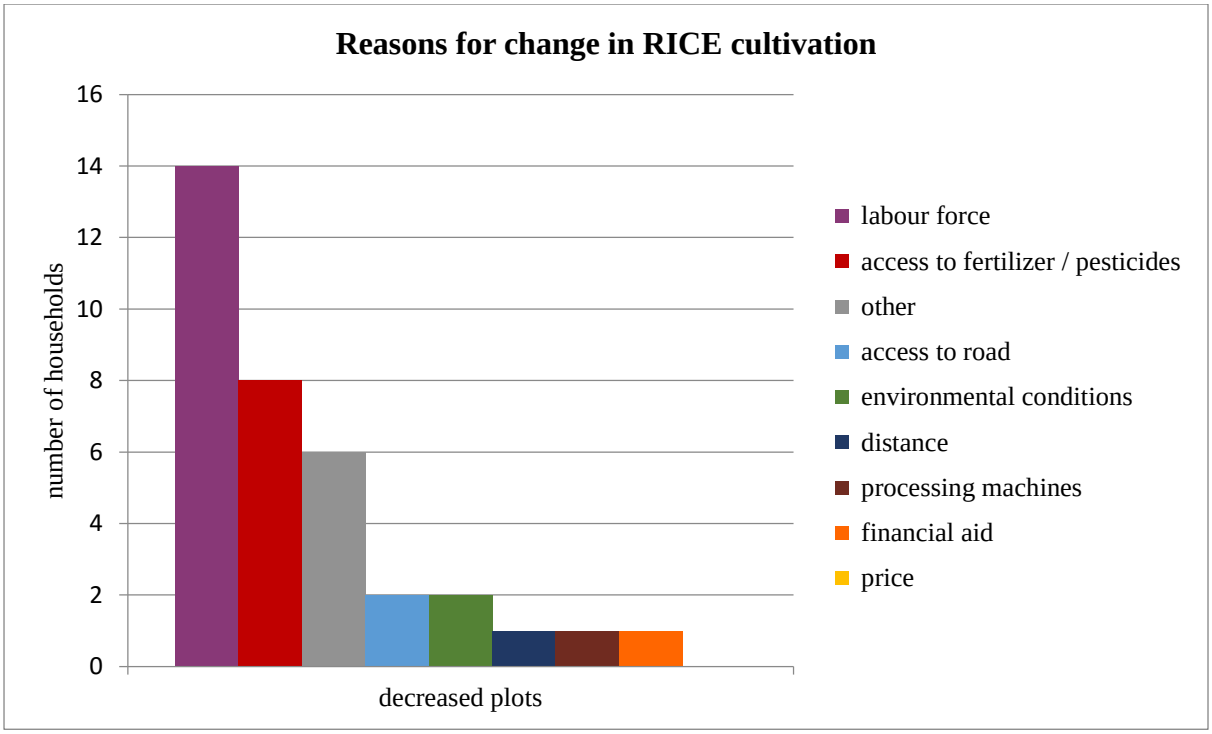

Figure 7: Reasons explaining the change in rice cultivation (n=19)

Rubber

All households who own rubber (19 out of 22), have either decreased their plots or left them unchanged. The question about change in yield per plot could not be answered easily, because no one has been tapping rubber for the last 4-5 years. The predominant reasons for farmers to not have increased rubber production are the price and the lack of labour force. Many respondents explain that they do not manage their rubber plots at the moment, but since the trees do not need special maintenance they can simply start tapping rubber again when the price goes up. The market price for rubber has significantly decreased since 2011; according to the price indications of the Malaysian Rubber Board (MRB), rubber has been traded for almost half of the price in 2019 compared to 2011 (Malaysian Rubber Board).

Pepper

Pepper cultivation has changed in both directions: 45% of the farmers decreased and 40% increased pepper cultivation (20 respondents grow pepper in total). Figure 8 shows different reasons, of why the farmers in Sebangkoi Undop increased or decreased their pepper cultivation.

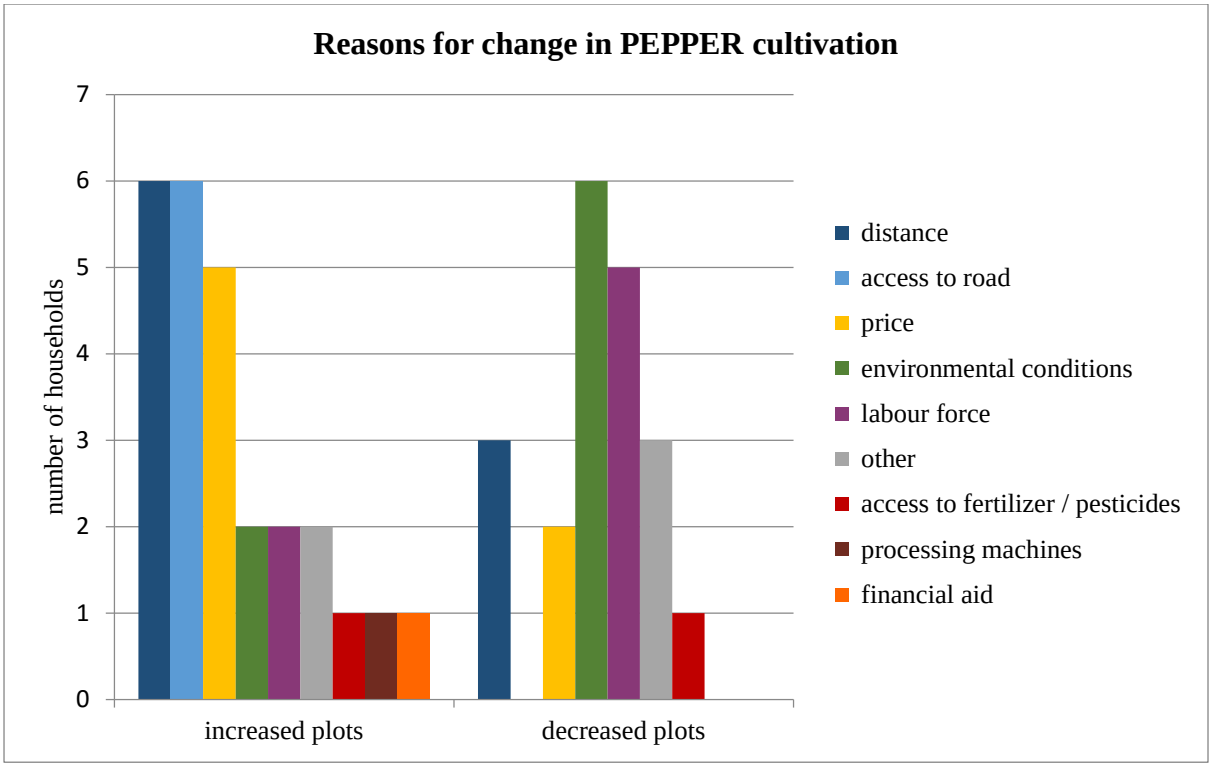

Figure 8: Reasons explaining the change in pepper cultivation (n=20)

Six respondents (out of 8 who increased pepper) say that the distance to the longhouse and the access to the road were reasons for them to increase pepper cultivation after moving away from the old longhouse. Interestingly, three farmers (out of 9 who decreased pepper) name the distance from the plots to the longhouse as a reason for decreasing their pepper cultivation.

Five farmers point out the price as a reason for them to having increased pepper cultivation. However price also seems to be a factor for decreasing pepper cultivation. Some farmers mentioned that they are not focusing much on pepper at the moment, because the price is quite low, but since pepper has a long shelf life they can maintain the plants and sell the pepper whenever they need money. The decrease in pepper cultivation due to price drop was observed also by Mertz & Wadley (2005). According to the Malaysian Pepper Board (MPB), the current pepper price in average is around 6,7 RM/kg for black pepper and around 12,7 RM/kg for white pepper (Malaysian Pepper Board). These prices have been confirmed by one respondent, who also remembered that in 2014/2015 the price for black pepper was around 32 RM/kg and for white pepper around 56 RM/kg.

Six farmers (out of 9) say that environmental conditions led them to decrease pepper. In connection to this especially the soil quality and pest infestations have been named by several farmers.

Also the lack of labour force caused a decrease of pepper cultivation for five farmers (out of 9). Mertz et al. (2005) points to the fact that labour migration can be a buffer in times of pepper price fluctuations, which might partly explain the connection between the decreasing plots and the lack of labour force.

Fruit orchards

Fruit orchards have been increased by half of the households, only two households decreased their fruit orchards (out of 16 who have fruit orchards). Six of the farmers kept their fruit orchards unchanged or are not sure about the actual size. Regarding the yield per plot, the respondents were not sure about the quantity they are harvesting. The leading reason for farmers to either increase or decrease their fruit orchards is the distance of the plots to the longhouse. It is interesting that so many households have increased their fruit orchards, even though we see an increased focus on cash crops in the community and fruits are mainly cultivated for own consumption. In fact, only two households are selling part of their fruits (out of 16), so commercialization does not seem to be a plausible explanation in this case.

Oil palm

Oil palm cultivation only started after moving away from the old longhouse. The reasons for planting oil palm now are: better access to the road, distance of the plots to the longhouse, access to fertilizer/pesticides and the price. According to Cramb (2007) small-scale oil palm cultivation in Sarawak accelerated during the 90's because of Government policies. However, according to our questionnaire the small-scale oil palm farmers in Sebangkoi Undop do not get any support from the Government for their oil palm cultivation, they have to come up for all inputs themselves. All of the small-scale oil palm farmers in the longhouse also own pepper and rubber as cash crops and rice and fruit orchards as subsistence crops, except for one farmer, who does not grow rice. Basically the small-scale

oil palm farmers in the longhouse live from their agricultural activities (i.e. cash crops); one household additionally gets remittance from family members working and living outside and one household has a family member working for SOP.

Figure 9 shows the major LUCs we have identified in Sebangkoi Undop during the last approximately 20 years. These are: the transition from forest to cultivated land and the other way around, the decrease in the cultivated rice area, the change pepper cultivated area and the opening up of small-scale oil palm plots.

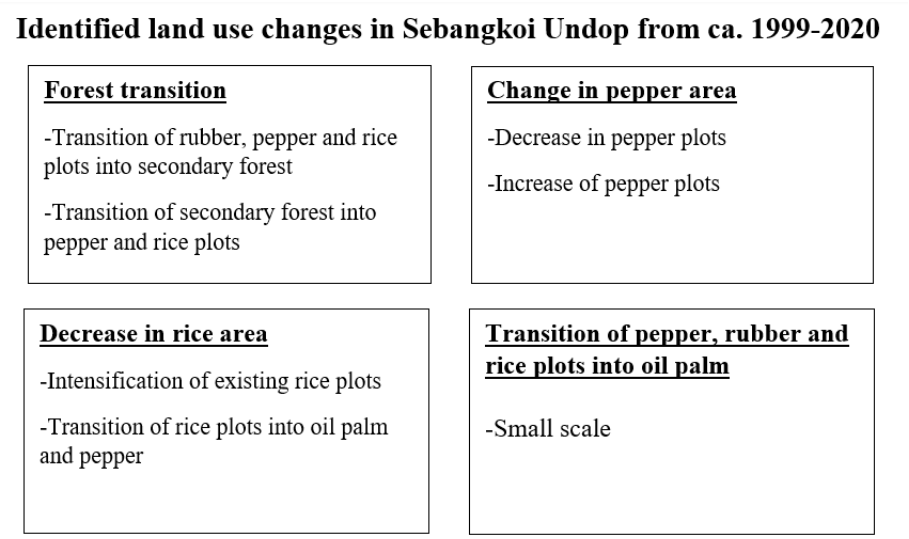

Figure 9: Summary of LUCs in the area of Sebangkoi Undop in the last 20 years approximately

4.2 Livelihood strategies

In this section, we seek to answer our research sub-question 2a and 2b. After giving an overview of the demographic composition of the longhouse and their culture, we explain more about their livelihood diversification. Other factors linked to livelihood and land use are explained by combining our data with secondary data, in specifically Government intervention and land ownership.

4.2.1 Out-migration

Sebangkoi Undop does not have many children and young persons living permanently in the longhouse, therefore we mainly interacted with people older than 45: 68 % of the respondents of the questionnaire are between 45-64 years old. An aging population is a common development among Iban longhouse communities according to Soda (2001).

Children in school age (especially from primary school to secondary school) come back to the longhouse during the weekends, but a lot of young adults move away permanently at least for some years. In fact 20 households out of 22 questioned have family members living outside of Sebangkoi Undop (in total 80 persons belonging to the 20 households). Figure 10 illustrates the reasons why these persons have moved away. According to the information gathered from the historical timeline, the outmigration of the youth increased since the longhouse community moved away from their old longhouse in 1999.

