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Rural-Urban Linkages and Land-Use in San Pandak, Malaysia

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Abstract

The case study of San Pandak, an Iban longhouse in Sarawak, Malaysia sets out to describe the main rural-urban linkages affecting the longhouse and to estimate the effects of rural-urban linkages on local land use. The land use in turn has socio-economic and environmental impacts, which are also considered.

Through the study it is found that rural-urban linkages are complex and significant. Most notable linkages are related to off-farm work opportunities, government subsidies and access to a market for cash crops. Migration is not a new phenomenon but the extent of migration and reasons for going seem to be changing. Government policies, most notably related to subsidies, have caused increases in yields and a move towards less shifting cultivation and more intercropping around the longhouse. Cash crops play an important role, but are not dominating. Choices of crops are strongly related to market prices and available labour. In conclusion, subsidies, market prices and available labour are main explaining factors for the diverse land use that is found in San Pandak. Currently, natural resources are abundant and generally in a good state and inhabitants have found ways to diversify income and minimize risk, but future possible changes in migration patterns and development of oil palm initiatives might alter the current situation.

Keywords: Sarawak, Iban, rural-urban linkages, land use, shifting cultivation, migration

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1. Introduction

As development countries becomes greater involved in the process of globalization they have increasingly become subject to the accompanying changes such as deforestation, degradation of land, intensification of commercialization and transborder trade. These changes in turn affect local communities in their options through increasing commercialization of agriculture, expanded and shifting labour migration as well as changing concept of household necessities and luxury. The global processes have arrived onto rural communities' social and economic lives, to which they have adapted their strategies of land-use (Mertz et al. 2005).

These above mentioned close and often very complex linkages between rural and urban areas are important for the livelihood strategies of both rural and urban households (Tacoli 2004). The rural system needs market for its products, supply of inputs of different kind and off-farm job opportunities from the urban system (Zeleke et al. 2006). Also, a significant segment of rural households depends on income diversification and on the combination of agricultural and non-agricultural income sources (Tacoli 1998).This diversification has led to "occupational multiplicity" among local people (Mertz et al. 2005, Tacoli & Mabala 2010), as well as households have become "multispacial" in their composition (Tacoli 1998).

The Malaysian state of Sarawak in Borneo is a rapidly growing economy (Hansen & Mertz, 2006), which has led to substantial government spending. Economic development has been skewed though, favoring urban centres as well as regions of commercially productive agriculture. Government policies for development of rural areas has mainly been concentrated around two strategies, which are somewhat contradictory. One focus has been on the large-scale land development schemes (Windle & Cramb 1997), while traditional small-scale farming is seen as an obstacle to economic development (Hansen & Mertz 2006). At the same time, the state continuously provides extensive support to these small-scale farmers (Windle & Cramb 1997).

The Iban, which constitutes about 30% of the population, mainly occupy the interior areas of Sarawak. Their livelihood activities are based on farming and collection of forest produce for subsistence as well as cultivation of certain cash crops. The younger segment are increasingly engaging in wage employment in urban areas. Part of the land-use has tremendous cultural importance to the Iban, in particular the cultivation of rice (Windle and Cramb, 1997).

According to Evans (1992), the urban system has a positive impact on the rural. Remittances from migrated family members can substantially add to the income of the rural household (Hansen & Mertz 2006, Soda 2001). Windle & Cramb (1997) argues that

road access is of great importance, which potentially can facilitate rural development, increase income, as well as reduce the problem related to remoteness. Tacoli (1998) states how access to urban centres and markets are crucial for agricultural producers. Wiggins and Brookes (2010) points out how government inputs can help increase agricultural production and thereby reduce poverty and enhance food security. These interactions between the two systems are fostered by backward and forward linkages between agriculture, industry and service sectors, which are a huge source of economic growth and development (Tacoli 2004).

2. Research questions and delineation

The enabling economic environment and investments in Sarawak has impacted the opportunities and the linkages between rural and urban systems has become more pronounced. San Pandak is likely to experience effects of these rural-urban linkages both in the natural environment and on the human. The objective of this study is therefore to identify and analyse the most important of these linkages, how they have affected the land use in the San area and which impact this have had on environmental and socio-economic state. Our aim is to better understand the role of rural-urban linkages for rural development by assessing how it has affected the livelihoods of the Iban in San Pandak. Our main research objective of the present paper is therefore:

To investigate the effect of rural-urban linkages on land use in San Pandak and assess the socio-economic and environmental impacts.

This is done through investigations relating to the following sub-questions:

1. What are the main-rural urban linkages in San Pandak?
2. What characterises the land use of San Pandak and how does this relate to the identified rural-urban linkages?
3. What are the environmental and socio-economic impacts?

The geographical focus of the present study is delineated to San Pandak, and the study represents a case study with clear time limitations. The study should be viewed as a case study in which a general overview of a research area is illuminated for potential further investigations. Focus is on the land use of San Pandak and related rural-urban linkages in present times and past. The study is conducted over a period of eight weeks with ten days of fieldwork in San Pandak and five weeks of preparation and data analysis in Denmark.

3. Methodology

An overview of used methods relating to research questions can be viewed in appendix A.

3.1.Observation

Throughout the stay in San Pandak we were attentive to our surroundings and made use of our senses to observe and experience life in the community. Some observation was planned out and other happened more at random. The conscious collection of observations was used to get a comprehensive background understanding and triangulate with other data.

We found it important to be visible in the community, showing curiosity and taking part in activities, and social gatherings as well. This gave a better understanding of the inhabitant's lives and their decision making. Additionally, important subjects could be discovered and the observation stimulated further questions.

The time and engagement that was put into being part of the community also led to more trust, which we benefitted from in the last days in terms of more talkative interviewees and a more open and relaxed atmosphere.

3.2.Transect walks and guided tours

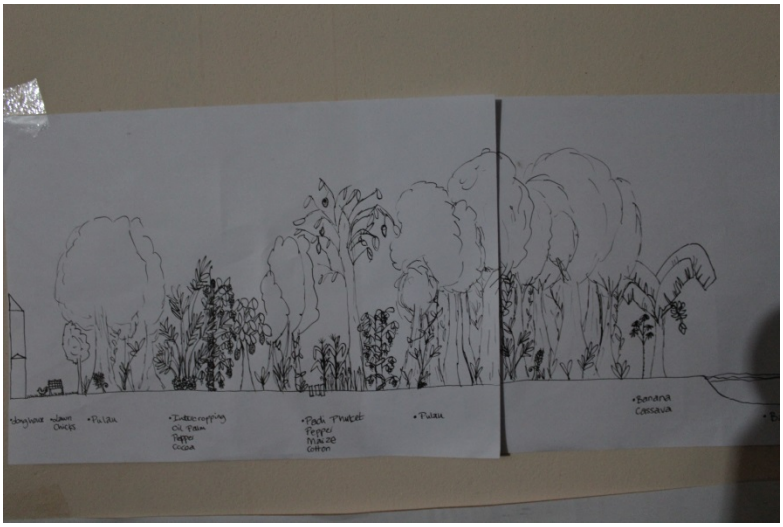
5 transect walks and guided field tours were performed. The transect is a 'transverse cut' of a landscape in which different aspects can be identified, described and analyzed (Selener et al., 1999: 62). In contrary, guided tour refers to field visit to enlighten specific themes. We found that the transect walks allowed for gathering of direct and indirect information primarily about land use through observations and interviews.

Due to the size of the San area, some guided tours took place in cars and led to less movement at the spot of interest. This created a more interview like situation. However, the transect walks, which took place by foot, created a companionable atmosphere and allowed for a shared point of view much like it is described in Lee and Ingold (2006).

Intentionally, one of the transect walks was planned to cover a diversity of landscapes, from the intensively used farming area to a large forest area at the northern side of the local river where we expected to see natural vegetation at different stages. In reality, the forest on the other side was not covered as it was too dense to be crossed.

Guided field tours were employed in the early stage of the research in order to gain overview important issues in San Pandak and helped to check the importance of logging activity, river siltation, and agricultural (dis)intensification. The locations in these tours

were guided much by the suggestions of the longhouse inhabitants and the tours facilitated evaluation and adaptation of the proposed research questions. Later guided tours and transect walks were used to deepen our understanding of land use and farming practices. It worked best when the roles of group members were well-defined, e.g. when dividing tasks regarding which themes to ask and make notes about.



Picture 3.2.1: Landscape drawing made based on observations from transect walk

3.3.GPS mapping

GPS waypoint- and transect tracking was used to note locations of most of the areas we visited around San Pandak throughout the research period.

Furthermore, 3 trails that led away from the longhouse were thoroughly mapped during walks on foot. On these walks, waypoints were sampled whenever there was a significant change in the land cover type. The waypoints were later added to Google Earth and a map was made to describe land use in the area adjacent to the longhouse. The waypoint sampling had several purposes. Waypoints that were sampled on trips by car helped to understand the extent of the San Pandak area and the location of certain landmarks. The waypoints that were sampled by foot helped in presenting a coherent understanding of the land use closer to San Pandak.Finally, waypoint made it easier to recognize different vegetation types when analyzing maps.

One disadvantage of the unguided trail mapping by foot is that it does not contain information on the ownership of the recorded fields, as we know that the fields of San Pandak are located in between fields from other longhouses.

3.4.Questionnaires and interviews

A questionnaire was prepared to capture general trends of the longhouse in terms of demographics and socioeconomic characteristics. We were interested in the workforce within households; migration, the main occupations and other sources of incomes as well as the use of natural resources by the inhabitants. Conducted in the very first days, the survey fostered our integration through interaction with household members. Since the San Pandak longhouse was formed of only 11 occupied *bileks* (households) at the time of the study, we directly surveyed 10 of them. Information about the last *bilek* was retrieved from other longhouse members due to the age and health of the household inhabitants.

The household Semi-Structured Interview (SSI) guide was designed after the questionnaires were carried out, and were based on our hypotheses in light of the preliminary findings. It was mainly related to decisions made about current farming management (choice of crops, farming systems, labour management), relative importance of subsistence and cash income activities, and the impact of rural-to-urban migration on household welfare and on-farm labour availability.