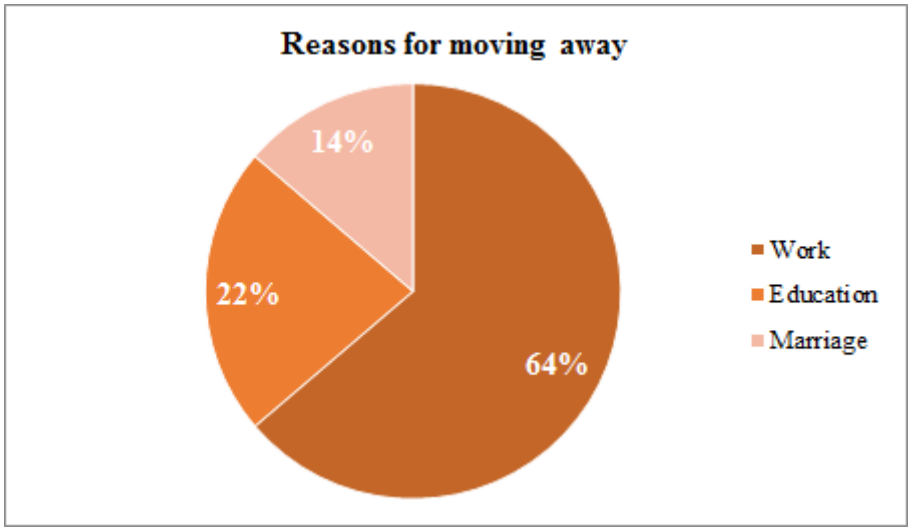

Figure10: Reasons for moving away from the longhouse

All participants in the SSI's confirmed that moving away from the longhouse is perceived positive in terms of education quality, income possibilities and opportunities for the future. Additionally, the Government promotes the importance of education in rural areas (Hansen and Mertz, 2006) and according to SSI4 an information officer came to Sebangkoi Undop regarding this matter (see figure 11).

> *"It is good that the they [referring to young people] move out because the farming system here is not that developed. They mostly move because of education and because they can work there [referring to cities]. The government gave a talk here in the longhouse about the importance of education… if young people have education they can work in the city instead of staying here"*

Figure 11: Quote from SSI 4

In general, the older generation encourages the youth to get an education and a job with a stable income, even though this means that agricultural activities in the longhouse might

decrease. Nevertheless the young person emphasizes during SSI2, that it is very important to him to continue cultivating and further develop the agricultural land which he will inherit from his father. Even if the young man, like many others of the same age, might move to the city for some years, he sees it as his duty to stay strongly connected to the longhouse community and to pass on the culture to his children. His dreams about the future can be read in figure 12.

"My dream is it to open a big plantation and become an agricultural entrepreneur because i have seen what is going on around here… I would be financially stable to live in the city and I could hire someone on the plantation, so I can go back and forth… I will just observe what has a good yield and price and that will motivate me to do more"

Figure 12: Quote from SSI2

An interesting point of contrast is the different generations' views on out-migration in connection to the land use. The young man in SSI2 said that he "must manage to return" to the longhouse when he gets older because he "felt obligated". At the same time the older man in SSI3 mentioned that there is no solid plan for the youth to continue the heritage. These different opinions gave us a more nuanced understanding of the dynamics of out-migration, which made us realize that out-migration is a complex factor for LUCs.

4.2.2 Culture

During the fieldwork we noticed that cultural beliefs, rituals and traditions play a crucial role in the life of the people in Sebangkoi Undop. The timeline underlines the importance of cultural beliefs in the community, as the reason why they moved away from the old longhouse was because that place became '*angat'*, which means that bad spirits were appearing there.

The practice of *berdurok* is a good example for a tradition interlinked with land use. It is a term in the Iban language to describe the reciprocal assistance, typically of neighbours and extended family members, during planting and harvest season. 50% of the respondents of the questionnaire confirmed that they are still practicing '*berdurok'*. During planting and harvest season they work together the whole day and rotate on each other's fields, including fields in Indonesia which belong to relatives who live on the other side of the border. From SSI3 we found out that in the past '*berdurok'* was an essential element of farming and usually up to 50-60 people participated. Even though nowadays this labour exchange is practiced in a much

smaller extent, it still helps to overcome the lack of labour force experienced within the single households.

During the same interview we also learned that several rituals which were habitually performed in the past, have not been passed on to the next generations and got lost. One example worth to mention is the *miring*. It is ritual which used to be followed when the farmers opened up a new land area for crop cultivation (see description in figure 13).

"Before opening a new plot, the longhouse community came together to perform the ritual. First we started a fire and waited for some time, then we began to plant the seedlings in the new plot… sometimes it could take up to 24 hours until we finished planting the whole plot. During this whole time the fire had to stay on stable… if the fire burned out, it was a sign that the chosen land is not suitable… in this case we left the plot and didn't plant anything there. Nowadays, we simply clear the new land by burning the forest in the specific area and then we apply herbicides"

Figure13: Quote from SSI 3

Although during our observations some persons mentioned, that nowadays almost none knows how to do handicraft out of forest products, e.g. rattan and bamboo, the questionnaire shows that 8 out of 22 households are still making handicrafts. This is an interesting contrast in the statements about transfer of knowledge inside the community. During the observations, we also noticed that some people have a large knowledge about medicinal and food plants growing wild in the surrounding area. This further indicates that some knowledge is being lost, while other knowledge is well preserved.

4.2.3 Livelihood diversification

Studies such as Soda (2001) point to the trend in increasing income diversification among Iban longhouses, and according to Mertz et al. (2005), income diversification is a common phenomenon which affects land use. The following figure, based on the answers from the questionnaire, shows the livelihood activities practiced in the longhouse community and the purpose of those activities for the people.

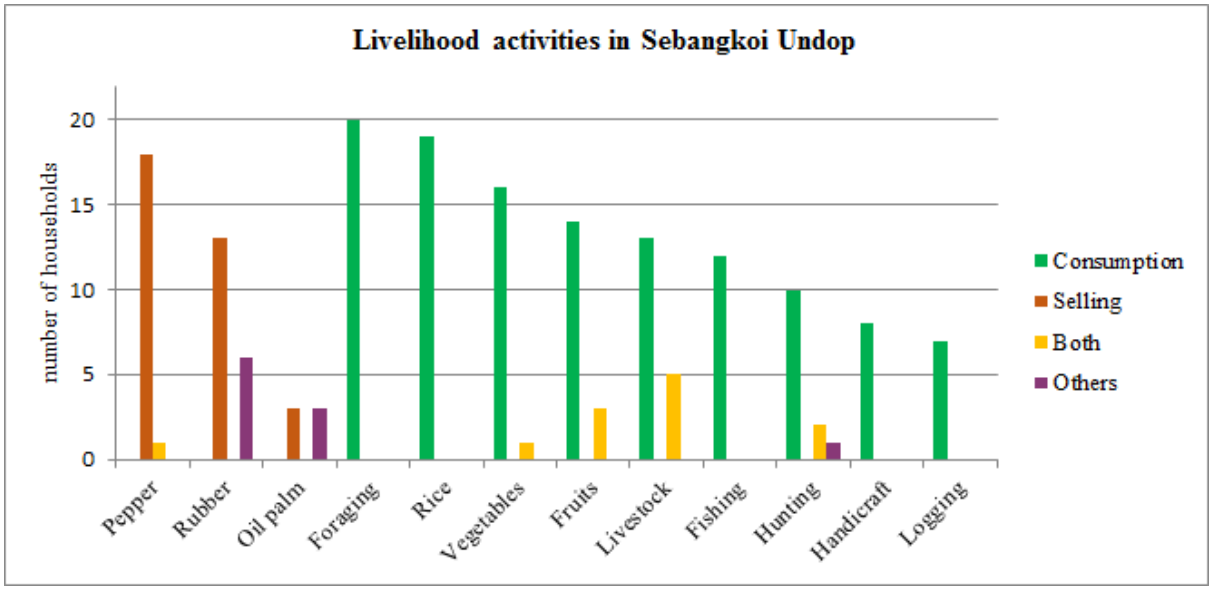

Figure 14: Livelihood activities in Sebangkoi Undop listed according to their importance for people's income and own consumption

Pepper, rubber and oil palm are seen as cash crops, since all people who cultivate those crops do it for selling purpose and not for own consumption. There are only two households (out of 22) who do not grow any cash crops. One of these households used to grow pepper and rubber, but does not do it anymore. These two households do not even grow rice and basically only live from growing fruits and vegetables and from collecting forest products. One of these two households additionally has some livestock and gets remittance from family members. The livelihood strategies of these two households are very particular and outstanding compared to the rest of the longhouse.

When looking at figure 14, the purpose of cultivating rubber is not shown exclusively for 'selling' because of some misunderstandings during the questionnaire. Since none of the respondents is tapping rubber at the moment, some interviewers crossed 'others', in the sense that currently the farmers are not selling. 19 households stated that they own rubber plots.

Regarding livelihood activities practiced for own consumption and consequently contributing directly to food security for the longhouse community, foraging and rice cultivation seem to be crucial. In fact these activities are practiced respectively by 20 and 19 households out of 22. Eighteen households (out of 22) are livestock owners, they primarily have chickens, cocks and pigs. This underlines how strongly connected the population in the longhouse is to their surrounding natural environment and to their traditional diets.

We are aware that there might be more livelihood activities practiced by some households in the longhouse, which we have not included in our analysis. For example we observed that one woman produced her own ‘tuak’ (rice wine) and sold part of it.

In terms of income from livelihood activities, it appears that in the preference ranking the women as well as the men consider pepper as the most important income source.

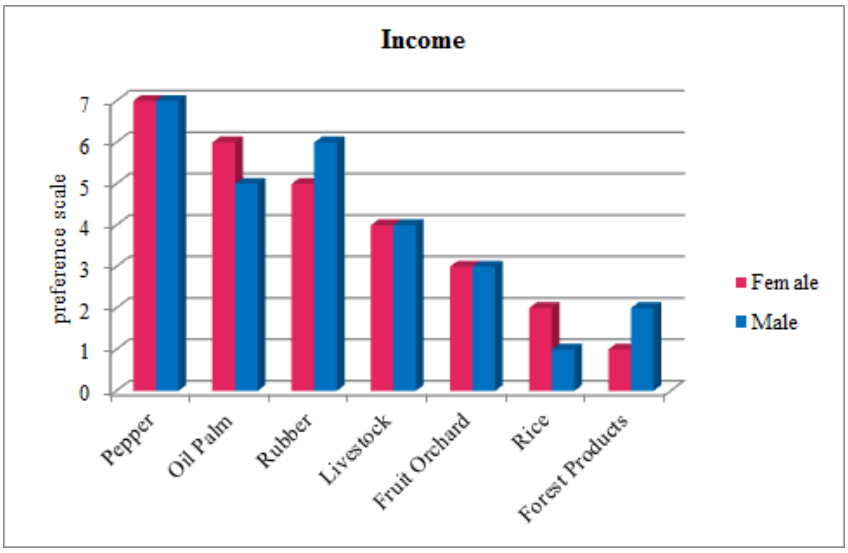

Figure 15: Outcome of the preference ranking for income from agricultural activities, listed according to the female group and compared to the male group

Figure 15 shows the result of the preference ranking of the female and the male group, where seven indicates the most important and one indicates the least important. Oil palm is ranked high, but especially the men underline that even though the earnings are high, the costs for planting and managing small-scale oil palm are considerable. That is also the reason why not more households start with oil palm. Rubber is ranked as the second and third most important income source respectively, which highlights how relevant this crop is for the local population despite the currently low price. Here we see once more that rubber is kept in standby with the hope that the price will go up and tapping becomes profitable again. Rice and forest products are not playing a big role in terms of income (as also seen in figure 14).

In general the people in Sebangkoi Undop see agriculture as their main activity, but many of them point out that the income from agriculture alone is not sufficient. 41 % of the households get remittance from family members working and living outside of the longhouse. The same percentage of households earns money from other employments, with at least one household member working for SOP. The increased monetization we observe is part of a larger trend in the Sarawak uplands (Cramb 2007).

Joint-venture companies (JVC) such as the SOP were invented during the 90's (Mertz et al. 2013). During the interviews we gathered more information on how SOP is influencing the life in the longhouse. It turns out that the salary from SOP has become the most important income source, after the pepper price went down (seen in general across the longhouse). Furthermore, the longhouse community has leased some land to the company for 60 years and should get dividends out of that. The 60 year lease on NCR land and the dividends are numbers established by the governmental Land Consolidation and Development Agency (ibid). According to the TR and the counsellor, the dividends are distributed as follows: 30% for the customary landholder, 60% for the company (SOP) and 10% for the Government. This information is confirmed by Mertz et al. (2013). Apparently the longhouse chose land for the joint venture, which had not been actively used by the farmers anyways.

During SSI1 the woman gave us some insight about working in the SOP plantation (see figure 16).

"*In the past we were paid 500 RM per month, now it is 800 RM/month… but it depends on the month, because if you do not go to work for one day, you will not be paid for that day. When we sell our crops from the farm we need to wait a certain period of time until we can harvest and sell again... this is different from working with SOP, there we get a monthly income. Additionally, if you reach a certain amount of days in the year SOP will give you bonus in the end of the year… sometimes 300 RM… but i never got it because we also have to manage the 'padi' [rice] fields on our farm and so sometimes I have to stop working at SOP, especially for planting and harvesting seasons*."

Figure 16: Quotes from SSI 1

4.2.4 External inputs

The questionnaire helped us to further investigate how the people use external inputs in farming the land. It results that half of the households does not have any special machinery for their agricultural activities, cultivating and processing the crops is done by manual work. This is presumably related to the topography of the area.