Both the questionnaire and household semi-structured interviews guides were reviewed, pre-tested and adjusted with help from our translators.

As it appeared to be feasible, we intended to interview all the households to avoid missing any valuable argument (especially from probable outliers) since the apparent homogeneity may not reflect personal motives. But a late compilation of data revealed that three *bileks* were not interviewed. We have unsuccessfully tried to interview households of San Panjai (from which San Pandak derives), as they share the same territory. However, this was not possible without breaking local customs of procedure and therefore the idea was abandoned.

Along the study period, topic-oriented interviews were also completed with key-informants, e.g. the headman and a special officer/member of the district council, to gain in-depth knowledge about the whole community, impact of government policies and its relation to statal and other external actors.

A characteristic of the SSI guide was that it had some closed questions. This gave us some information that we had not thought to ask for in the questionnaire. Furthermore, it was a safe way to make sure that interviews did not go off-topic which was perceived as a risk with many people doing interviews. A disadvantage of the chosen setup was that the more closed questions did not encourage discussions about the themes. As a result, short answers have been recorded, and follow-up questions were seldom. Moreover, the themes identified were not broad enough to highlight other rural-urban linkages than the ones we have presumed.

The first key-informant interview, which was carried out with the presence the full student group, was challenged by personalities and insufficient common understanding of assigned roles. As the interviewee was subsequently available, follow-up questions occurred afterwards to fill gaps.

3.5.PRA methods

The PRA methods used in this study were community mapping, crop-preference ranking and population development timeline and were primarily used to find information related to farm management.

The methods were carried out in group of 4 participants or less. The PRA methods were challenging because a larger group of people are more difficult to handle, especially when dependent on a translator, but they were also pleasant as they were more informal and because participants were comfortable with statements because they were knowledgeable within the topic.

Having multiple participants will normally have a corrective function (Mikkelsen 2005), but in the mapping exercise this was not the case because the headman took part and was allowed too much dominance. Thus, a second mapping exercise was performed later without him.

The PRA's functioned well when there was a shared internal understanding of the purpose and during the crop ranking we especially experienced how the lively discussions that lead to the ranking turned out to be just as important for data gathered from this exercise as the ranking itself, as it is also pointed out by Mikkelsen (2005).

3.6.Soil sampling

The soil sampling compared soil quality on 3 sites (table 3.6.1). One rice field that had been cultivated for 1 year, one rice field that had been cultivated for 4 years and a reference site under secondary forest growth. The location of sites and profile were chosen based on landscape readings and management information provided by field owners and a field guide. Almost adjacent, the three sites were chosen based on the method of 'space for time substitution'.

On each site 3 profiles were dug and samples were collected in three depths. One sample was taken from the topsoil, one was sampled in the layer immediately below the topsoil and one was sampled at 35 cm. All profiles were dug approximately halfway down the hill at a slope of 13 degrees, which was measured with a clinometer. Soil texture was determined using FAO guidelines for classification (Amerling et al., 2006) and was a silt

loam for all sites. Samples were collected in situ in 100 cm3 cores for bulk density assessment. Core samples were sun dried and brought back to the lab in Copenhagen for analysis of pH, active Carbon (using Permanganate Oxidizable Carbon method, Weil et al., 2003), total Carbon and total Nitrogen (using Isotope-Ratio Mass Spectrometry).

The purpose of the soil quality study was to see the effect of longer farming periods as fields in San Pandak used to be grown 1-2 years consecutive, but are used for longer periods today.

Soil sampling in the amount that was allowed for this study is not enough to make certain comparisons between fields. With just one field representing 1 age it is difficult to assess whether the differences between fields actually reflect the number of years the field have been used or whether differences arise from factors which we have tried to control which is usage history and topography.

The collected data did not prove to be useful for ANOVA testing for which reason focus will be on descriptive statistics. For Pox-C, 6 samples are left out due to lab work complications. For total carbon and nitrogen 9 samples were tested. One profile from each site was chosen, meaning that there are no duplicates.

Table 3.6.1: Quick overview of sample sites

Site 1 – Dennis' field	Site 2 – Niellie's field	Site 3 – reference forest
4 years padi – previously old forest	1 year padi – previously 15 years fallow	Fully grown – signs of previous cultivation
		

3.7.Water sampling

Water sampling was conducted with the purpose of assessing the environmental impact of present farming practises in relation to fertilizer and pesticide use. The sampling area was upstream (station 1) and downstream (station 2) of an agricultural area surrounding river San (Figure 3.7.1). The land cover upstream of station 1 is forest and can be assumed to be 'pristine', that is, to not lead to any pollution of the river. Thereby it should be possible to detect any pollution occurring due to the farming practises near river San by the inhabitants of San Pandak. The distance between upstream and downstream sampling sites is approximately 1.3 km. According to field guide, no other sources of potential pollution occur.

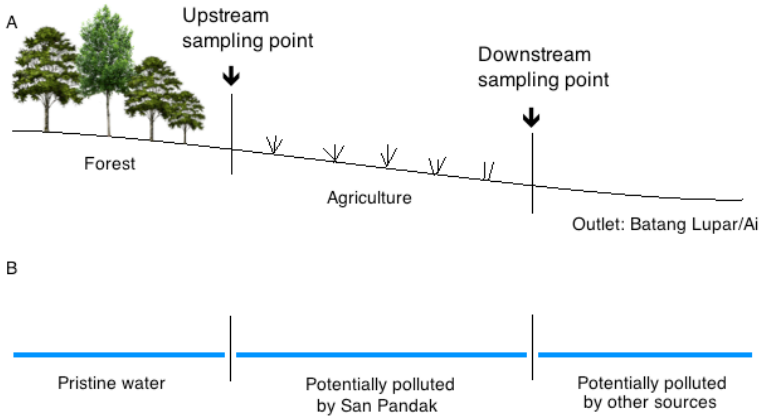


Figure 3.7.1: Overview of water sampling design. (A) Land cover and use in relation to the river San and sampling points. (B) Theoretical assumptions regarding corresponding water quality.

The agricultural area between sampling stations consists of a mixture of rice, pepper, oil palm, fruit orchard and rubber forest (Figure 3.7.2). Further, some secondary forest was unintendedly included in the area between upstream and downstream sampling points (Figure 3.7.2).

A third sample (station 3) was conducted in the gravity fed water system on request from the inhabitants of San Pandak.

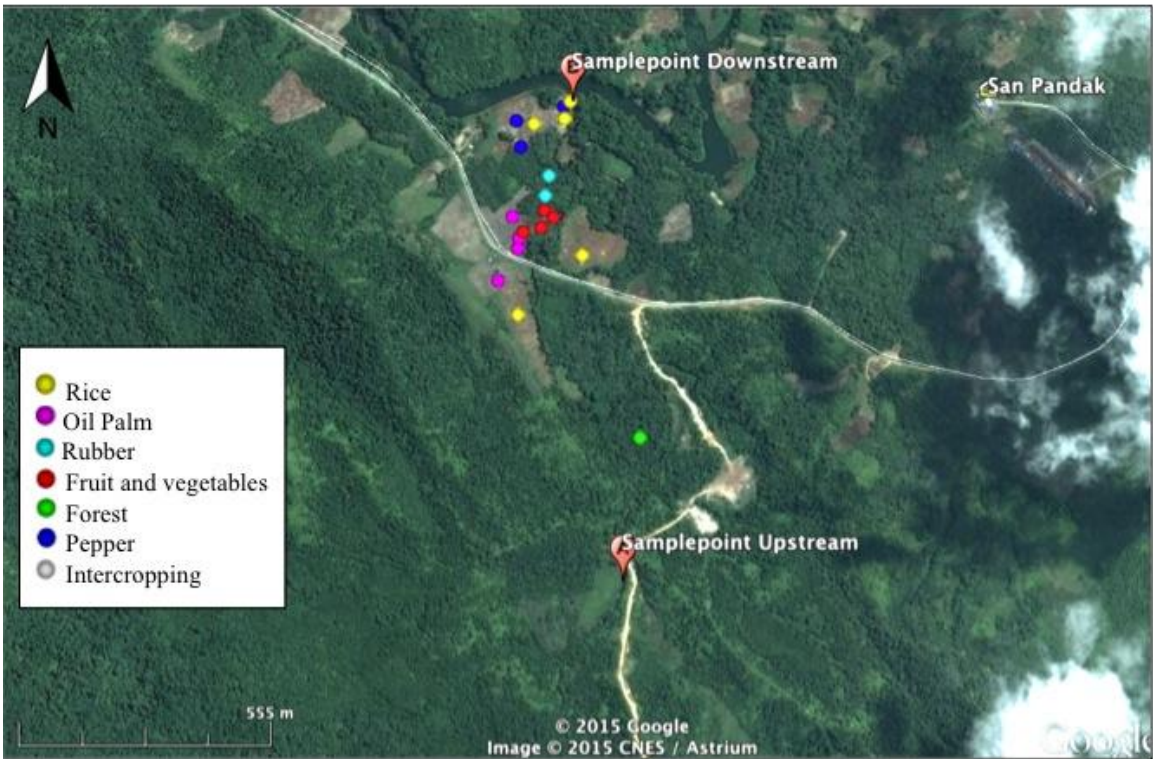


Figure 3.7.2: Land use in relation to sampling area (waypoints and observations)

In-situ and ex-situ analysis were performed on 15 parameters as part of the standard water quality analysis (Table 3.7.1). Analysis followed the 'Standard Methods for the Examination of Water and Wastewater' and 'HACH methods' as far as possible (Guan, 2014). All samples for ex-situ analysis were obtained from surface water (approximately 10 cm below surface). In-situ sampling was conducted using a multiparameter water probe, while ex-situ analysis was conducted using a variety of equipment including HACH DR890 colorimeter and various reagents. All in-situ sampling was conducted in the morning and 2-3 replicates performed on each parameter, except for TSS due to limited amount of water in sample.