What is clearly influencing the work on the agricultural fields over the past years, is the use of fertilizer and pesticides. All farmers apply fertilizer and pesticides on their rice and pepper fields. The farmers who have oil palm, use fertilizer and pesticides for that. Also for fruit orchards the use of fertilizer and pesticides is very high: 88 % of people who plant fruit

orchards use fertilizer and 53 % use pesticides. This indicates that Sebangkoi Undop is following a general livelihood strategy of intensifying the agricultural land by applying fertilizer and pesticides described in Rasmussen et al. (2016).

4.3 Institutional processes

4.3.1 Government intervention

The counsellor underlines that the communication with public institutions has become better since moving to the current Sebangkoi longhouse, due to better road access and electrical power supply. In fact, 64 % of the households confirm in the questionnaire that they get some kind of subsidy / governmental aid. The type of support, people in Sebangkoi Undop receive from the Government, is explained more in detail in figure 17.

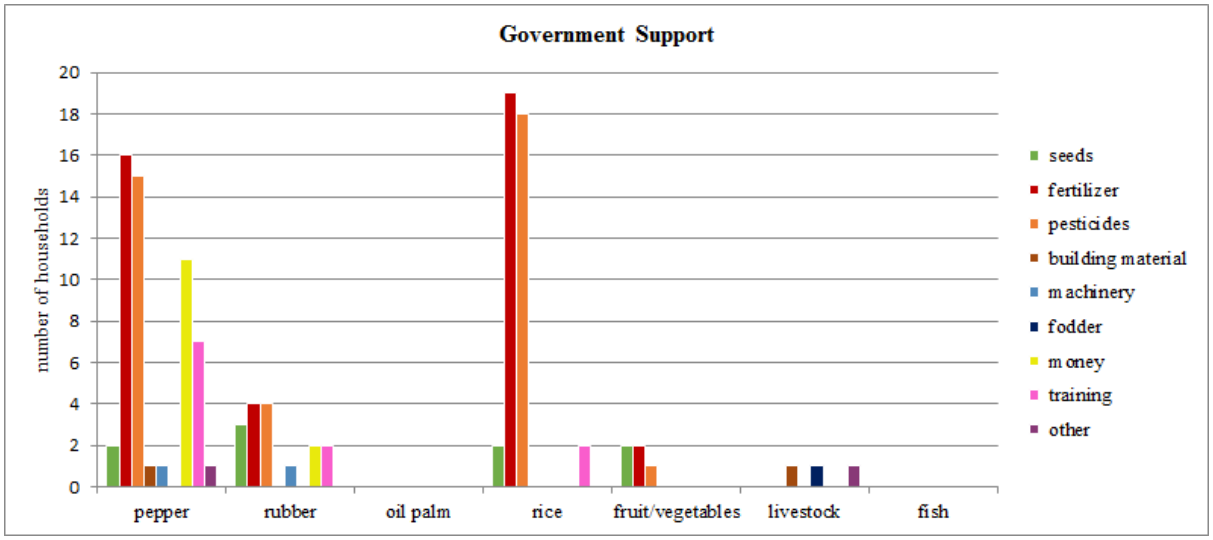

Figure 17: Type of Government support for the different agricultural activities

It appears that the Government supports primarily pepper and rice. Most notably the farmers receive fertilizer and pesticides; for pepper also money. In 1972 the Pepper Subsidy Scheme encouraged pepper cultivation in Sarawak (Cramb 2007), and according to Tanaka et al. (2009) the Agricultural Department has continued to strengthen the commercialization in rural areas through different subsidy schemes since then. One farmer explained that the agricultural department had advised them to grow pepper and rubber. This shows how the government is influencing the farmer's choice of agricultural activities.

The support for rubber has to be interpreted with caution, since the farmers explain that they got Government support, in form of fertilizer, pesticides, and seeds, during the first three years of planting rubber, but currently they are not getting any support. When the Rubber

Planting Scheme started in 1956, government policies have encouraged the use of hill land for rubber even though primary forest had to be cut down (Cramb 2007).

Households with oil palm or fish ponds do not get any support for these activities, which might explain to some extent that not more households own it. Two households get governmental aid for growing fruit/vegetables, unfortunately we did not follow up on the type of fruit/vegetables which are subsidised. Regarding the support for livestock, several households stated that they applied for subsidies but did not hear back yet.

When asking for special guidelines which the farmers might have to follow in order to get any support, only four households out of 22 were not aware of any rules and regulations. During SSI3 and SSI4 some rules have been described more in detail. For example, the farmers have to state the size of their rice plots on the application form and then an inspector from the agricultural department will come to verify; only afterwards the farmers get confirmation/rejection for Governmental support. In the case of pepper, the MPB is in charge of regulations and monitoring, i.e. the farmers must have a minimum of 200 vines in order to be eligible for support. From these examples we can see that the government also influences the amount of land which is used for each type of crop.

4.3.2 Land rights

According to the FAO, land tenure is crucial for rural households to stabilize their resources and to define their livelihood strategies. Together with labour, land rights are the most important aspects for rural households to guarantee food security from planting subsistence crops and to produce income from planting cash crops. Furthermore, land rights do not only play a role in an economic perspective but also on a social and cultural basis. In order to get out positive results of policy intervention in land tenure, the policies should build on correct information and on the ability to adapt to varying circumstances (Studies, 2002).

In the case of Sebangkoi Undop, only five households confirm that they have land titles for their own land, the rest of the respondents in the questionnaire refers to NCR. The Government is promoting land registration and according to the counselor, the Government even promised land titles to those households, who lease their land to SOP, which might have increased the willingness to accept the joint-venture.

From the information during SSI4 it appears that up until now there were no problems regarding the land division in Sebangkoi Undop. But it is mainly the older generation who knows exactly which land belongs to each household and since less and less young people

continue cultivating land, there might arise issues in the near future. Therefore the interviewee underlines that it is important to get land titles. This gives the future generations more security but also more flexibility, in the sense that once the land is registered it does not have to be necessarily cultivated and it could even be sold. Some interesting points from SSI4 are also reported in figure 18.

"I think that people will abandon their plots if they get land titles, because then it is officially theirs, no matter what... so maybe they do not plant anything there"

"We are encouraged to keep cultivating our plots [read: because of NRC]... for the plots near to the longhouse is no problem, but we are worried about the land which is far from us because we do not plant anything there… We are worried that the new generation does not know the land and that other people can take the land because it is not marked"

"*It is important to have registered land, so it is official on the papers and future generations can claim that land… this also causes less issues within the family."*

Figure 18: Quotes from SSI4

4.4 Environmental factors

In this section, we seek to answer our research sub-question 2c. The perception of several farmers in Sebangkoi Undop is that some environmental conditions have become worse since moving away from the old longhouse, i.e. more crop diseases, worse soil quality, more muddy rivers. We tried to follow up on some aspects of these perceptions through analysing our soil and water samples.

According to 64% of the respondents from the questionnaire, crop diseases and pest infestation have increased since moving away from the old longhouse. In the preference ranking the participants were asked to explain which agricultural activity suffers the most from diseases. Rice and pepper have been ranked as the most vulnerable crops to infections.

4.4.1 Soil

In the questionnaire, 73 % of respondents state that the soil quality has become worse since moving away from the old longhouse (see figure 19).

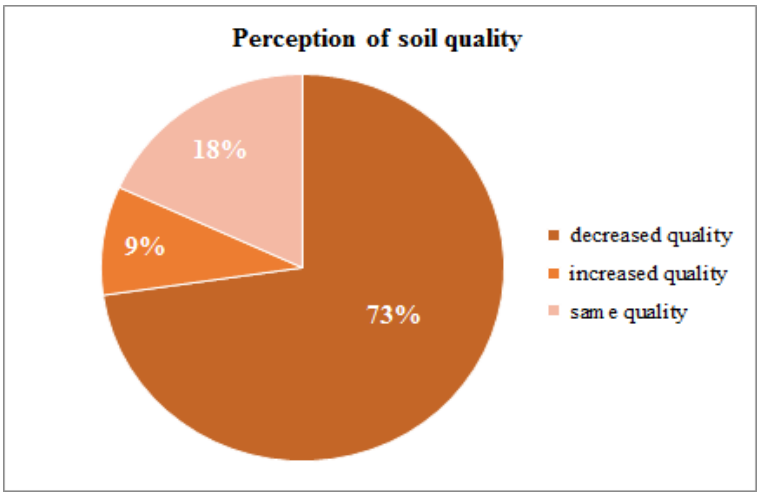

Figure 19: The respondent's perception of the soil quality since moving away from the old longhouse

We investigated this perception by collecting soil samples from target plots for testing. The purpose of collecting soil samples for analyses was to determine the effects of the interaction between land use changes and the environment on the soil properties of target plots. We were able to test for one variable, the hydronium ion concentration (pH). Therefore our analysis is based on this variable. See the measurement results in table 1.

Sampling Area	pH Readings		Average pH Reading
	1st reading	2nd reading	
Secondary Forest	3.63	4.31	3.97
Pepper plantation (near Sebangkoi river)	4.56	5.25	4.91
Rice Field on a hill overlooking the river	3.80	3.83	3.82
Fruit Orchard	3.83	3.67	3.75
Oil Palm Plantation	3.72	3.61	3.67
Rubber Stand	3.71	3.80	3.76

Table 1: pH readings, 4th March 2020

In addition the pH values of some of the plots were not significantly different from the pH of the secondary forest. The discoloration of leaves in mature pepper vines were significantly higher for pepper plots on the slopes than on flat lowlands, this could be caused by higher nutrient loss from rain water that flows down the slopes. The pale yellow discoloration could indicate magnesium deficiency (Ravindran 2000). The collection of samples at different depths and determination of the pH from the average of two tests, increased the accuracy of our data.

Some metals like Iron (Fe), Zinc (Zn), and Manganese (Mn) are essential in low concentrations. Other metals like Lead (Pb), Chromium (Cr), Arsenic (As), and Cadmium (Cd) are toxic to living organisms, including humans. The heavy metals, that are found in agricultural plots, are introduced when fertilizers are applied (Singh et al 2019). Our questionnaires revealed that the use of fertilizers and pesticides is high. Also, the farmers in the longhouse believe that pepper, rice and fruit orchards are vulnerable to pests. "Among soil properties, soil pH was found to play the most important role in determining metal movement, and eventual bioavailability to plants due to its strong effects on solubility of metals in the soil solution" (Zeng Fanrong et al 2011).

Studies show that there is a negative correlation between the presence of heavy metals in rice grains and soil pH. As the pH value decreases, heavy metal concentration increases (Zeng Fanrong et al 2011). Our pH data show low values for the secondary forest and cultivated plots, thereby increasing the likelihood of heavy metals transfer into humans through the food chain. Elements in the soil, including heavy metals could cause health challenges. This could affect the labor available for livelihood activities in the long house. In addition to the pH, the movement of heavy metals from the roots of the rice plant to the grains are dependent on other variables like soil organic matter. We were unable to determine the organic matter content of our soils because of coronavirus related lockdown.

4.4.2 Water

According to one small-scale farmer, the water was polluted by pesticides from the large-scale plantation. Other farmers mentioned that when it rains the water becomes dirty because of erosion from the plantation. We tried to investigate this perception by collecting water samples from target plots for testing.

Location	Phosphorus	Ammonia (mg/L)	DO (%)	DO (mg/L)	Salinity (ppt)	TDS (mg/L)
Gravity feed	0.26	0.21	76.83	6.37	0.00	10.33
Oil-palm	0.16	0.16	87.33	7.11	0.01	15.00
Fishpond	0.15	0.16	56.5	4.36	0.01	15.00
Mixed crops	0.22	0.19	77.5	6.24	0.01	13.00

Table 2: Chemical parameters

Location	Turbidity	pH	Temp (°C)	Conductivity	Total Suspended Solids (mg/L)
Gravity feed	1.0	9.00	24.83	0.016	28
Oil-palm	13.0	8.90	25.80	0.023	40
Fishpond	15.5	8.26	29.00	0.025	195
Mixed crops	9.0	8.40	29.30	0.021	65

Table 3: Physical Parameters

Land use changes affect soil quality which in turn affect the quality of the water in the vicinity of farmlands. Land use changes are driven by livelihood pursuits. As our questionnaire shows, the decision regarding the crops that are cultivated by the longhouse residents are in part influenced by the price. Measures to maximize yields from cultivated plots often require inputs like fertilizers and pesticides. These necessary products can also damage surrounding ecosystems when they are applied indiscriminately. Considering that environmental remediation of damaged ecosystems can be costly, careful use of these products will slow down the rate of pollution. Phosphorus pollutes natural water as runoff from farms that use phosphate fertilizers. Excessive amounts of nutrients in water including phosphorus, can cause algae to grow, when the algae die, they are decomposed by bacteria which uses the dissolved oxygen (DO) present in the water, this results in eutrophication, a type of water pollution (Best 1999). Severe eutrophication results in fish dies and disruption of the food web. The level of phosphorus is an indicator of the extent of eutrophication in freshwater rivers because it occurs in the least amount relative to the needs of plants. The maximum amount of phosphorus in streams or rivers that do not flow directly into reservoirs should be 0.1 mg/L (Mueller and Helsel 1999). The level of phosphorus in the water from our sites show figures that are above this threshold. The gravity feed contains the highest amount while the fishpond contains the least amount. Our DO data show that the oil palm site

contains the highest amount of DO, this was related to the larger water volume in the sampling area, while the fish pond contains the least. Several factors can affect the amount of DO in a water sample. These factors include: The velocity and the volume of the water: The higher the velocity of water flowing through rocks and stones, the higher the amount of dissolved oxygen. The season: The amount of dissolved oxygen in a location is usually higher in colder weather than in warm weather. The altitude: The higher atmospheric pressure at low altitudes makes oxygen to be more easily dissolved at this altitude than at high altitude. Dissolved solids: There is more dissolved oxygen in water with low levels of dissolved solids, accordingly, freshwater has more dissolved oxygen than sea water. Organic wastes: Higher amounts of organic wastes lead to lower amounts of dissolved oxygen.