Table 3.7.1: Conducted measurements, abbreviation, description and location of analysis. Besides these, qualitative observations were made at each site on fauna (fish, prawns, invertebrates), algae and colour of water body. It was unfortunately not possible to measure pesticides or metals. Highlighted in grey are the parameters most relevant to our research questions. Temperature and coliform count were included as part of the standard testing. Description and classification mod.e. Guan, (2014)

	Parameter	Abbreviation	Description	Analysis
Physical	pH	-		*In-situ*
	Temperature	-		*In-situ*
	Conductivity	-		*In-situ*
	Total suspended solids	TSS	Insoluble solids	Field lab
	Salinity	-	Salts	*In-situ*

Chemical	Dissolved oxygen	DO		*In-situ*
	Total dissolved solids	TDS	Dissolved inorganic salts and organic matter	Field lab + analysis by technicians
	Ammoniacal nitrogen	NO_3-N	Nutrient	Field lab
	Nitrate	NO_3^-	Nutrient	Field lab
	Nitrite	NO_2^-	Nutrient	Field lab
	Phosphate	PO_4^{3-}	Nutrient	Field lab
	Biochemical oxygen demand	BOD	Oxygen needed by microorganisms to degrade the chemicals in the water	Field lab + analysis by technicians
	Chemical oxygen demand	COD	Oxygen needed to degrade chemicals chemically	Field lab
Biological	Total coliform count	TCC	Indicator of number of bacteria present	Field lab
	Fecal coliform count	FCC	Indicator of number of *E. Coli* present	Field lab

The water sampling was constrained by various factors such as time and communication, entailing that we could not investigate the whole distance between sampling points for alternative sources of pollution and misunderstandings leading to the inclusion of a stretch of forest in the sampling area.

Figure 3.7.3: Pictures from work in the mobile lab, equipment provided by UNIMAS. From left to right: Preparation of FCC and TCC samples for incubation, heating of samples before analysis, colorimeter DR890 used in determination of nutrients, and an example of reagent added for coloration.

3.8. Ethno-botanical assessment

An ethno-botanical assessment was conducted to identify how San Pandak uses forest products, as it became clear in the first days through experience and observation that most meals in a day contain nature-collected products. Moreover, we wanted to examine how changes in farming management and impact from urban markets potentially affected collections and value.

The ethno-botanical walk was carried out in three different locations and settings following a 50 meter long path, and lead by a knowledgeable guide. The first walk started just behind the longhouse where different planted and natural occurring plants were pointed out as usable. The next walk took place in secondary forest where additional fruit trees were planted. The last walk was carried out in San Pandak's nearest primary forest, which was chosen for the purpose of reference (no plantings).

Each walk was tracked with GPS, and additional waypoints were taken for each usable species to evaluate the richness and abundance. Each species is photographed and noted for its use; when appropriate smelled and tasted.

The choice of a path of just 50 meter was enough to come across many different species, but at the same time it was so short that the field guide was encouraged to take his time and it was easy to ask in depth questions about each plant.

4. Case area description

San pandak is located at 1.040684N and 111.793166E with a territory covering approximately 15.80 sq km (Figure 4.1).

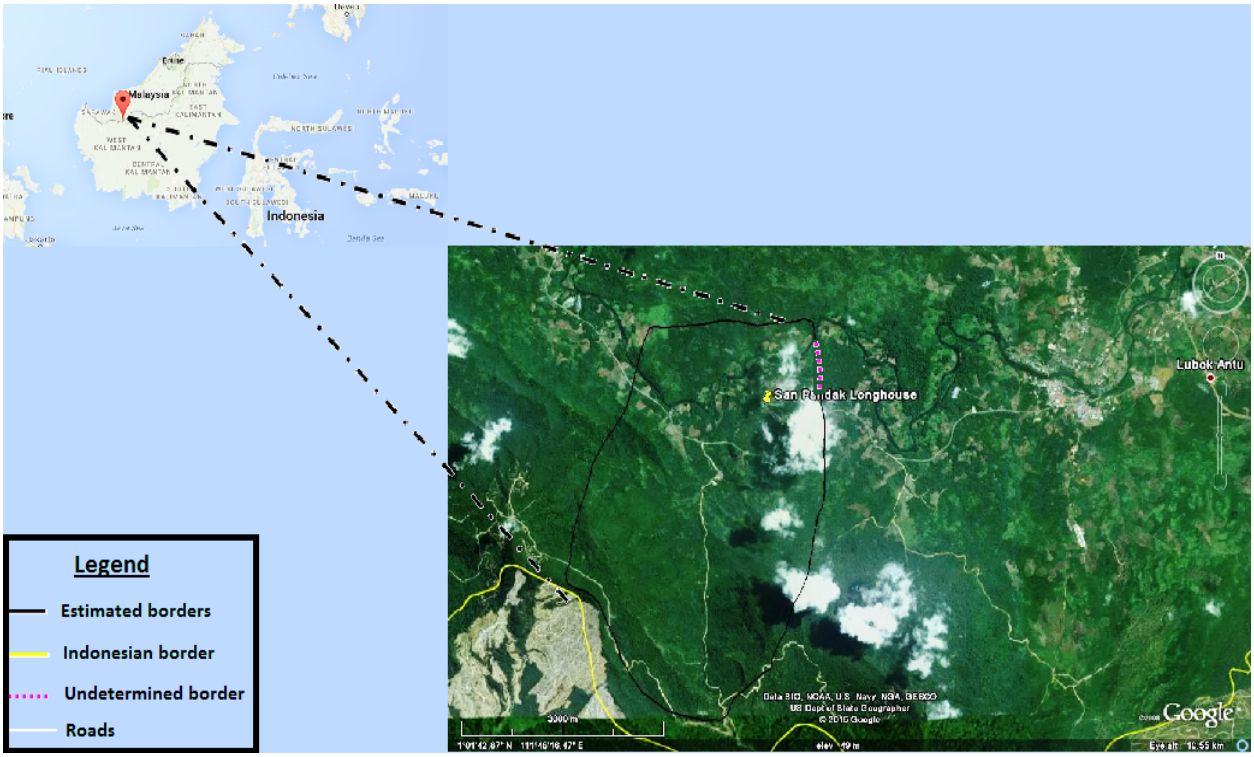


Figure 4.1: Overview of the study area.

The rugged landscape is dominated by hills in the uplands. The territory is bordered on the eastern side by a forest shared with Batu Bobini's longhouse, on the western side by the Nvembungan stream, and Indonesia at the south. There is a large forest area under logging located far away at the north. A large part of the area (approx 80%) is currently covered by forest in different stages. Farmland, comprising tree plantations, annual crops are also found. River Batang Ai permanently runs through the area, with some tributaries feeding into it. Most of the farms are found alongside the river, and some nearby the tarred road.

In 1992, San Pandak was built after the former overcrowded longhouse Nanga San split into San Panjai and San Pandak. From 10 pioneer households, the community currently consists of 44 inhabitants living in 11 *bileks*, with one additional *bilek* that is currently empty. The population is age skewed with only 20 % in the range of 21-40 years. Social hierarchy only differentiates the 'headman' occupying the central *bilek*, as the leader of the community. All the households are led by their own heads, of which only 2 are female. Main occupations are farming and off-farm jobs in various sectors, mostly held in the urban centers.

There is a primary school by the neighboring longhouse, and other basic services can be found in the nearest town, Lubok Antu, to which there has been a tarred road since 2008.

5. Results and analyses

5.1.Rural-urban linkages

5.1.1. Government policies

Policies are not rural-urban linkages *per se,* but they do influence these linkages, in terms of access to and redistribution of resources, economic and social interactions (flow of people, goods, money and information). The main policies implemented in San Pandak by Sarawak government are related to poverty eradication, agricultural development, forest exploitation and land tenure.

One of the recent poverty eradication program implemented in San Pandak since 2010 is the 1AZAM-Tani program, which focuses on generating income based on agriculture. The purpose is to increase food security and agricultural productivity, for the whole country relies on rice importation. Poor households, registered in the *e-Kasih* database are given opportunity to engage in a desired economic activity. A lump sum of RM 12000 is dedicated to each beneficiary and are used for seeds, management (fertilizers + pesticides) and training if needed. The headman of San Pandak yearly applies on behalf of all households and redistributes inputs after delivery. The process is not a part of the present study. All households presently gains from this programme, and do perceive it as a necessary input to maintain soil fertility and increase yield. Before 1AZAM-Tani, fertilizers and herbicides were supplied from the government for rice production in relation to food security and the pride not to import rice since the 1970s.

Besides the subsidized fertilizers and pesticides, the government also provide the so-called BR1M allowance, which is government support as a part of a welfare programme. All villagers receive this allowance, and it constitutes of 850RM.

5.1.2. Land tenure

Locally, the Iban custom of adat includes a social safety net in terms of righteousness that within and in between Iban communities ensures an equity related to land sharing. San Pandak that is formally part of San area is continuously, but friendly, negotiating land use rights with San Panjai. Lands are divided between each longhouse community, and further divided to individual households, which retain inheritable user-rights on assigned land. The headman is in charge of ensuring all households have sufficient farm land to sustain a livelihood.

Beside adat rules, land rights are officially governed by the 1959 Sarawak Land Code which recognizes Native Customary Rights (NCR) and aim to entitle these lands after a survey recognition to its rightful owners. San area was recognized as NCR land in 2008 based on a perimeter survey done by two representatives from the government measuring the total

area, including forest and possible overlapping lands with neighboring longhouse communities (SSI). However, the surveys suffered from being manually carried out, without involving any locals. This makes it very expensive, time-consuming and the results may be subjected to contestations due to uncertainties and limited knowledge of the area by the surveyors. For instance, some borders seem to be very difficult to determine precisely even among inhabitants (Headman interview, participatory mapping 1+2), but it still the base for the classification (special officer SSI).
The classification is used in relation to land administration, managed by Sarawak Land and Survey Department to convert "idle lands" (constituted by "State lands" and "Interior Area Lands") into productive assets optimally utilized for economic development. To do so, it is the main strategy to engage smallholders in large scale agricultural development schemes with land titling as an incentive.

Considering the effects and consequences of the above mentioned surveys, land ownership perception and continuous government subsidizing, there is no sensed fear from San Pandak dwellers of losing land or risking land rights even if the land is not cultivated. The only concern is about neighbors imposing on the land if it is left more than 3 years without cultivation.

5.1.3. Market access and infrastructure

The close connection to nearby urban centers is made possible by infrastructure development. Today, several inhabitants of San Pandak have cars and access to other areas have been eased with the development of tarred road. The fully tarred road to San Pandak was finished in 2008 and driving to the nearest town, Lubok Antu takes just 10 minutes.

In Lubok Antu, a demand has grown for food products, following urban population growth. Consumer preferences have made it possible to develop a niche market for traditional rice, but also for non-common fruits and vegetables. As a consequence, an 'open marketplace' has been constructed for local fruits and vegetables. The improved infrastructure makes it easier for inhabitants of San Pandak to take advantage of the urban opportunities both in terms of buying and selling products. Better urban access makes it possible for San Padak producers to reach more customers, thus improving the bargaining power. The price fluctuation is also better monitored, as physical checks are more frequent. These observations are in line with Tacoli (2003) who also noticed urban-to-rural flows of goods and services.

With automobile transportation goods can also be transported faster and in larger quantities. This is for example a prerequisite for oil palm production, which need to be taken to a mill rather quickly for processing.

For oil palm and cocoa, there is a national Board which regulates price fluctuation by offering higher prices to farmers than the market price. However, these crops are of lesser significance for San Pandak and for other crops farmers in San Pandak continue to rely on middlemen for information and trade. Social ties may further impede the 'perfect competition'. Distance to other urban centres constrains trade outside of Lubok Antu's district.

Beside road connection that ease access to urban centres, other facilities enhance well-being in the longhouse, such as electricity and gravity fed water. They are part of structural investments that intend to close rural-urban gaps, by fostering urbanization of rural areas. Additionally, inhabitants of San Pandak raise their lifestyle quality with market products such as TV's, kitchen appliances and modern toilets and thus depend more and more on urban-based services and goods (oil and gas, car maintenance, daily purchases in shops and supermarkets, leisure).

Above all, the enhanced mobility free people to work away from home without having to migrate due to short distances. As a consequence, only one adult from San Pandak has migrated to Lubok Antu for a job purpose while 5 inhabitants hold a job position in Lubok Antu or nearby while still living in San Pandak.

5.1.4. Migration

An important part of rural- urban linkages is the flows of people moving between rural and urban settlements. (Out)migration is not a new phenomenon for Iban young males who previously were expected to go on a journey related to the headhunter custom. After the ban under Brooke times they continued to leave the longhouse temporarily to obtain money or material goods, while the females were responsible for the subsistence activities (Soda, R., 2001). According to the San Pandak headman, the "new" out-migration started with the Japanese invasion in 1952, where young men went to war. In San Pandak, a total of 21 close family members live away from the longhouse, hereof 13 are occupied in the Sarawak area with close connection and frequent visits to the longhouse while 8 stay more permanently in other parts of Malaysia (Figure 5.1.4.1).

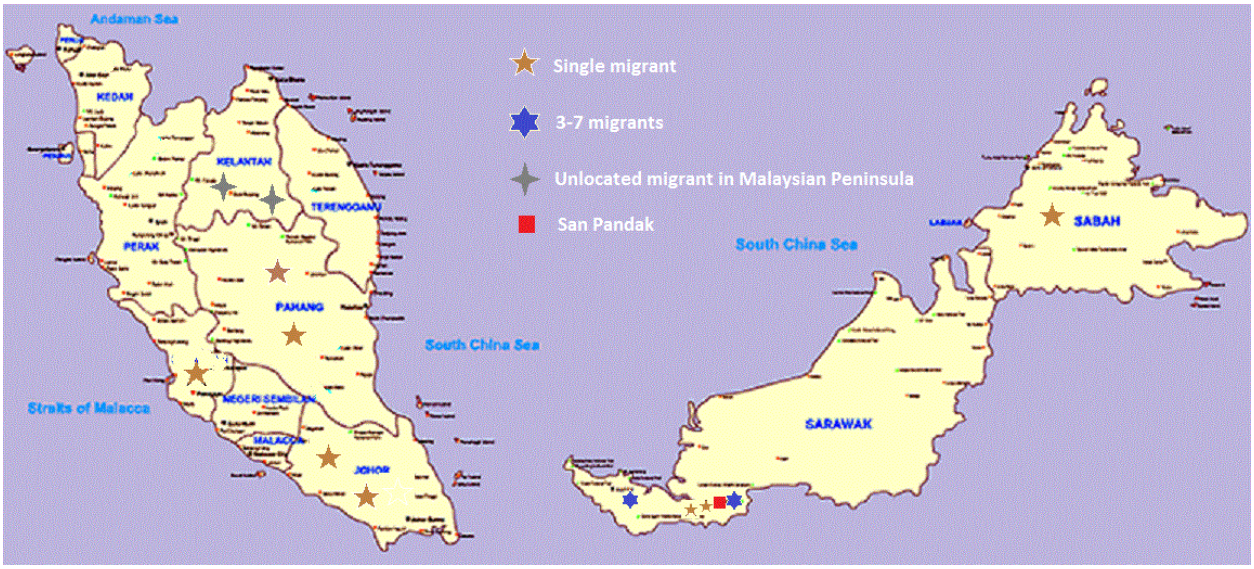


Figure 5.1.4.1: Location of migrants in Malaysia

Generally it is the younger generation (both females and males) in age around 20 who leaves the community to marry, study or work. All children go to school and are prepared for a life that does not have to include farming and some choose hired work for the monetary salary, while others choose to stay in the longhouse. One argument for staying is that the money that can be earned is not more than what must be spent for buying food, while staying in the longhouse provides the security of belonging in the community.

In San Pandak the population is assessed by inhabitants to have been stable since establishment (1992, Figure 5.1.4.2), as many migrants tend to return. The return is explained by the cultural Iban tradition of *bilek* inheritance as both a living space and a basis for identifying origins. The continuity is symbolized particularly by the inheritance of sacred rice which is an important symbol of the *bilek*-family. Tradition thus requires at least one child to stay in or to return after migration to maintain the family *bilek*, including the belonging farming land.

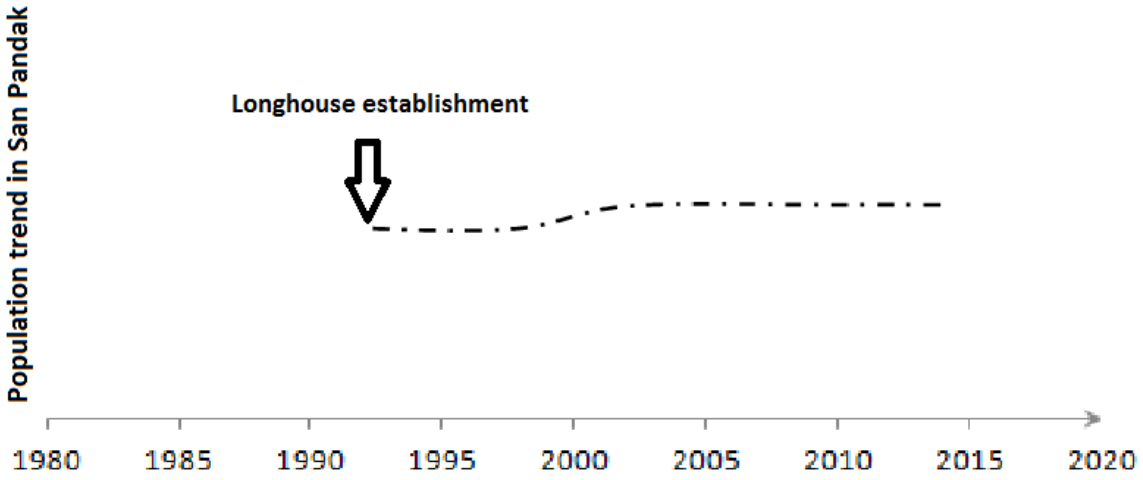


Figure 5.1.4.2: Population graph for San Pandak. Population has been relatively stable since establishment of the longhouse. One *bilek* has been added to the original house. Today there are 44 longhouse inhabitants.

Due to the migration tendency among the younger generation, the age distribution among inhabitants is skewed towards an elder population. Half of the adult (above 20 years) population is above 50 years whereof 10 % is above 70 years old. This corresponds to an urban retirement around 60 years which is followed by continuation of cultivation practices, when migrants are back in the longhouse. The age distribution limits the available workforce putting constraints on farming practices as will be developed in later sections.

5.2.Effects of rural-urban linkages on land-use

Though large scale agriculture was absent in San Pandak, smallholders have responded to changes in their socioeconomic environment by producing surplus rice, embracing cash crops and adapting farming practices in accordance to their capacities.

5.2.1. Choice of crops

The main cultivated crops are: rice, pepper, rubber (Figure 5.2.1.1). Typical fruit trees are Durian, Rambutan, Tapadia, while vegetables are cassava, pineapple, banana, eggplant, cacao-yam, chili. Leafy and root vegetables are widely grown as side-crops. Marginal crops are cocoa and oil palm.

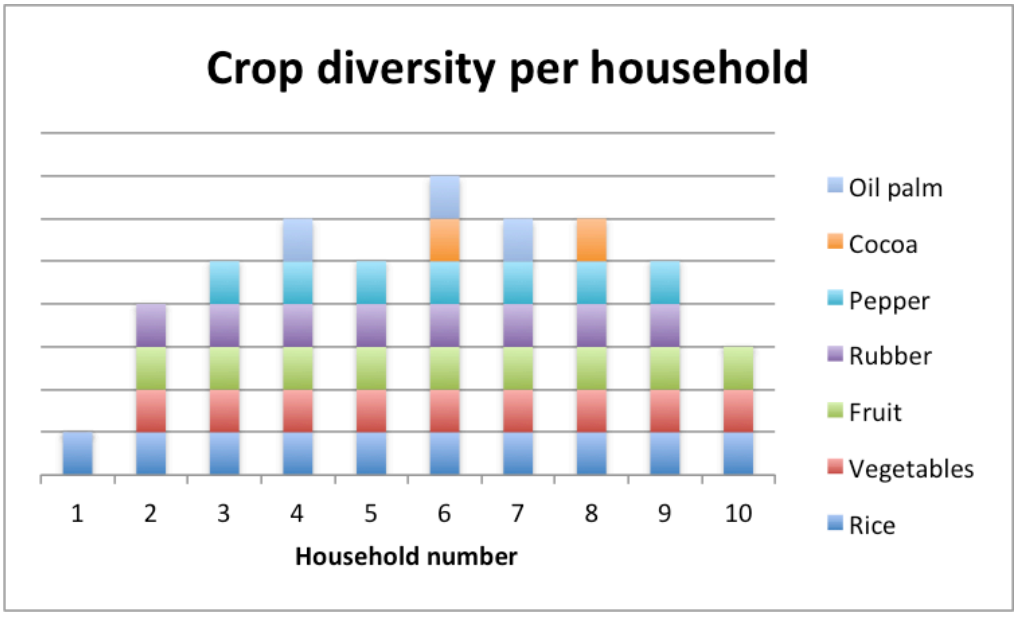


Figure 5.2.1.1: Distribution of crops per household. 10 out of 11 households grow crops.