Nitrogen is present in water as nitrite or nitrate ions (NO_2^- and NO_3^-), and as the ammonium cation (NH_4^+). The nitrogen content was determined by measuring the amount of ammonia present in a sample, the use of synthetic fertilizers containing ammonia affects the amount of nitrogen present in natural water (Mueller and Helsel 1999)

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$$

The form of ammonia present will depend on the pH of the sample, an increase in the pH will lead to a decrease in H^+ concentration, and an increase in OH^- concentration. This will shift the equation to the left, thereby increasing the amount of aqueous NH_3. When the pH is below 8.75, NH_4^+ predominates. At pH 9.24, half of NH_3 is transformed into NH_4^+. Above 9.75 NH_3 predominates (Hem 1985). Ammonia is more toxic to living organisms in water than the ammonium ion. Ammonia was not predominant at the sites we sampled because the highest pH value that we got was 9.00. The limitation of the analyses is that it does not report total dissolved nitrogen.

An increase in the turbidity (cloudiness) of water could be related to the death and decay of aquatic plants, which reduces the amount of dissolved oxygen present. (Khan and Ansari 2005). High amounts of suspended solids in the water can reduce the rate of photosynthesis of the plants that grow in the water, thereby increasing the prospect of eutrophication.

Besides the chemical and physical analysis of the water, we also applied the miniSASS method in two stations. Table 4 shows the overall results, which we analysed according to the guideline on minisass.org (figure 20).

Ecological category (Condition)		River Category	
		Sandy Type	Rocky Type
	NATURAL CONDITION (Unchanged/untouched – Blue)	> 6.9	> 7.2
	GOOD CONDITION (Few modifications – Green)	5.9 to 6.8	6.2 to 7.2
	FAIR CONDITION (Some modifications – Orange)	5.4 to 5.8	5.7 to 6.1
	POOR CONDITION (Lots of modifications – Red)	4.8 to 5.3	5.3 to 5.6
	VERY POOR CONDITION (Critically modified – Purple)	< 4.8	< 5.3

Figure 20: Guideline to interpret the average score into ecological categories (source www.minisass.org)

Groups	Sensitivity score	Sample site 1 (Undop river)	Sample site 2 (water intake)
Flat worms	3		
Worms	2	●	●
Leeches	2		
Crabs or shrimps	6	●	●
Stoneflies	17	●	
Minnow mayflies	5		
Other mayflies	11	●	
Damselflies	4		
Dragonflies	6	●	
Bugs or beeties	5	●	●
Caddisflies	9	●	●
True flies	2	●	
Snails	4	●	
Total score		62	22
Number of groups		9	4
Average score		**6,89 (good condition)**	**5,5 (fair condition)**

Table 4: miniSASS results

It is surprising that sample site 2 (gravity feed) has poor conditions since the location is in the middle of a secondary forest area and we would have expected to find a higher score. One reason for this outcome could be that the miniSASS was not conducted in the flowing river, but on the edge of the rather static water pond where naturally less invertebrates can be found. Furthermore, we did not spend as much time on the 2nd location as in the 1st, we were a lot more people sampling at the 1st location and we did not have the same tools. Therefore the result from the gravity feed turns out to not be very reliable.

5. Discussion

In this section, we seek to answer our research sub-question 3 by connecting our findings to the two frameworks introduced in the beginning.

5.1 Causes and drivers of LUC

In the previous analysis of our findings we have identified the factors interacting with LUC and how they interact. The following figure is inspired by the framework in Geist & Lambin (2002). It gives an overview of the proximate causes and underlying factors of LUCs in the area surrounding Sebangkoi Undop over the last approximately 20 years:

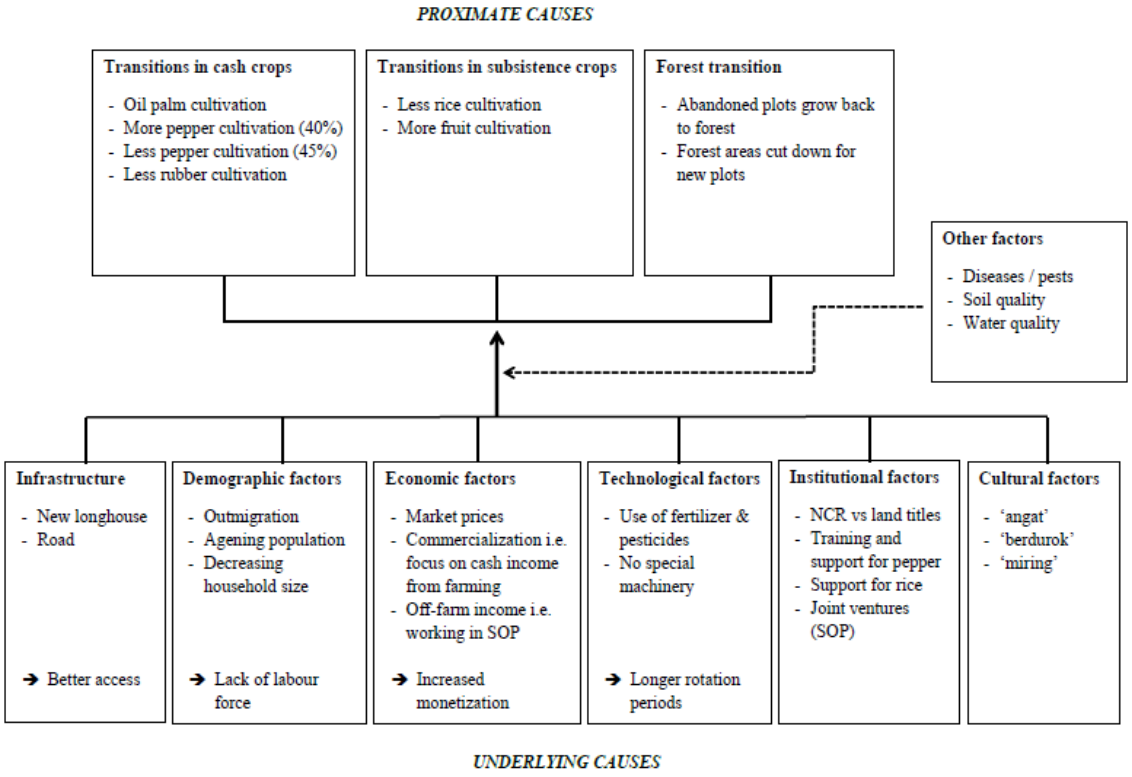

Figure21x: The top row shows three clusters of proximate causes (the ones that directly affect the land), in the middle are environmental factors, which play a role but can neither be categorized as proximate causes nor underlying drivers, and the bottom six boxes show clusters of underlying drivers (which underpin the proximate causes).

The proximate causes are primarily identified through the data from our questionnaire and the transect walks, whereas the underlying causes are identified through a variety of methods, including the SSI's, participatory observations, the timeline and the rankings.

The figure summarizes all proximate causes and underlying drivers, but it does not illustrate the relationships between the factors. It is important to mention this distinction, since it is not only the factors themselves, but also their interaction with each other that leads to LUC. In order to make this distinction we have made a causal chain for each of the four identified major LUCs. Here we show an example of the causal chain for the LUC 'decrease in rice area' (the causal chains for three other major LUCs can be found in the appendix):

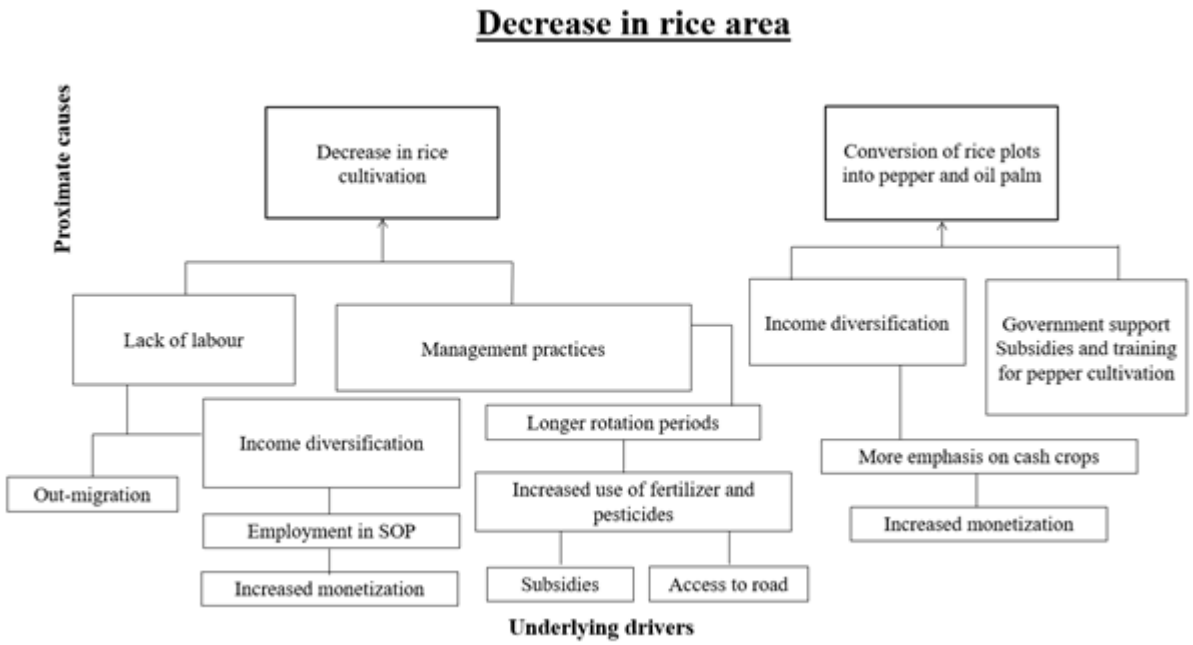

Figure 22: The two top boxes show the proximate causes for a decrease in the rice area, and in the remaining boxes the underlying drivers are listed.

This causal chain shows how different factors through their interactions lead to a decrease in the rice cultivation in the area surrounding Sebangkoi Undop. We have identified two proximate causes for the decrease: therefore it is two causal chains leading to this LUC. The causal chains should be understood in the way that the most distal box is the start of the development towards decreasing rice cultivation. For example, in the chain to the right, 'increased monetization' underpins the increased emphasis on cash crops, which then leads to income diversification within the longhouse. The income diversification along with the Government support for pepper cultivation then leads to the proximate cause, that the farmers are converting from rice as a subsistence crop to cash crops.

5.2 Livelihood strategies and LUC

The focus of this study has been on livelihood strategies and LUC. Therefore we further discuss how each of the livelihood strategies mentioned by Scoones (2015) can be linked with LUCs and how our findings can contribute to this academic debate.

First, we will relate to the debate on how agricultural intensification and can lead to a LUC by sparing land. Hansen (2005) claim in her paper that smallholder agriculture of Sarawak has been increasingly intensified over the last 30 years as shifting cultivation has been replaced with perennial cash crops on permanent fields. Our study confirms this claim as we have found indicators that the agricultural land in Sebangkoi Undop has been intensified in parts.

Rudel et al. (2009) argues that the link is determined by the elasticity of the crop demand. In case of an elastic demand for a crop, increased yields would cause prices to drop and agricultural land to decrease. Although some of former rubber and pepper plots have transitioned into secondary forest in our study area, this mechanism is probably not explanatory, as both rubber and pepper have a relatively long shelf life (rubber by not tapping the trees), hence the farmers have the possibility of sell their crops when demand and prices goes up. However, it can explain the transition of rice plots into secondary forest, as the demand for rice as subsistence crop has decreased, due to the decrease in household sizes and the increased input of fertilizer and pesticides.

Rudel et al. (2009) furthermore argues that over time, farmers accumulate knowledge about their place, and therefore limit their agricultural production to the more fertile land. However, our findings are completely contradicting to this argument. We have found that the land near to the old longhouse, where the soil quality is presumed to be better, has transitioned into secondary forest. The main reason for this is the distance to the plots. We would therefore argue that, not only the farmers perception on land fertility, but also the increased labour input from walking the extra distances can be significant in the decision of which land to cultivate. This point can be emphasised by the fact that new land has been cleared for cultivation near the ‘new’ longhouse (see figure forest transition).

Another reason for cultivating less land could be that many households in Sebangkoi Undop have a diverse portfolio of livelihood activities, including some off-farm activities. Especially the off-farm work on the SOP plantation seems to influence the amount of cultivated land by the household and has created an option for the households to further diversify their livelihood by leasing land to the joint venture. We would therefore argue that

livelihood diversification could influence the LUC and the LUC in some case can affect livelihood diversification. Birch-Thomsen and Reenberg (2014) have argued that livelihood diversification can be important for LUC, because it gives the population more stability (in terms of income) and at the same time they can continue to cultivate some crops in the traditional way.