According to farmers, market prices are the most important factor for decision making. Moreover, neighbouring success or failures also heavily influence decisions. Fluctuating market prices make it impossible to rely on only one cash-crop to obtain a continuous financial income, and various strategies may thus be developed. Market prices and allocation of land to cash crops are as well a debated subject among farmers. The same trend is observed historically, where San Pandak has proved flexible to adopt new cash crops introduced in the region. Today, pepper and rubber are found to be more preferred than cocoa and oil palm, though their adoption time highly varies among households: two households have been growing pepper over 30 years, whereas some households started recently (1-3 years ago). Reasons are related to price trends as confirmed by times series of prices (Pepper: Liew et al. (2000); Rubber: Purcell (1993)). Additional arguments for growing rubber are related to its low day-to-day management needs (since the most labour demanding activity is the tapping) and the fact that it acts as a long-term investment and a 'safety net' in hard times. Due to low market prices, farmers do not currently tap rubber in San Pandak.

80% of farmers spend more time in rice cultivation than other crops, but only 40% consider it as an important source of cash-income (figure 5.2.1.2). The current crop diversification strategy can then be understood as primary based on subsistence crops (rice, fruits and vegetables) whose surplus are marketable, and complemented by two main cash crops (rubber and pepper). The price volatility of the latter is well apprehended and obliges farmers to have both. Indeed, only two households grow less than 4 crops, and the average number of crops grown by household is 5 (Figure 5.2.1.2).

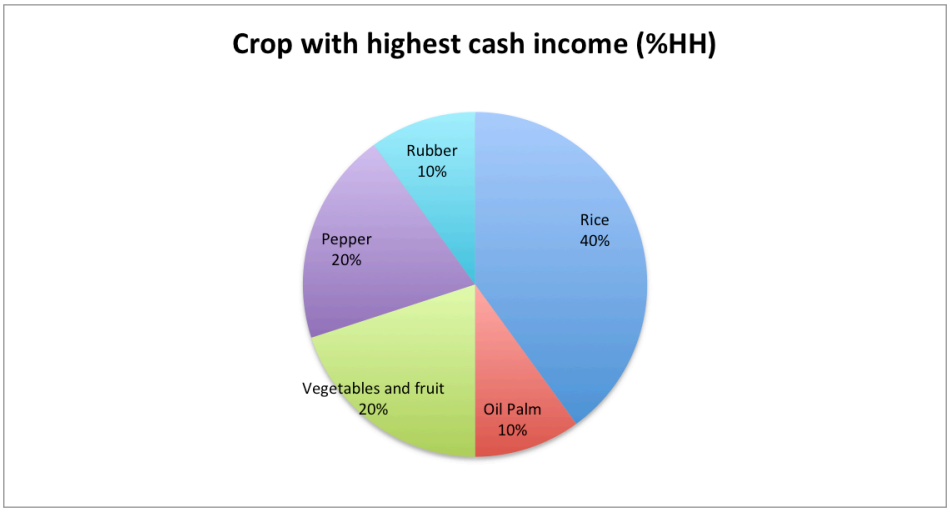


Figure 5.2.1.2: The diagram presents how important each crop is perceived in relation to income among villagers.

With reference to oil palm, success stories have flourished and after the opposition of the former headman to engage in large scale scheme, smallholder plantations have started 3 years ago. The initial investment in seedlings and the lack of facilities to support smallholders appear to be the main 'entry barriers' to have an oil palm plantation.

5.2.2. Change in farming systems

The choice of crops reflect the change in farming systems, from shifting cultivation to more sedentary practice. However, small scale fields are maintained with a diversified range of crops (figure 5.2.2.1).

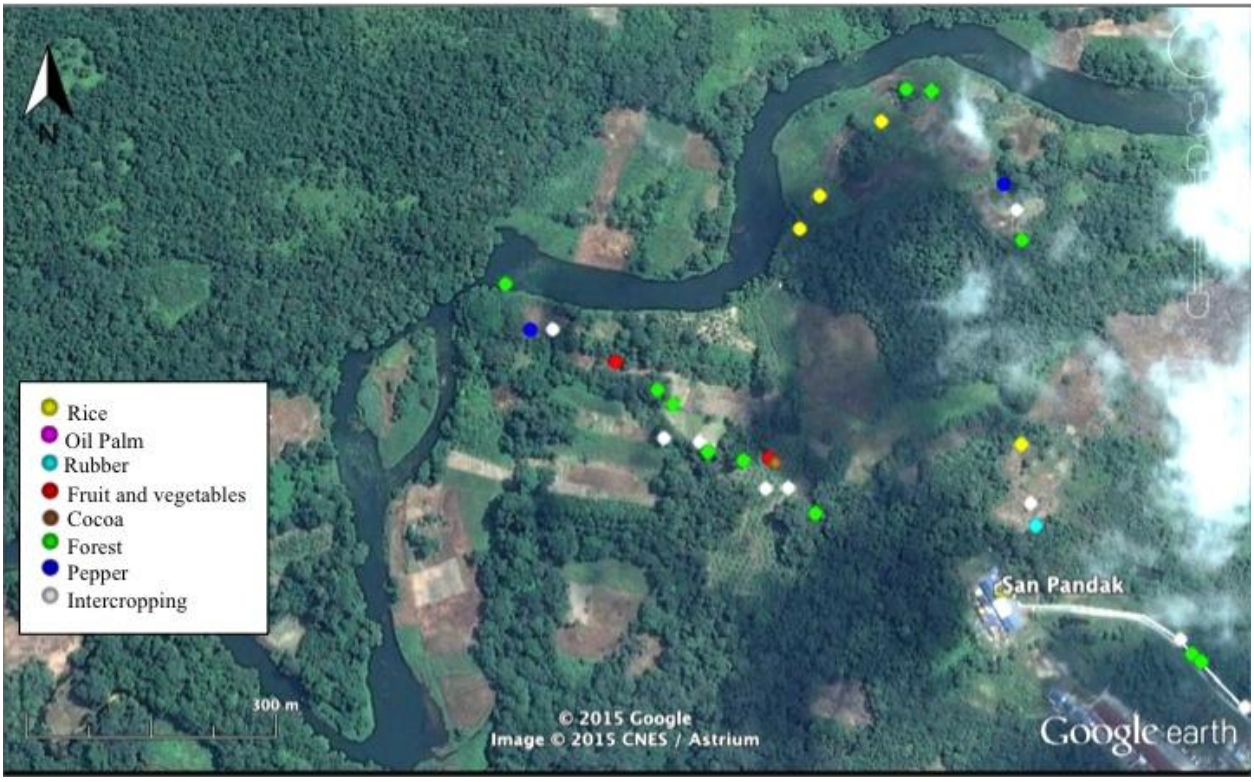


Figure 5.2.2.1: Map showing crop types in area near longhouse marked on transect walks (waypoints). A large amount of intercropping and *pulaus* ('forest islands') can be noticed (see section 7.3.4).

According to the elder generation, farmers practiced a rotation of one or two years cultivating hill rice after clearing forest land and before shifting to another plot. Most households claim to have abandoned shifting cultivation, but a few explicitly recognize having opened a new field during the last two years. Sedentary farming has been made possible through subsidized fertilizers. In fact, San Pandak farmers use 50-120 kg/ha of urea on their rice field (SSI, guided tour), which allow them to guarantee good yields. Moreover, herbicides are used before planting, and they practise 'controlled burning' when needed during field preparation. Typically, 5 to 8 years of continuous cultivation have been noticed, with some cases of up to 20-40 years.

The second most important factor pushing farmers towards sedentary farming systems is the labour scarcity, with the average farmers' age of male and female inhabitants at 52 and 43 years, respectively. The constraint towards opening new fields is on this note the low availability of young men.

The labour management is therefore in many cases dependent on *beduruk*, which literally means "helping each other", and is a labour exchange system often practised, especially during planting and harvesting of paddy rice (guided tour). It allows households to set a reasonable size for paddy fields. Labour force was also found to be an important factor for

choice of crops, and for at least one oil palm plantation the owner counted on *beduruk* to harvest the fruit. Otherwise households rely on their own labour force and seldom on hired labour.


Picture 5.2.2.1: *Beduruk* in the rice field

It can be concluded that shifting cultivation has decreased drastically and is replaced by more permanent agriculture with reduction of fallow period, mostly due to labour scarcity and use of fertilizers and herbicides. Moreover, fields are located in near distance to the longhouse, and crops is managed in arrangements guided by the crop specific needs and their compatibility.

The near distance may also be an explanation for increased intercropping of e.g. vegetables (cassava, bananas, pineapple, durian etc.). Intercropping is identified across almost all visited fields, where applicable (Figure 5.2.2.1). The decision to suppress one of the crops is then postponed, and can be further guided by the price trends. This specific case, even though not extensively practised, shows how farmers can raise the land productivity despite different plant requirements, and reduce risk of total harvest failure.

5.2.3. Changes in distribution of farmland

According to information obtained through transect walks, mapping and interviews, there seems to be a tendency of the area actively farmed moving closer to the longhouse and road compared to previous times. There are two main areas that used to be farmed, but are now to a large extent left fallow: the area located north to the river (Figure 5.2.3.1, area A) and the area across the logging road (Figure 5.2.3.1, area B). Regarding area A, only one household is still farming in this area at present (SSI, HH5), while more used to do so 20-30 years ago.

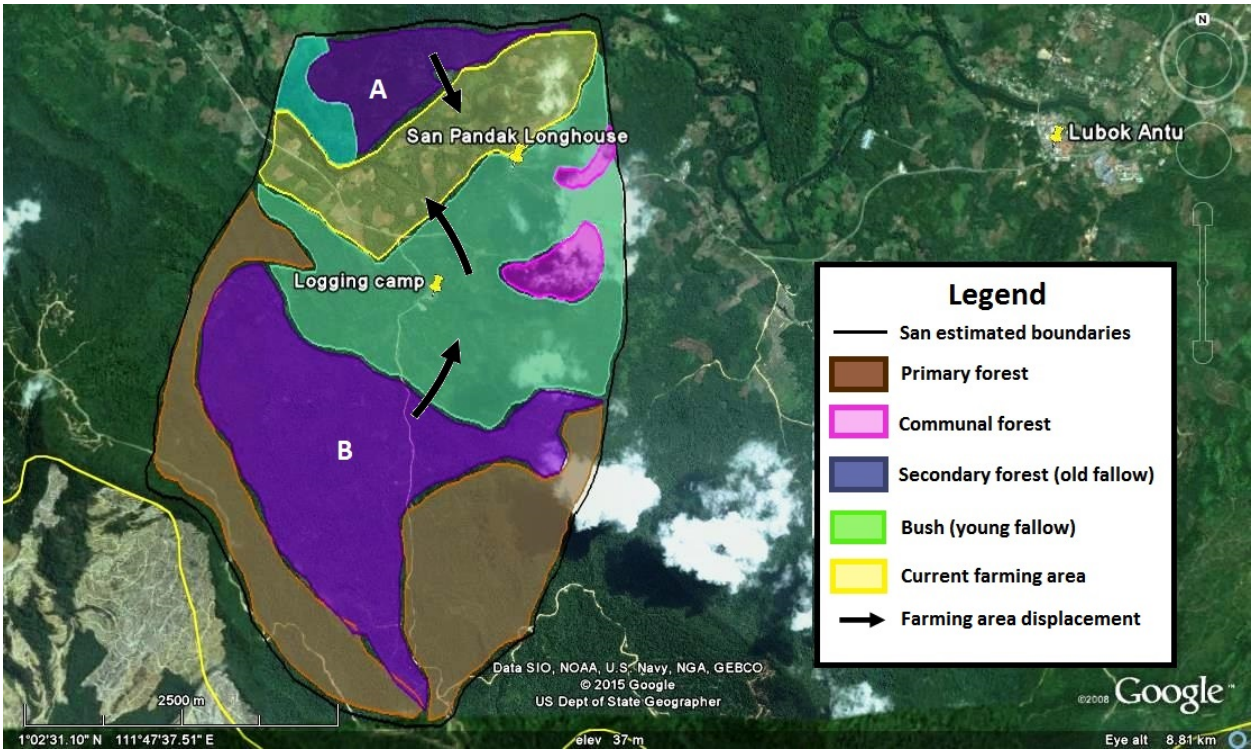


Figure 5.2.3.1: The map shows farming area displacement over time.

Area B has been left fallow for more than 70 years (Forest walk, Participatory mapping) and part of it has been subject to logging activity about 20 years up until August 2014.

According to inhabitants, fields closer to the longhouse are used due to 'convenience'. In earlier times, farmers had to stay in a *longkaow* (small hut) near their fields for one or several days to farm their fields far from the longhouse, when the distance was too large to be undertaken each day. Life in the *longkaows* was simple and made feasible by hunting of wild game. In present times, the urbanization of the longhouse has affected a range of commodities to be present in the longhouse giving increased motivation for staying in the longhouse permanently. Further, due to the increased accessibility there now is larger competition regarding the hunting of wild game animals as people of both Indonesia and Lubok Antu are coming to the area of San Pandak to hunt (Transect walk, Forest walk). This means that it is less appealing to stay in the *longkaows* and more appealing to stay in the longhouse.

5.2.4. Use of non-farmland

A large amount of the area of San Pandak is covered by forest. It was observed through the transect walk that a large amount of products are harvested from the forest areas for consumption, manufacturing of handicraft such as woodcraft and baskets for sale at the local market, and for other necessities such as fibres for string-making for closing rice bags. Most of the forest close to the longhouse is termed *pulaus,* which can be translated to forest islands. Some of the *pulaus* are primary forest, while other secondary; some of the

harvested plants are planted, others grow wild. The distinction is not clear-cut: planting often occurs by the process of finding a local and useful plant nearby at e.g. a field meant for clearing, taking this plant in order not to loose it in the fire, and planting it in a *pulau* where it might easily occur by itself as well. Thus most of the planted plants are natural to the area.

The ethno-botanical assessment revealed the density of useful plants to be higher in the secondary forest than the primary (Table 5.2.4.1). The plants in the secondary forest were noted to be wild, however the distinction may not be clear as described above. This entails that the transformation of primary forest into secondary forest does not - at least after some regrowth - decrease the amount of forest produce that may be harvested. However, the nature of produce is different at the two locations (Table 5.2.4.1), and thus it may give the inhabitants a special advantage that they have both types.

The people of San Pandak do not only gain produce of plant origin from the forest but also meat (see full list in appendix D). Especially wild boar is mentioned to be popular (informal talks), and it was observed during one night that they also catch and eat porcupine and frogs/toads. In earlier times mouse-deers were hunted, but today it is rarely seen.

Finally, the river resources are also used not only for drinking water - but also for food such as fish, turtles and snails.

Table 5.2.4.1: Results from the ethno-botanical assessment (full list in appendix E)

	Primary forest	Secondary forest
Number of species used per transect	10	17
Dominating type of usage	Timber	Consumption

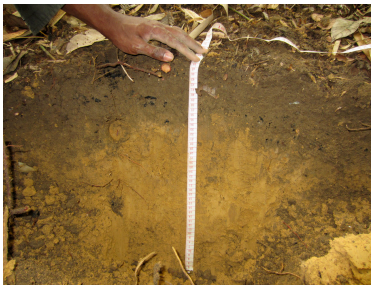
5.3. Socioeconomic and environmental impacts

5.3.1. Soil

The following section will focus on between-field differences as these might have been affected by the field age difference, especially nitrogen and carbon are of interest. Soil might also become compacted by several years of use, especially in the top layer, but no such change is visible from bulk density results (table 5.3.1.2). Bulk densities are typically between 1,0 and 2,0 g/cm in mineral soil and lower bulk densities are favorable for plant growth (Tan, 1996), so bulk densities are within a good range for the tested soils.

Farming might lead to depletion of nutrients. Looking at the soil profiles, the younger field had a darker topsoil layer indicating more organic matter (table 5.3.1.1), but the total carbon content as measured in the lab was not higher in the younger profile.

Table 5.3.1.1: Soil profiles. One picture representing each site.

Site 1 – Dennis' field	**Site 2 – Niellie's field**	**Site 3 – Reference forest**
4 years padi – previously old forest	1 year padi – previously 15 years fallow	Fully grown – signs of previous cultivation
		

Pox-C results are generally very low. Averages and standard deviations are based on just 2 or 3 samples. No clear difference can be seen between fields, but there is a clear indication that labile carbon amounts are larger in the topsoil as could be expected with appliance of fertilizer. Both fields were reported to be fertilized with site 1 only receiving half the amount of fertilizer per ha. as field 2. This might help explain why the carbon content in the topsoil is higher for the older field, both in terms of total carbon and Pox-C. High amounts of urea could have affected pH on site 1, but no real difference can be seen between fields.

Table 5.3.1.2: Lab result averages from top and bottom samples with standard deviation in parenthesis.

	Site 1 – Dennis' field – 4 years	**Site 2 – Niellie's field – 1 year**	**Site 3 – Reference forest**
Bulk density avg. topsoil (g/cm^3)	135 (±16)	127 (±21)	122 (±27)
Bulk density avg. 35 cm depth (g/cm^3)	150 (±2)	163 (±4)	158 (±8)
pH avg. top soil	4,58 (±0,35)	4,81 (±0,44)	4,94 (±0,27)
pH avg. 35 cm depth	5,13 (±0,11)	4,66 (±0,41)	4,89(±0,21)
Pox-C avg. top soil	240 (±231)	324 (±50,91)	240 (±109,98)

(mg/kg)			
Pox-C avg 35 cm depth (mg/kg)	0 (±0)	0 (±0)	216 (±374,12)

Table 5.3.1.3: Total C and N results.
One profile as each site was tested.

Site	Depth (cm)	C %	N %
Site 1	5	4.05	0.28
Site 1	17	1.5	0.13
Site 1	35	0.6	0.07
Site 2	5	3.46	0.24
Site 2	16	2.99	0.16
Site 2	35	0.58	0.06
Site 3	5	2.94	0.24
Site 3	22	1.79	0.15
Site 3	35	1.35	0.13

The total carbon and nitrogen results reflect a higher nutrient content in top soils on the fields and a steeper decline with depth in the fields than in the forest (table 5.3.1.3). This is an effect that can be expected from fertilizer appliance and crop growth on the fields.

Overall, there is not a basis to claim any significant difference in soil quality between the two fields and the reference forest apart from carbon content being higher on the fields' topsoil. These findings support the argument of the farmers in San Pandak that fields can be utilized for longer without significant depletion of soil C and N status.

5.3.2. Water quality assessment

Some of the major ways agriculture can affect water quality is through run-off and leaching of nutrients, pesticides, organic matter and sediments.

The overall water quality of river San in relation to the two sampling areas has been calculated in relation to the parameters DO, BOD, COD, pH, TSS and NH3-N (see appendix G). The results show the water quality to be a class II at both locations, and slightly better upstream than downstream (Table 5.3.2.1). A Class II signifies a relatively good water quality, where one however must take measurements to protect sensitive species (Guan, 2015).