Rural out-migration has been claimed as determinant factor influencing the rural area by many scholars e.g Soda (2001), Lambin and Meyfroidt (2011). Lambin and Meyfroidt (2011) argue that out-migration from rural areas decreases the labour force. However they add that out-migration rarely causes land abandonment, instead it leads more to extensification. Our finds support this claim to some degree. We did find that out-migration leads to loss of labour force, but in our case several households mentioned that this lack of labour force induces them to declining certain crop cultivation. Therefore, in our case out-migration could be an indicator of land abandonment. However, we have to clarify that in an agricultural system like the one in Sebangkoi Undop, it is hard to determine if land has really be abandoned or if it has rather be left fallow, which is quite common in the area. It would be interesting to do a follow up study in 10 years, to see if the presumably 'abandoned' land areas are cultivated again or if they are definitely abandoned as a consequence of the intensification, the livelihood diversification and the out-migration.

We found that the livelihood strategies are linked to the LUCs to some extent, according to the literature. However, on the basis of our study, we argue that these strategies should be combined to further research on rural LUC, as the linkage between the two concepts can be quite significant in a rural setting like Kampung Sebangkoi Undop.

6. Conclusion

We were able to detect some interesting linkages from the data collected in Sebangkoi Undop about the interaction between land use change and livelihood strategies. According to the LUC framework we divided the factors into proximate and underlying causes.

The major LUCs identified were the transition from forest to crop land and the other way around, the decrease in rice cultivation area, the change in pepper cultivation area and the opening up of small-scale oil palm plots. The predominant underlying causes identified were the better access due to moving to the new longhouse, the lack of labour force, the increased monetization and the change in cultivation strategies, i.e. more use of fertilizer and pesticides. These factors are all interlinked and tightly connected to further underlying causes, such as increased out-migration of the youth, persistent traditions, focus on cash crops, off-farm income from SOP and Government interventions on rice and pepper.

In terms of environmental factors correlated to LUC, people in in Sebangkoi Undop notice degradation compared to the conditions at their old longhouse, i.e. for crop diseases, soil and water quality. Due to measurement and analysis issues it is not possible to make any concrete statement regarding the soil and water quality in the area. However, we detected that the soil has low pH values which influences the interaction of fertilizer with the crops. In terms of the water, the pH values show that we do not have ammonia pollution in any of the sampling sites.

In general, our findings about LUCs and livelihood strategies in Sebangkoi Undop coincide to a large extent with the general trend in the area described in the literature. Nevertheless, to make any significant conclusions in a broader perspective, our data is too small and more research is needed.

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Appendix

Appendix 1: Final synopsis

University of Copenhagen Faculty of Science

Interdisciplinary Land Use and Natural Resource Management

Field Work synopsis

Location: Sebangkoi Ulu Undop, Sarawak, Malaysia

Group members:

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February 2020

Introduction

The development and intensification of smallholder agriculture has been discussed by scholars of different disciplines such as economy, political ecology and geography. Esther Boserup (1965) argued in her book "The Conditions of Agricultural Growth" against the ideas of Malthus (1798), claiming that instead of causing famine and scarcity, population growth would drive agricultural intensification at the expense of increased labour input per yield. However, this rigid view on agricultural intensification has been criticised by scholars such as Brookfield (2001), who claims that population pressure is only one part of the story of intensification. Organisational skills and diversification of production, livelihood opportunities and investments within social, demographic and environmental contexts are equally important for agricultural intensification.

Crumb (2007) claims that over the past century and a half the agricultural practices in the Southeast-Asian uplands have undergone a transformation. The transformation is driven by the introduction of new agricultural crops and technologies impacting the livelihood of small-scale societies. It took place in a context of population growth, migration and extension of global markets into rural hinterlands that were once secluded, leading to intensification and agricultural commercialization. Tanaka et al. (2009) and Hansen & Mertz (2006) have studied the agricultural development in Sarawak, Malaysia, focusing on the soil fertility under commercial crops and policy implications on shifting cultivation respectively. Tanaka et al. (2009), like Crumb (2007), connects the agricultural development of Sarawak to an increased commercialization, claiming that the rising need for cash income in a monetary economy has enhanced the importance of cash crop farming. The transformation from traditional shifting cultivation, characterized by low external input, toward long term farming practise with a higher input demand, could influence the upland agricultural system. Hansen & Mertz (2006) claim that this transition has been pushed by various policies, including a ban on open burning, by promoting joint venture agreements between private companies, villages and the state government, and by the extension of services such as road infrastructures. However, at the same time subsidized fertilizer is being provided for hill rice farming (Hansen & Mertz, 2006).

Stone (2001) argues that, the Boserupian assumptions on the cost and benefit trade-off borne by the farmer for intensification, neglect the possibilities for external subsidies, such as government provided fertilizer, which could raise the production without further costs for the individual farmer.

Our study will be focus on some of these scholar's debates as we will investigate the dichotomy of intensification of agriculture and the decreasing labour force in our study site interesting. The study will be based on fieldwork in the longhouse in Sebangkoi Ulu Undop, Sarawak, Malaysia. The longhouse consists of 23 *bileks* (apartments), of which 20 are in a longhouse and 3 are individual houses. It is located around 5 km away from the border to Indonesian Borneo, 40 km away from Sri Aman town and a couple of hours walk from a primary forest. The longhouse was built in 2012 and has access to a tar sealed road since 2017. The inhabitants of the longhouse cultivate hill rice as their main subsistence and they are cultivating rubber, pepper and oil palm. Traditionally they practiced shifting cultivation, but with the introduction of fertilizers, they now utilize the same plots up to 6 years. The younger people of the longhouse tend to move to Kuching or other urban areas for work, therefore the Sebangkoi Ulu Undop longhouse is primarily inhabited by older generations.

During our fieldwork we are trying to understand the role of external agricultural inputs, such as fertilizer, as an interface which links the Ibans of Sebangkoi Ulu Undop to the global market. This leads to the following research question:

How is the introduction of external inputs affecting the labour inputs on agriculture, the livelihoods of small-scale farmers and the physical environment in Sebangkoi Ulu Undop, Sarawak, Malaysia?

Further, we will examine the following sub questions:

- Which institutions and regulations affect the use of external inputs i.e. subsidies, national/local policies, farmer association, control committees?
- How has infrastructure affected the commercialization of crops and the access to external inputs?
- In which agricultural systems are external inputs used?
- What are the effects of external inputs on soil and water quality?
- How have the livelihoods of smallholder farmers changed in response to the introduction of external inputs (change in both farm and non-farm income activities)?
- How is the labour distribution connected to the use of external inputs on agriculture?

We will utilize various natural and social science methods and frameworks (e.g. Sustainable Livelihood Framework), as we view our study site to be a social-environmental system that should be examined from an interdisciplinary perspective. A task that can prove challenging due to the differences in ontology and epistemology borne by the different disciplines (Rasmussen and Arler, 2010).

Methods

Social science methods

Questionnaire

The questionnaire is a convenient tool to gather information from a wide range of respondents in relatively short time. We therefore plan to do the questionnaire in the first days of the field trip, enabling us to get an overview of the household compositions and activities. This might also help us to identify informants for semi-structured interviews during the field trip. The results of the questionnaire will then be analysed and compared to the outcomes of other applied methods.

We are aware that there are cultural differences and language barriers between the indigenous and the students, which might lead to misunderstandings. To avoid that, we try to design our questionnaire as clear and short as possible, but at the same time keeping enough space for more open questions and answers.

Limitations of household questionnaires:

- It can be a challenge to clearly define a household. Some may see it as only comprising the people living in the bilek, while others may see it as something that includes family members who are staying somewhere else for work etc.
- We might face gender bias, as the spokesperson of the household is often a man, but we will try to include the women as well.

Participatory mapping

In our research project we plan to use participatory mapping as a tool for learning more about certain aspects of our research site. Participatory mapping is a visual method, in which members of the community draw a map of their area (Narayanasamy, 2008, 2).
The mapping, that we will use, is the resource mapping, which is designed to show information about for example land use and resources (ibid 17).

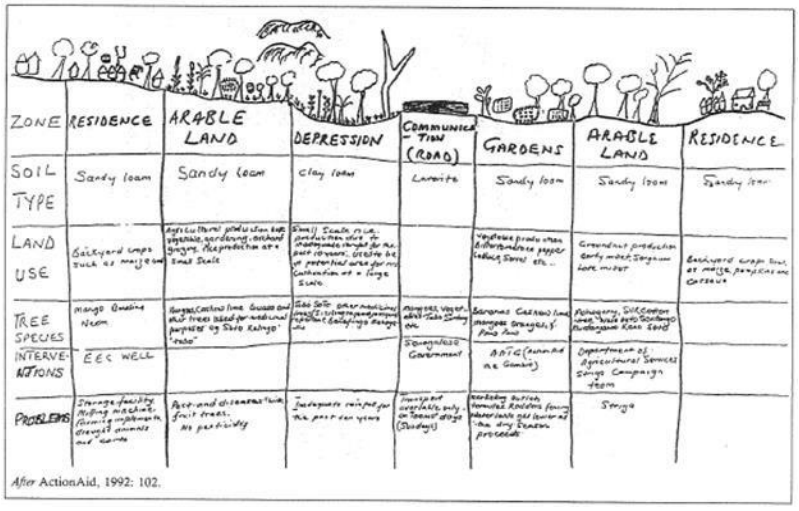
With the participatory mapping we wish to answer questions such as "In which agricultural systems are external inputs used?" and "What role does external inputs have on food crops vs cash crops?". We also aim to get a better overview of the areas, that are important to the farmers of Sebangkoi Ulu Undop. We will ask them to add any water streams to the map, that they know are close to agricultural plots. This information will be used when we go and take water samples and do a miniSASS of the streams. We furthermore ask them to draw in the roads and mark the quality of the roads, to assess their means of access to external inputs.

Timelines

Timelines is a participatory technique for mapping out the perceived changes in land use and use of external inputs over time (Mikkelsen 2005, 92). This will allow us to better assess, whether the use of external inputs, that we are witnessing, is on a long-term basis or more of a short-term fluctuation.

Transects

One way to get a detailed overview of the area is to use transects, "cross-sectional maps or diagrams of an area" (Mikkelsen 2005, 90).
This figure shows an example of such a transect map:



(ibid, 91)

With a transect like this, we would note down the important factors for each area; the perceived soil type, the crop(s) grown there, whether they are used for subsistence, cash, or both, the type of agricultural system, whether external inputs are used, how much is used and what kind, to whom it belongs, as well as any perceived issues with the area.

Semi-structured interviews

We will conduct one-to-one, semi-structured interviews of the residents in the longhouse. In one-to-one interviews, the respondent may express their point of view without interruption and without fear of

social repercussions (Martin 2004, 111). This may allow us to be aware of conflictual issues within the longhouse.
It will also be easier for us to steer the conversation in the direction, that we want, as well as maintain a sense of discretion and trust between us and the respondents (Brinkmann 2013, 27). That the interview is semi-structured means that we will have a list of specific questions to ask the respondent - but the questions are open-ended and do not need to be posed in any specific order (Casley & Kumar 1988, 13-14). Questions, that do not appear on the list, may also be added along the way, allowing us to focus on issues, which unfold as the interview develops (Brinkmann 2013, 21). Since we have never been to Sebangkoi Ulu Undop before, it would be a huge disadvantage to rely too heavily on our own predetermined questions.
The advantages of this type of interview include, that the results from different respondents are comparable, as they will be asked many of the same questions, it is not too time consuming and it does not rely too heavily on the skills of the interviewer (Casley & Kumar 1988, 14).
An implication that we have to keep in mind, is how the dynamics in the interview are influenced by the interviewer and the observer, i.e. interviewer bias (Martin 2004, 111).

Participatory observation

Participatory observation means to take part in the lives of the people, who are part of our study (Martin 2004, 96). It means to take an active part in ritualistic or festive activities as well as subsistence activities such as harvesting, cooking etc (ibid). According to anthropologist Gary Martin, the most significant tools in participatory observation are "curiosity, a willingness to learn from other people and an ability to adapt to their rhythm and lifestyle" (ibid, 107). We have the great advantage to stay in the same house with the people from Sebangkoi Ulu Undop, which will allow us to more easily adapt to their lifestyle and participate in their daily life, e.g. collect fruits, harvest rice, cook and eat together, participate in cultural and religious activities etc.
A more practical tool is the field diary, which we can use to take notes of important events, that happen during each day (ibid). The notes can include important facts that the people of Sebangkoi Ulu Undop tell us during the day. The notes also describe activities and interactions among the residents of the longhouse. We will use the participatory observations as a tool to open our minds to the unexpected aspects of the life in the longhouse that would be interesting to investigate further.

Ethical considerations and limitations

Ethical considerations:

- We have some preconceptions about the people in Sebangkoi Ulu Undop and they have some preconceptions about us. In that sense, we must consider that stigma may have an effect on communication in both ways.

- We will try to avoid confirmation bias by not asking leading questions that aim towards a specific conclusion.

- We are going to ask about private matters such as economy - this information is confidential and needs to be handled with respect towards the privacy of our informants.

Limitations for social science methods:

- Some people might seem more eager to talk to us, which could lead to selection bias.

- The language barrier will be a limitation, as we must communicate with our respondents through a translator. Some points may be misunderstood or left out.

Natural Science Methods

GPS

We will use GPS in order to get a better overview of the study area. This allows us to mark relevant points of interest in the field and to remember the exact sampling sites, the transect walks, etc. The saved waypoints and tracks will be uploaded to Google Earth and can then be used in analysis process.

Water Quality Assessment

The idea is to choose one of the rivers or creeks that runs through the area with the help of the local people (through participatory mapping and transects). We want to examine different sections of the body of water and understand the effects of farming practices on long-term water quality.

1. step: participatory mapping of streams
2. step: analyze water samples taken at different sections of a river/creek for specific contaminants
   - miniSASS analysis upstream and downstream of the fields
   - we will try to relate contaminants to local source
   - we will use GPS equipment to mark the waypoints of the different sections of the creek where water sampling activities occurred
   - list of materials: aquatic Nets; rubber boots; GPS Equipment; digital cameras
3. step: Statistical analysis to see if there is a significant difference up and downstream

Limitations:

We will not be able to point to the fields that has contributed to the potential decrease in water quality. Heavy rainfall would influence the results as the water pressure in the streams would increase.

Soil Quality Assessment

Upland rice can be grown by shifting cultivation as it is the case in areas of Sarawak, Malaysia. Shifting cultivation can help replenish soil organic carbon (SOC) during the time that the plots are left to grow fallow. However, in Sebangkor Ulu Undup perennial crops such as pepper, rubber and oil palm are also cultivated to some extent. Therefore, soil samples of hill rice- and different perennial agricultural fields can be investigated to determine the characteristics and nutrient levels of different soil samples.
We are planning to take several samples from plots with different types of crops with different application of external inputs, using samples from the nearby forest as a baseline. The relevant plots will be determined during the transect walks and participatory mapping and will be more clearly stated in the final report.

1. step: Participatory mapping to identify on which fields external inputs are applied and which kinds of inputs there are used e.g. synthetic fertilizer, manure and pesticides.
2. step: Characteristics of the fields - crop types, soil types, location (distance to longhouse and topography).
3. step: Sampling in fields - we will take soil samples from different depths on distinct areas i.e. plots cultivated with different crops, fruit orchards, forest
4. step: Analysis of soil samples based on soil organic matter, nitrate and phosphorus content;

bulk density; electrical conductivity; water holding capacity; pH concentration

5. step: Statistical analysis to see if there is a significant difference in soil quality

Limitations

- Do the farmers know exactly how much of the external inputs they apply (under/over estimation)?
- Differences in soils - sandy soils would have a higher porosity and thereby higher ground water leaching; clay soils would have an effect on surface runoff.
- Irrigation and precipitation - When are the external inputs applied? Is it always in the same period of the year?
- Slopes: Fields on steep slopes would probably have a lower nutrient content than fields in low lying areas.

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Appendix (from the synopsis)
Research matrix

Overall objective To see how external inputs are used and how it influences the life in the longhouse in Sebangkoi Ulu Undop (in terms of socio-economic impact, environmental impact, etc.)			
Themes	**Sub questions**	**Data required / output**	**Methods**
Governance	Which institutions and regulations affect the consumption of external inputs i.e. subsidies, national/local policies, farmer association, control committees? How do the people of the longhouse interact with the different institutions?	Stakeholder map Local knowledge about existing laws and rules	Participatory mapping Semi-structured interview with the headmen Timeline
	How has infrastructure affected the commercialization of crops and the access to external inputs?	Local knowledge on exciting roads and the history of their establishment	
Livelihoods	How have the livelihoods of smallholder farmers changed in response to the introduction of external inputs (change in both farm and non-farm income activities)? How is the labour distribution connected to the use of external inputs on agriculture?	Historical agricultural practices Income diversification	Questionnaire Semi-structured interview with - older people in the longhouse - farmers - female inhabitants Timeline
	What led the local farmers to start using external inputs?	Historical background	
	Are there gender issues related to the use of external inputs i.e. access, utilization, etc.?	Distribution of household activities and who benefits	
Land use and Agriculture	In which agricultural systems are external inputs used?	Field map Local knowledge about farming strategies	Questionnaire Participatory mapping Transects Use of GPS Semi-structured interview with farmers
	What role does external inputs have on food crops vs cash crops?		
	What kind of external inputs are used?		
	What are the effects of external inputs on soil and water quality?	Soil and water analysis	soil and water sampling

Questionnaire Draft

GPS-point: x:_____y:_____z: _____	Interpreter/Interviewer:
Longhouse name:	Note taker/Observer:
Bilek:	Date & Time:
Respondent:	Pictures:

We are students from the University of Copenhagen (Denmark) and UNIMAS University in Kuching. Our objective is to understand how external inputs are used in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of smallholder farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially and the participants will remain anonymous. When we refer to 'external inputs' we mean fertilizer and pesticides.
Please note that we are not funded in any way and that the purpose of our study is merely academic.
The questionnaire will take about_minutes.

General information about the respondent

Gender (assumed by interviewer): O Male O Female

1. Position in the household _____

2. Age

O under 18 O 18-29 years old O 30-44 years old
O 45-54 years old O above 55

3. Marital status

O single O in a relationship O married O divorced
O widowed O other O I don't know

5. **Household composition** *("household" refers to all members of a common decision making unit that are sharing income and other resources)*

Gender [1)]	Age [2)]	Familial relation [3)]	Living situation [4)]

1) male, female; 2) same intervals as in question 2; 3) relation to the household head: wife, father/mother, father/mother in law, son/daughter, son/daughter in law, grandson/granddaughter, uncle/aunt, cousins, other, not related; 4) living permanently in the longhouse, commuting, living permanently outside the longhouse, other

Household activities and income

7. Crops cultivated by the household of the respondent *(multiple options possible)*

And please rank the crops according to what gives the highest income among these cultivated crops *(1=highest income;…)*

O_____pepper
O_____rubber
O_____oil palm
O_____rice
O_____fruit orchards / horticulture
O_____other crops planted
O_____don't plant any crops

8. Other activities done in the longhouse (or in proximity) by the household of the respondent (multiple options possible)

And please rank the activities according to what gives the highest income among these activities *(1=highest income;…)*

O_____fishing
O_____livestock production
O_____tourism
O_____handicraft
O_____other
O_____none

9. Rank the income sources of the household according to what gives the highest income

(1=highest income;…)

_____selling crops (named in question 7)
_____selling other forest products
_____on-farm activities (activities inside / in proximity of the longhouse named in question 8)
_____off-farm activities (working on plantations etc.)
_____remittance by household members living outside the longhouse
_____subsidies from public institutions, NGOs,...
_____other
_____I don't know

Agriculture & Land use

10. How many plots do you crop this year: _____

11. Has the size of cultivated land significantly changed during the last ten years?

	pepper	rubber	oil palm	rice	fruit orchards	other crops
increased						
decreased						
unchanged						
I don't know						

12. What are the reasons for that change?

	pepper	rubber	oil palm	rice	fruit orchards	other crops
moving to the new longhouse						
improving road conditions						
price fluctuations						
lack of labour force (outmigration)						
environmental conditions						
subsidies for seeds or external inputs						
other						
I don't know						

External inputs

13. Are you using any kind of external inputs?
O yes – what kinds do you use? O no

14. For which crops do you use external inputs?

O pepper O rubber O oil palm O rice
O fruit orchards / horticulture O other crops O I don't know

15. Are there official rules (from public authorities, farmer associations, etc.) you have to follow regarding the amount and time for applying external inputs?

O yes O no O I don't know

16. How are you getting the external inputs?

O merchant comes to the longhouse O distribution by headman
O market/store in next bigger town O other O I don't know

18. Has your income changed significantly in the last ten years?

O increased O decreased O no change O I don't know

If increased/decreased - Do you think that is connected to the use of external inputs?

O yes O no O I don't know

Commercialization

19. Do you notice a difference in the amount of crops you produce after the introduction of external inputs?

O increased O decreased O no change O I don't know

20. How are you mainly selling your crops?

O through merchant who comes to the longhouse O through headman
O on the market/store in next bigger town O other O I don't know

Thank you very much for participating in the survey! Are there any questions from your side?
[May we contact you again, in case we have further questions?]

Interview guide

First introduce yourself - tell the respondent where you are from and what you are doing here. Inform the respondent of the nature of the questions; they are about their use of land, their experience with governance and their income. Inform them that they at any time have the right to not answer a question, if they do not feel comfortable doing so. If they are being recorded, inform them about it and ask for their consent.

Land use and agriculture

- How do you decide what to grow on which plots?
- How do you consider the quality of the soil? Do you notice a difference in the past years?
- Do you grow crops that are mainly for your own consumption and not for selling? Which ones?
  - Why do you grow these ones?
- Do you grow crops that are mainly for selling? Which ones?
  - Why do you grow these ones?
- Are there crops which used to be essential in the past, but you don't grow anymore? Which ones?
- Are there new crops you started to cultivate recently? Which ones?
- Do you have access to use external inputs for the crops that you grow? Do you use it?
  - If yes: Why?
  - If no: Why not?
- Can you describe when you started to use external inputs? What happened?
- Do you use less or more area of land now that you apply external inputs?
- What type(s) of external inputs you use? Why?
- Do you fertilize your crops all in the same way, or are there differences? How so?
- Since you moved to the new longhouse, did you experience any change in terms of:
  - the crops you grow?
  - the use of external inputs?
  - your access to land?

Governance

- Are there any rules for applying external inputs in this area? If yes - Are you following the rules?
- Who makes the decisions on land use and the use of external inputs around here? What is your relation to the decision maker?

- Do you know of any farmers associations? Do you take part in one?

- Do you experience any interference from the government in your use of external inputs - such as being rewarded or fined?

- Have you or do you take part in any schemes such as rubber scheme or oil palm scheme or another one

Livelihoods

- From where do you get you main income?
    - Do you have other sources of income? Which ones?
- Do you share income with someone? Who?
- Do you see a change in the number of farms after the introduction external inputs?
- Do you have a higher income from the farming activities after you got the external inputs compared to before?
- Do the members of your household share the same responsibilities, or are there specific tasks for each?
    - How are farming activities specifically distributed among members in your household?

Thank the respondent for their time and input.

Preliminary timeplan

Date	**Activity**	**Who**
Monday 24/2	Meeting at Telang Usan, Kuching at 5 pm	Everyone
Tuesday 25/2	Meeting our counterparts and discussing time plan and methods with them	Everyone
Wednesday 26/2	Heading off to the longhouse in Sebangkoi Ulu Undop - Welcome party in the longhouse and socializing!	Everyone
Thursday 27/2	Morning - Afternoon: Getting to know the people, participatory mapping of land use in 2012 and now, transect walks	Everyone

Friday 28/2	Morning: Pilot sample for the questionnaire Midday: Adjusting questionnaire Afternoon: First samples for questionnaire (Making contact with the farmer) Morning-afternoon: Semi- structured interview, actor mapping and timeline with headman Evening: Transcription/ Sampling control for Q.data and participatory dinner making	- Two (choose) - Two (choose) - Everyone
Saturday 29/2	Morning/midday: Semi-structured interview with farmer/s Morning/midday: Semi-structured with older people and timeline Afternoon/evening: Transcription of interviews, enjoying, Saturday night or semi-structured interviews with people who are home for the weekend	- Two - Two - Everyone
Sunday 1/3	All day: Open day Maybe going to church Potentially semi-structured interviews with people at home for the weekend.	- Everyone
Monday 2/3	Morning-Afternoon: First soil samples with a farmer/s Morning-Afternoon: Questionnaire samples Evening: Samples control (drying of soil samples and typing of Q.-data	- Two - Two - Everyone
Tuesday 3/3	Morning- midday: Finishing soil sampling Morning- afternoon: Participatory miniSASS sampling	- Two - Two
Wednesday 4/3	All day: Semi-structured interview with women All day: Missing data collection	- Two - Two

Thursday 5/3	All day: Missing data collection and data control	Everyone
Friday 6/3	Prepare for presentation with counterparts	Everyone
Saturday 7/3	Presentation for group and community in Sri Aman (with all groups) Goodbye party in the longhouse!	Everyone
Sunday 8/3	Leave for Kuching	Everyone
Monday 9/3	Free :)	

Appendix 2: Questionnaire

GPS-point: N 01°2'28" E 111°37'16"	Interviewer:
Longhouse name: Sebangkoi Undup	Interpreter:
Bilek no:	Note taker/Observer:
Respondent: O Male O Female	Date & Time:

We are students from the University of Copenhagen (Denmark) and UNIMAS University in Kuching. Our objective is to understand factors of the land use change in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially and the participants will remain anonymous.
Please note that we are not funded in any way and that the purpose of our study is merely academic.
The questionnaire will take about ____ minutes.