Table 5.3.2.1: Results on the overall water quality at each sampling station according to the Water Quality Index (WQI)

Parameter	Upstream	Downstream
WQI	79.81	74.49
WQ Class	Class II	Class II

One can further assess the water quality according to individual parameters. This is done for all results in Table 5.3.2.2. It can be seen that the river San at the two sampling stations have a good water quality in relation to most factors, except for COD, DO and TCC.

Table 5.3.2.2: Results (±standard deviation, where replicates). Classification of water quality in relation to individual parameter values. Assessed in relation to reference (a) Guan, 2015 (b) NREB 2015 and (c) WEPA 2015 (Appendix G). The parameters of temperature and FCC have been omitted due to relevance and high standard deviation respectively.

Parameters	Upstream	Downstream	Change
pH[a]	7.06 (±0.18)	7.32 (±0.30)	No change
Salinity[b] (ppt)	0.01 (±0.00)	0.01 (±0.00)	No change
Conductivity[b] (mS/cm)	0.02 (±0.00)	0.02 (±0.00)	No change
DO [a] (%)	66.40 (±1.71)	43.55 (±0.78)	Decrease
DO [a] (mg/l)	5.46 (±0.13)	3.54 (±0.06)	Decrease
BOD[a] (mg/l)	0.91 (±0.01)	0.39 (±0.27)	Decrease
COD[a] (mg/l)	100.50 (±4.95)	80.50 (±3.54)	Decrease
BOD/COD	0.01	0.00	No change
TDS[b] (mg/l)	9.75 (±0.00)	14.30 (±0.92)	Increase
TSS[a] (mg/l)	0.00	0.00	No change
NH_3-N[a] (mg/l)	0.00 (±0.00)	0.00 (±0.00)	No change
NO_3^- [c] (mg/l)	0.13 (±0.01)*	0.13 (±0.01)*	No change
NO_2^- [c] (mg/l)	0.00 (±0.00)	0.00 (±0.00)	No change
PO_4^{3-} [c] (mg/l)	0.99 (±0.00)*	0.97 (±0.05)*	No change
TCC[b] (index count)	1800.00 (±212.13)	4100.00 (±424.26)	Increase

* No functional reference for phosphate and nitrate in Malaysia found, cf. appendix G.

Class I : Excellent quality, undisturbed.

Class II : Good water quality, suitable for human use. Protect sensitive species.

Class III: Moderate water quality. Protect common and moderately tolerant species.

Class IV: Poor water quality. Useful for irrigation purposes.

Class V : Very poor water quality. Not suitable for any use.

Nutrients

The most direct assessment of nutrient pollution is by measuring the amount of nutrients themselves. Results show levels of the three species of nitrogen to be very low (class I according to NH_3-N which is used by Guan (2015) for classification), while levels of phosphate rather high (up to 1.0 mg/l). There is no major change between the two stations however, which indicates no effect from agriculture.

Pesticides

It was unfortunately not possible to measure pesticides directly due to lack of technical equipment in the field. However, one can notice a very low BOD/COD ratio and according

to literature, this could be due to pollution by e.g. pesticides that inhibit the biological organisms (Samudro & Mangkoedihardjo 2010). However, it is just as likely that the low ratio is due to experimental errors, as BOD is a sensitive parameter in the sense that one is dealing with biological organisms that may decrease activity due to suboptimal treatment, e.g. in terms of temperature during storage.

Particles: Organic matter and sediments

Results show a very low value of TSS and no change between upstream and downstream stations, indicating no effect from agriculture in terms of particulate matter.

One can notice a high value of COD, which could be due to a high amount of organic matter. The factor is decreasing across stations indicating no effect of pollution from agriculture. The high COD is correlated with a low DO, however DO is decreasing across stations. This can be due to an increased flow velocity at upstream station, which corresponds with observations. TDS is increasing across stations, however continually very low compared to reference values (class I up to 500 mg/l, WEPA 2015).

No effect of agriculture in terms of salinity or conductivity was detected.

Limitations

A major limitation of the present study is that sampling was conducted in only one day. Release and entering of nutrients and pesticides into a water body is very dependent on rainfall as is acts as a carrier of the pollutants and concentrations thus show variations across time (Ling et al. 2014). Further, the pollutants are carried away in a stream fast, meaning that sampling just a few days after the release would likely not show any results. Thereby results also depend on time since application of compounds to field and in the present case, no or few fertilizers and pesticides had been added within the last month prior to sampling due to harvest season. The conclusions that can be drawn from the present study are thus limited, and further investigations over a longer time period should be performed to assess the full environmental impact of agriculture on water resources.

Further limitations regards the experimental process and equipment, which was affected by analysis having to be performed in a field lab with inadequate supplies of e.g. demineralised water.

5.3.3. Socio-economic impacts

With cash crops and off-farm jobs, households in San Pandak have more options to diversify their income, which is a strategy to become less vulnerable to poor harvests or fluctuating prices. Most households in San Pandak cultivate several crops to meet a baseline of staple income, while some additionally diversify into waged labor occupation (figure 5.3.3.1). On-farm diversification occur mainly due to cash crop price volatility. The

opportunities for off-farm employment has increased parallel to the economic development in Sarawak since 1960's, and today, 2/3 of the households have an off-farm employment income from a permanent inhabitants. Off-farm activities are listed as the most important in relation to cash income by 1/3 of the households. Among other important income sources are vegetables, non-timber forest products (NTFPs), rice and rubber; taken both monetary and non-monetary sources into account.

A part of migration is the financial flows, primarily financial remittances from migrants to their relatives. While most households do receive remittances, only 1 out of the 9 questioned list remittances (income ranking, questionnaires) as an important income source. The general dependency on remittances is categorized as less important or even not important, but most households who receive remittances use them for school expenses, buying groceries, for food and fertilizers, emergency cases or medical expenses. Indications are that monetary remittances are still highly appreciated, and have influenced the living standard positively (special officer interview), but remittances are too unstable for households to depend on it.

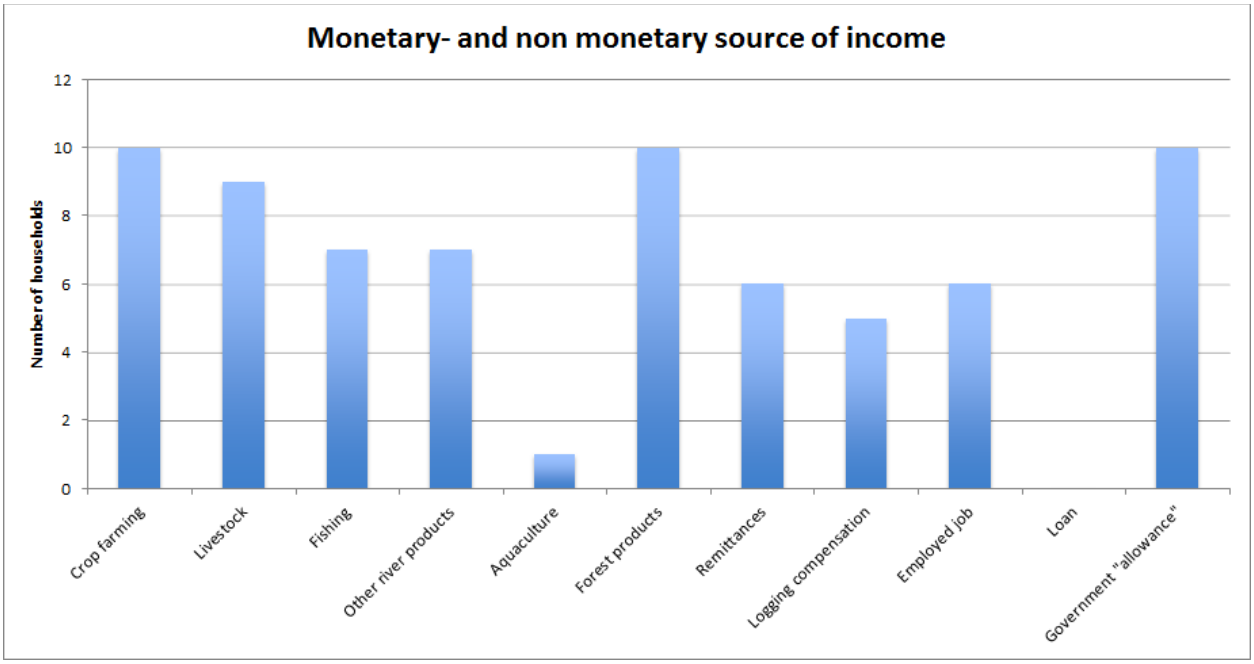


Figure 5.3.3.1: Monetary and non-monetary sources of income presented related to the amount of households stating that they use the source.

The overall livelihood of the San Pandak inhabitants is affected by more than income and is deeply interlinked with the different available capitals. Based on the livelihood framework explained by Ellis (2000) and analysed based on DFID (1999), the scope within each asset is evaluated and subjectively estimated (figure 5.3.3.2). Values are estimated based on San Pandak as a community, smoothing out differences among households. The pentagon makes a combined overview of the strength and weaknesses in the context of local

circumstances. Focus is put on relevant parameters for San Pandak. The evaluation is later discussed in relation to vulnerability (ref. section 6.2.2).

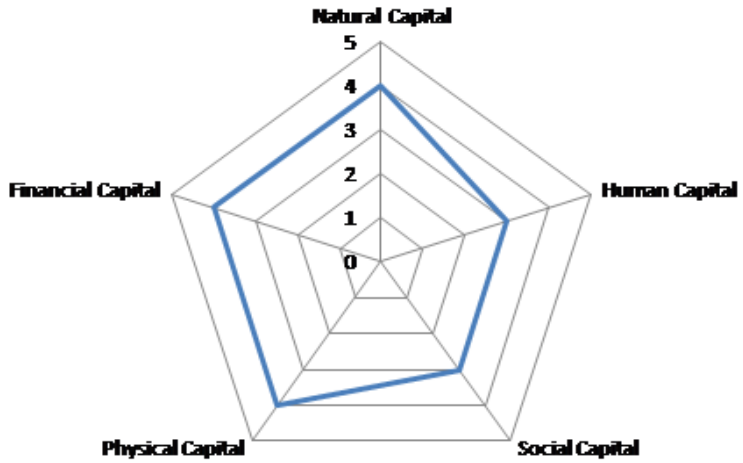


Figure 5.3.3.2: Estimated relative status of the livelihood assets in San Pandak.