General information about the respondent

1. Age

O under 18 O 18-29 years old O 30-44 years old
O 45-54 years old O 55-64 years old O 65 and beyond

2. Do you have any family members who are living outside Kampung Sebangkoi, Undup?

O Yes O No

Reason for moving away	Check	Number
Education		
Work		
Mariage		
Others		

Economy: Household activities and income

3. Can you tell us which crops are cultivated by your household *(multiple options possible)*
And please explain the purpose of the different crops to you *(important for cash income, for own consumption,…)*

	Consumption	Selling	Both	Others
Pepper				
Rubber				
Oil palm				
Rice				
Fruits				
Vegetables				
Other crops				

4. How are you mainly selling your crops?

O consumers come to the longhouse O driving around to other longhouses
O through headman O on the market/store in next bigger town
O Refused to answer O through middleman
O other

5. Are there any crops you used to cultivate in the past, but you don't now (e.g. cacao,…)?

_____

_____

6. What other livelihood activities is your household practicing?

Activities	Consumption	Selling	Both	Others
Fishing				
Livestock production				
Foraging				
Hunting				
Handicraft				
Logging				
Other				
None				

7. Which of the following cash income sources are relevant for your household

Remittance by family members living outside the longhouse O yes O no
Subsidies / financial aid from public institutions, NGOs,... O yes O no
Pension O yes O no
O other
O Refused to answer

Agriculture & Land use

8. Have you noticed a change in the agricultural yields since you moved away from the old longhouse (Tembawai)?

	size of plot	**yield per plot**
pepper	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know
rubber	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know
oil palm	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know
rice	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know
fruit orchards / horticulture	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know
others	O increased O decreased O unchanged O don't know	O increased O decreased O unchanged O don't know

9. What are the reasons for the change?

	pepper	rubber	oil palm	rice	fruit orchards	other
distance / transportation						
access to road						
processing machines						
access to fertilizer and/or pesticides						
price						
labour force						
environmental conditions (soil, water)						
Government/ NGO financial aids						
other						
I don't know						

Technology

10. a) Are you using fertilizer for any of this crops?

O pepper O rubber O oil palm O rice
O fruit orchards / horticulture O other crops O I don't know

b) Are you using pesticides for any of this crops?

O pepper O rubber O oil palm O rice
O fruit orchards / horticulture O other crops O I don't know

11. Do you have special machinery for crop cultivation?

O planting machine O truck O harvest machine O other
O processing machine O no

Legal

12. Are there official guidelines (from public authorities, farmer associations, etc.) you are advised to follow for applying external inputs?

O yes O no O I don't know

Social: Government intervention

13. a) Are you receiving any support from the Government for the following agricultural activities?

type of support	pepper	rubber	oil palm	rice	fruit/vegetables	livestock	fish	other
seeds								
fertilizer								
pesticides								
building material								
machinery								
fodder								
money								
training								
other								

b) If you haven't received training, did someone pass down the knowledge from government training to you?

O Yes O No O Refused to answer

14. Do you still practice *berdurok*?

O Yes O No O refused to answer

15. Do you have appropriate land tenure / ownership on your agricultural land?

O Yes O No O refused to answer

Environment

16. Do you see a difference in soil quality since you moved here?
    O Increase quality O Decrease quality O Same quality

17. a) Do you notice any crop disease/ pests on your crops?
    O Yes O No

b) Do you notice a change since you moved away from the old longhouse (Tembawai)?
    O More O Less O The same

Thank you very much for participating in the survey!
Are there any questions from your side?

[May we contact you again, in case we have further questions?]
Name:
Bilek no.

Appendix 3: Interview guides

SSI1, woman

GPS-point: N 01°2'28" E 111°37'16"	Interviewer:
Longhouse name: Sebangkoi Undup	Interpreter:
Bilek no: 15	Note taker/Observer:
Respondent:	Date & Time:

We are students from the University of Copenhagen (Denmark) and UNIMAS University in Kuching. Our objective is to understand factors of the land use change in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially, and the participants will remain anonymous.

Please note that we are not funded in any way and that the purpose of our study is merely academic.

Themes

Gender roles
Keywords: Gender division in the household; The women roles in the longhouse; Women vs men in the plantation

How do you divide the between the duties of the husband and wife in your household?
What are the roles of the women in the longhouse community?

Livelihood diversification – SOP
Keywords: Impacts on daily routine; Security; Involvement in farming

How is it for you to work with SOP?

- Why did you decide to work at the SOP?
- Has it had any impacts on your daily routine in the household?
- Has your employment at the SOP secured your household income?
    - Why are you still active in farming?
    - Did you have to stop cultivate some of you crops, because you got employed?
    - Why do you priority the crops you are still cultivating?

Community and future?
Keywords: Community vs the individual household; Future for the community;

Have you seen a change in the community collaboration since some people started working at the SOP?
What do you think is going to happen in the longhouse community in the future?

- Do you think people will practise *bedurok* in the future?

SSI 2, young man

GPS-point: N 01°2'28" E 111°37'16"	Interviewer:
Longhouse name: Sebangkoi Undup	Interpreter:
Bilek no: 15	Note taker/Observer:
Respondent:	Date & Time:

We are students from the University of Copenhagen (Denmark) and UNIMAS in Kuching. Our objective is to understand factors of the land use change in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially and the participants will remain anonymous.

Please note that we are not funded in any way and that the purpose of our study is merely academic.

The semi structured interview will take about ____ minutes.

Themes:
Economics

1. What job do you want to have in the future?

   - Does agricultural activity interest you? Why and why not?
   - How is it for you being a young person growing up in the longhouse community?
   - How do you perceive life in the city? How is it vs here?

Social

2. Expectations

   - What are your expectations for yourself and your future? Is it the same with your parents'/ family's/ friends'expectations?

3. Challenges for future

   - What are your challenges for the future?

4. What do you think would attract more young people to the rural areas? Is it important?
5. In your own opinion – what do you think is going to happen with the agricultural practices of Sebangkoi Undop in the future?
6. Do you want to come back to the longhouse when you get older?

SSI 3, elderly man

GPS-point: N 01°2'28" E 111°37'16"	Interviewer:
Longhouse name: Sebangkoi Undup	Interpreter:
Bilek no: 15	Note taker/Observer:
Respondent:	Date & Time:

We are students from the University of Copenhagen (Denmark) and UNIMAS in Kuching. Our objective is to understand factors of the land use change in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially and the participants will remain anonymous.

Please note that we are not funded in any way and that the purpose of our study is merely academic.

The semi structured interview will take about ____ minutes.

Themes:

1. *History of initial agricultural practices & main agricultural activities*

How do you see the agricultural activities in sebangkoi undup and what is your main agricultural activities?

2. *Cultural belief and ancestry land maintenance*

Does this village have formal and / non-formal rules (including customary norms, myths, traditions) concerning using or entering the agricultural land (also consider the spirit world), which underlies the tradition that allows (or prohibits) access the agricultural land? (shifting cultivation or further details)

3. *Labour exchange (berduruk) and seasonality*

How effective these households' practices the "berduruk" to increase agricultural productivity (paddy) and what are the difficulties in sustaining that practices right now compared to the past?

Tell me more about soil suitability and water quality or access to sustain the intensity of agricultural practices?

4. Land sharing & plot shifting

Where will you shift your rice or other crops plots to next? What is the available area for that? And how the bonding between communities in land issues is (land sharing or land division).

5. Source of income & product demand

Is your outside job income stable? If you have a stable income from an outside job which crop do you still cultivating?

6. Challenges in sustaining agricultural practices & opportunities

What are the challenges and opportunities in sustaining the agricultural activities at sebangkoi undup?

SSI 4, counselor

GPS-point: N 01°2'28" E 111°37'16"	Interviewer:
Longhouse name: Sebangkoi Undup	Interpreter:
Bilek no: 15	Note taker/Observer:
Respondent:	Date & Time:

We are students from the University of Copenhagen (Denmark) and UNIMAS in Kuching. Our objective is to understand factors of the land use change in Sebangkoi Ulu Undop and how that affects the physical environment and other aspects in the life of farmers. Therefore, we would like to ask you a series of questions. In case you feel uncomfortable regarding some questions, you are free to not answer them. The results of this study will be treated confidentially and the participants will remain anonymous.

Please note that we are not funded in any way and that the purpose of our study is merely academic.

The semi structured interview will take about ____ minutes.

Themes:

Legal
Keywords: Land tenure system, Land leasing, Land registration

- Duty as a counsellor: What is your duty as a counselor?
- Land tenure/ rights - Pros/ Cons
- How do the villagers involved with land leasing? When does it start?
- Land registration: How does land tenure works in the past, and how it has changed now?

Oil plam
Keywords: Introdution of oil palm; SOP land leasing

- When were oil palm introduced to the Sebangkoi, Undup community?
- Can you tell us the community participation in establishing SOP and road access? What is the argument for and against, if any?
- Lease to SOP
- Land title given after 60years of leasing to SOP, why is it important compared to NCR?

Land security
- Is it important to have registered land? Why?
- How secure is the current land rights system for you?

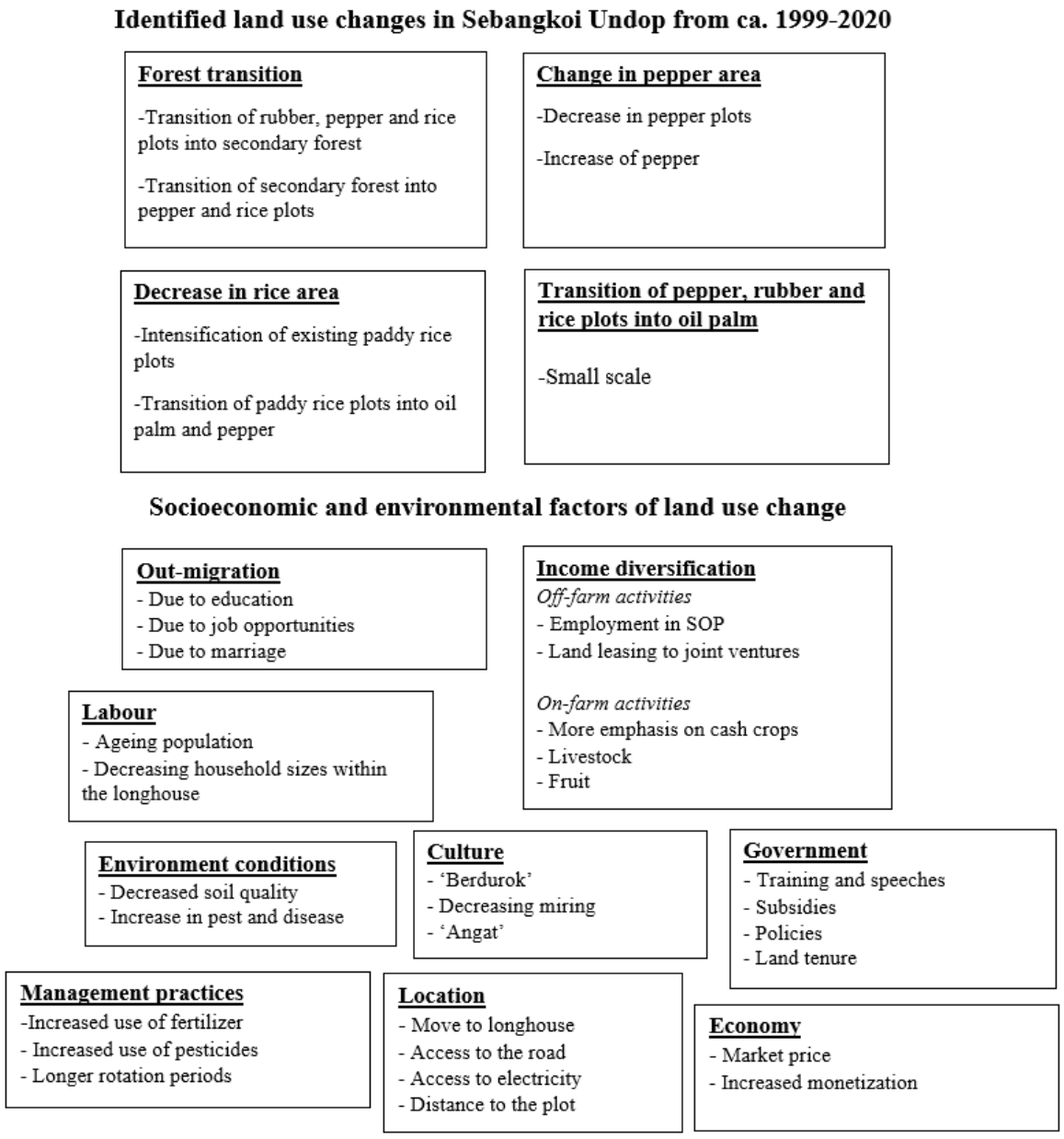
Access
Keywords: Equal distribution; Development schemes and project; Women vs men; Access to government (Subsidies, Training)

- Is it distributed equally among the bileks? What is the requirement/ eligibility if any? Did different bileks receive different welfare/ aid? How come?
- How is the process of development scheme?
- Have there been any particular **projects to promote women's and men's participation** in agricultural practices? Describe these projects.
- What **development projects** have taken place in this village during the past 10 (ten) years to enhance agricultural intensity / productivity?

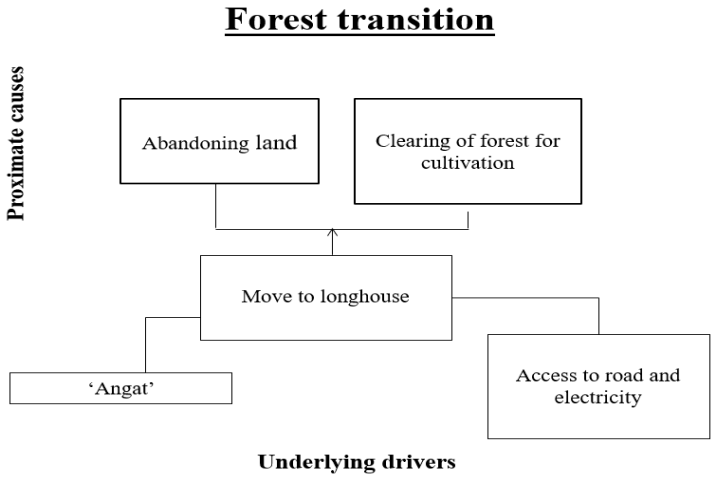
Socio-economics
Keywords: Migration; General economy; Welfare; Out-migration

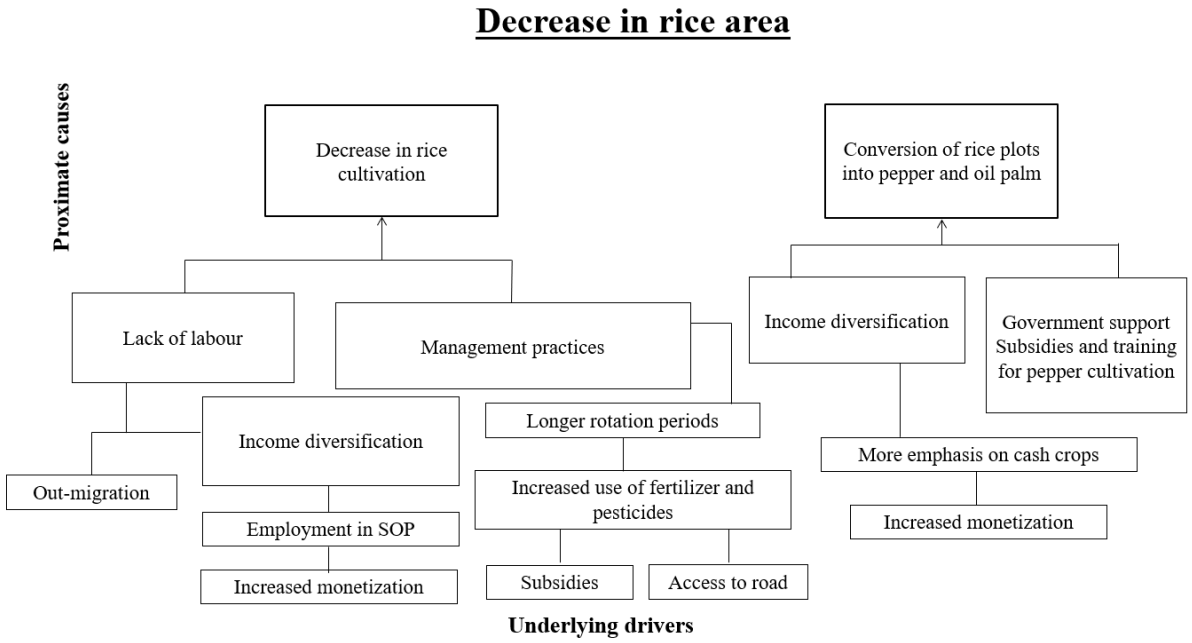
- What is your view about out-migration? What is the reason for out-migration?
- Is the government promoting development when youngsters move out to town to work? Could that be a reason of out-migration?
- Is there any effort to reduce out-migration?
- Which contribute the most in source of income? Land-use diversification works?
- What are the welfare scheme available for the villagers? Does it work?

Appendix 4: Summary of findings & Causal chains

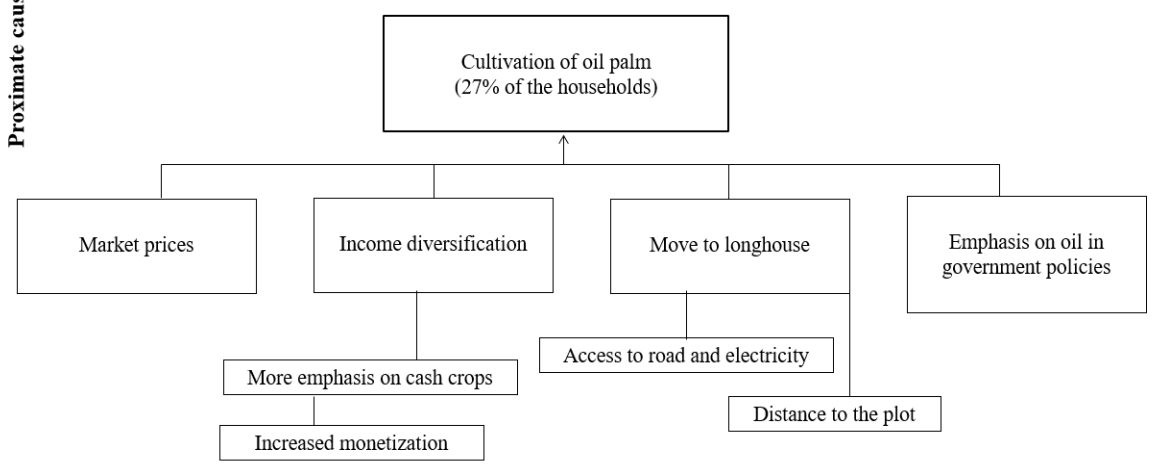


Causal chains

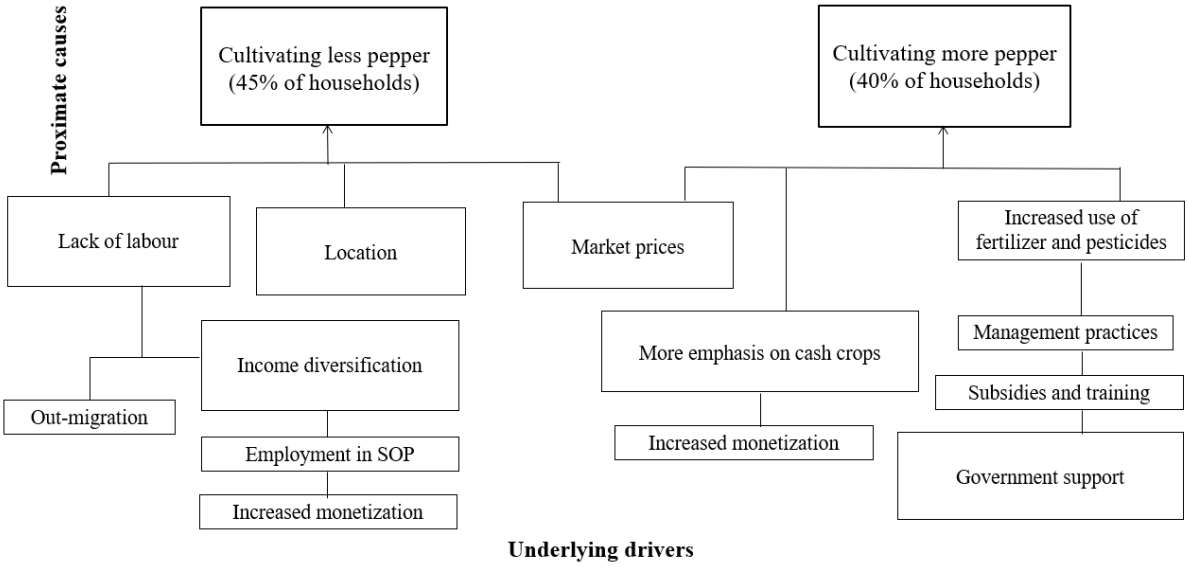




Transition of pepper, rubber and paddy rice plots into small-scale oil palm

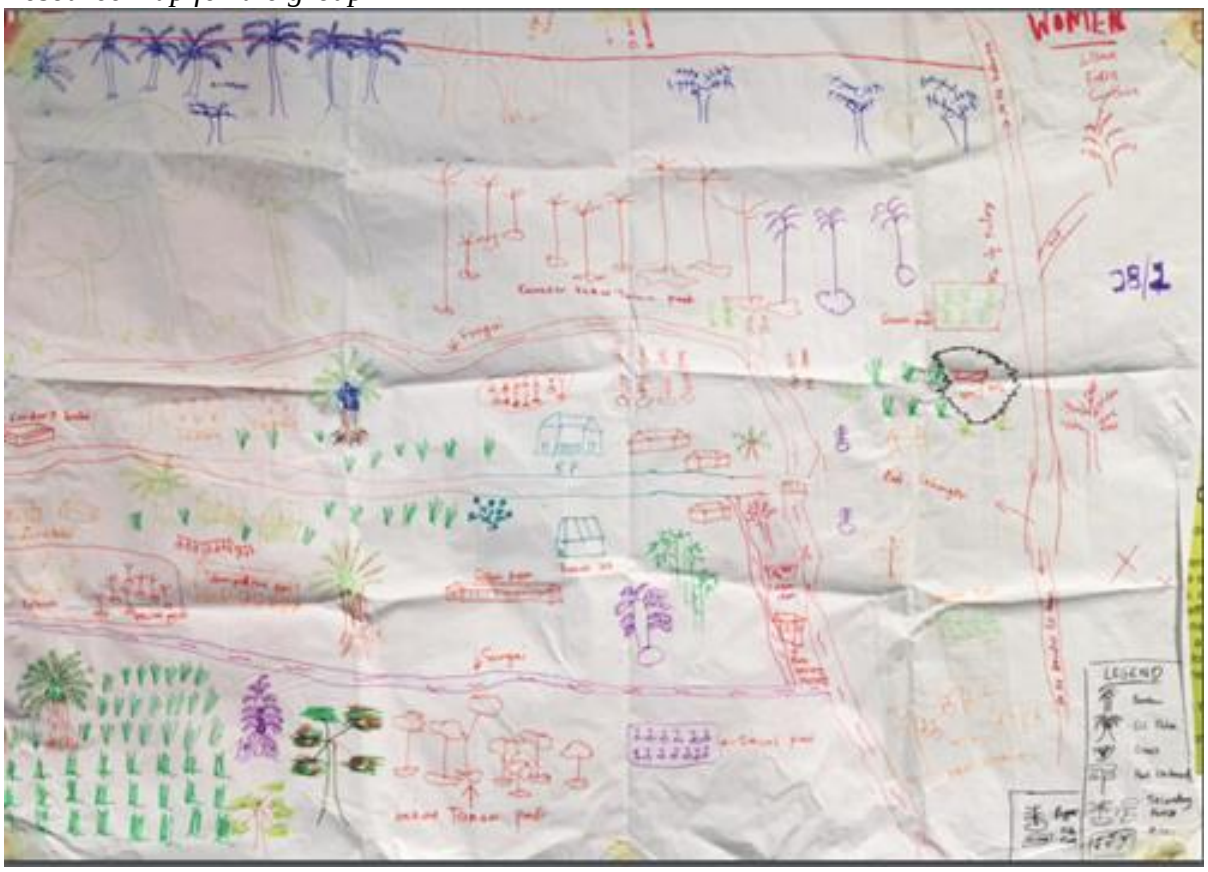


Change in pepper area



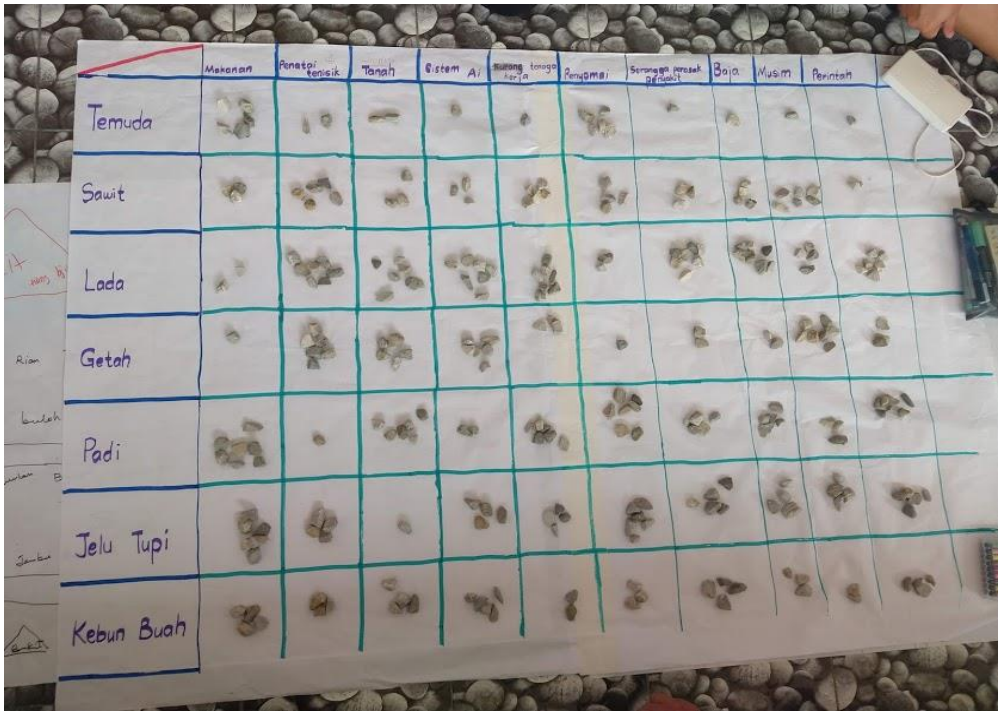
Appendix 5: Participatory resource maps

Resource map female group



Resource map male group

Appendix 6: Preference ranking matrix



Appendix 7: Method matrix

Participatory observation	
Semi-structured interviews	4
Transect walks	2
Questionnaires	22
Timeline	1
Participatory resource mapping	2
Participatory resource ranking	2
Water sampling sites	4
MiniSASS	2
Soil sampling sites	6