San Pandak's capacity within each asset, and thus the basis for valuation, is listed underneath:

Human capital: San Pandak inhabitants are skilled and knowledgeable in agriculture production as well as for the other subsistence activities they are engaging in, and use it to improve flexibility. The age distribution of the population is not optimal for hard, labour demanding farm practices. Moreover, some of the inhabitant has serious health issues, which make them not able to work or less able.

Natural capital: The San area is abundant in land, and big areas are left unexploited. Access to land makes the high degree of self-sufficiency and subsistence activities possible. The natural environment has been degraded to some degree, e.g. by timber extraction activities that has led to a decrease in wild game for hunting.

Financial capital: A large part of the households have no savings. Also, credit for farming activities is limited as loans are only possible through the Agrobank if you are registered with the Malaysian Palm Oil Board. Remittances are received, but are not substantial. However, received BRIM allowance raise the bar considerably for the financial assets.

Physical capital: The basic infrastructure is generally good, even though clean water is still not provided. There is an easy access to information on market prices, which can be obtained through middlemen or the different agencies and boards. Two centres in the district are currently created to facilitate communication between the rural segment and state government.

Social capital: Though Ibans are characterized as competitive, rather than a close unit of community, San Pandak inhabitants still very much depend on each other for *beduruk* and also helps each other out (e.g. borrowing rice from their neighbours in the case of failed harvest). Some inhabitants also mentions having a safety net function in the migrant population, and the possibility of them providing extra funding in times of hardship.

6. Discussion

6.1. Reflections on fieldwork

The quality of our data collection and the validity of our results are impacted by conditions provided by the setting under which the field study was carried out.

The main challenge lays in the fact that we do not speak Iban and had to rely entirely on translation, making information alterations and losses unavoidable. This can partly be explained by the translator's proficiency, partly by the fact that some words do not translate well from English to Iban, though key concepts were revisited. Along the process we got better at including interpreters in our meetings. In hindsight we should initially have spent more time talking about expectations for their work, which might have made it easier to ask for their participation.

The language barrier also impeded socialization and trust building. In this aspect it was helpful that our counterparts spoke Iban and they quickly made social ties that we also benefitted from. The good social bonds meant the inhabitants were generally glad to participate in our data collection. The drawback is that they easily took over when we were working together, especially when interests and understandings diverge. In the field we attempted to share information through note taking and debriefing and this was even more important, when roles were not being kept, or when time was not given for translation.

Due to cultural differences, we feel frustrated by the way our counterparts were extremely cautious, slowing down the process. However, it seems that trusting their judgment was right as inhabitants became more open with time.

Time was also a big constraint in many ways. Time was short enough to accommodate preferences and allow common understanding with our counterparts, especially in the first days. We further had little time to agree on a research question and to get a shared understanding. This was reflected in our work when we carried out methods and at times it became apparent that we had different focuses. Limited time also meant that the process of adjusting our research question was not fully reflected in our methods and there are aspects of rural urban linkages that we now realize have been partially overlooked.

One way of working with the uncertainties stemming from the above described setting was data triangulation. We especially focused on having several sources for findings that seemed to be of much importance. Structured data triangulation of all information would have been improved if been shared continuously as it was gathered, which was difficult with the overwhelming pressure. Daily debriefings help to attenuate it, though been disturbed by need of being present and socializing. For our specific case, we were further challenged by the fact that we were not able to hang any posters in a private space, so we took into account if information was alright to post publicly.

The above-described conditions only affected social science methods. The natural science methods were mostly impacted by constraints on time and equipment, and both disciplines were supported by observations and being in the field.

As many details were lost due to the described constraints, the total well roundedness of the study was limited. Important biases are our own presumptions, which have impacted choice of questions, as well as a cultural unwillingness to talk of conflicts, which might have kept some subject from being brought up. Our results are reasonably valid but insufficient and this study should be seen as a pilot to build on rather than complete in itself.

6.2.Effects of rural-urban linkages on land use change

6.2.1. Rural-urban linkages leading to agrarian transition

Global scale land-use changes in the form of commercial logging and plantation development are also taking place in Sarawak, where the economic growth and agricultural development has transformed the landscape. Large scale cash crop productions with oil palms, pepper fields and rubber plantations have led to forest decline and and rice production areas are left to less fertile hill sites or low-lying swamps that are not suited for cash-crops. A similar trend of land use change and landscape alteration is described in several other studies of rural agricultural development from developing countries (Mertz et al., 2013; Ichakawa, M., 2007).

In the San area the transition seems slower and different in the sense that there are no large-scale cash crop productions. Instead small-scale agricultural fields are dispersed within patches of secondary forest in different stages. Small-scale cash crops are grown, while rice cultivation for self-sufficiency are also maintained and forest- and river products still make up a large fraction of daily nutrition. This is consistent with the study of Ichikawa (Ichikawa, M., 2007) who made similar observations about the use of “Iban territory” land.

However, even though small scale farming remains, the traditional Iban farming practice of shifting cultivation is being out-phased and replaced with more efficient sedentary agriculture both for subsistence- and cash crops. Driving this change are governmental

subsidy programs that cover initial establishment costs as well as the continual maintenance (seeds, pesticides and fertilizers). In this way it becomes easier for the rural population to diversify their agricultural income sources, and through subsidies the government steers affordable alternatives and have an effect on farmer's crop choices that strengthens commodity flows between rural and urban areas.

Fertilizers create incentive for sedentary agriculture and make it possible to maintain soils for longer time periods without the traditional obliged fallow in between rotations. Fertilizers have thus been a major causal factor of the decline in shifting cultivtion, as the need for discovering new fertile soils are no longer persistent. Farming systems have thus changed into more permanent structures of perennial crop plantations and successive rice cultivation.

The transition in farming practices has several effects, which have not yet been fully evaluated or understood (Bruun, et al., 2009). Studies on Southeast Asia conclude a decline in soil quality, but stress that local management and crop type is essential. The same accounts for the effect on biodiversity, (Bruun, et al., 2009). A change in soil quality in hill rice due to the transition was not recorded in San Pandak. This is likely because they apply fertilizers to maintain the nutrient flow and increase yield.

As an effect of the ongoing transition to sedentary farming in San Pandak, remote fields have been abandoned and left for succession. In fact, in San Pandak approximately 80 % of the area is fallow or forest. This trend is contradictory to the trend in the rest of Sarawak, as other areas experience land scarcity, and in these other areas abandoned land would not be reasonable. Land scarcity is moreover argued as the main driver for agricultural transition to sustain a still growing population (Cramb et al, 2009; Hansen and Mertz, 2006).

The choice of leaving land for natural succession is made possible by the decision of the government to support the native population in their right to land, which may be argued to contradict economic development initiatives. On the other hand, the government stays out of trouble with the natives by accommodating their wishes and through lucrative subsidy schemes development and transition is helped on its way.

As an example, San Pandak has the right to the unused land north of the river, but they do not have a title, and this land is being evaluated by SALCRA for plantation development. Arguments from San Pandak is that it is a convenient solution for cultivating fallow fields and to gain income, where labour would otherwise be a limitation. The various consequences of collaboration with SALCRA are complex, especially if considerations include ecological change, forest decline and alternative opportunity costs. As contracts are typically formulated today, it is likely that oil palm plantations are established for a period

of 60 years. Although the planned area in San is now fallow and does not create income, other future alternatives might underestimated at present by inhabitants of San Pandak.

Conversion into large-scale oil palms would further determine the locations and sizes of existing fields and not allow for expansion or movement according to changing environmental conditions. It might also limit options for population growth, as new *bileks* would be sharing the existing farmland, and as such risk of local land scarcity would increase.

The direction towards sedentary, commercial agriculture and waged labour is in deep contrast to Iban tradition and cultural identity, which builds on subsistence with forest- and river products and rice cultivation as the main farming system. In San Pandak many of the old customs, beliefs and structures are in parallel balanced with the ongoing modernization, which indicates an internal conflict of which initiatives to embrace, and which to dismiss. For instance both secondary and primary forest is valued for food-, and fruits collection and protected as home for spirits; and rice cultivation is still perceived honorable. These traditional values and behaviors are challenged by urban opportunities and in some cases replaced by canned food and products wrapped in non-biodegradable material, such as biscuits and water bottles, which indicates an impact from urban markets and increased convenience of having cash.

6.2.2. The effect of rural-urban linkages on livelihood outcomes of San Pandak

Livelihood outcomes are normally characterized as the objectives that people are trying to achieve through their livelihood strategies (DFID 1999). In this discussion, we use them as a parameter to assess in what direction rural-urban linkages has affected the livelihoods in San Pandak. This correspond well with the fact that assessment of outcomes normally is used to verify whether development activities are contributing to livelihood outcomes or not (Ibid.).

Increase in Income

Many rural-urban linkages have had an impact on the income generated in San Pandak, and have expanded the possible sources of income. The livelihood strategies emerging from these possibilities have increased the income of the households as rural-urban linkages are related to most important sources of income. For instance, the primary source of income for many households is off-farm work which is made possible by improved infrastructure. Similarly sale of vegetables and fruits is also made possible by good market access.

If participation in a SALCRA oil palm scheme is indeed carried out, there is the possibility that income will increase further, though opportunity cost should be considered as described above.

Improved Food Security

Food security is a core dimension of vulnerability (DFID 1999), which highlights the importance of the agricultural subsidies that helps to increase the yield and secure the availability of food. The storage of rice affects the stability of food and provides a safety net in the occurrence of a failed harvest. Moreover, paid labour can be initiated in the case of harvest failure and thereby give the household the necessary purchasing power to provide for their consumption. The solidarity of the community also plays an important part here; as a safety net, households are able to borrow rice from others and in these ways a sense of food security is created among the inhabitants.

Increased Well-Being

Another important outcome that the rural-urban linkages have provided is an increase in well-being. This enhancement is very much related to the general infrastructure, such as electricity and running water (however still only gravity fed). Agricultural government subsidies have also had a direct impact on well-being as generally perceived by the community, expressing how life was "hard" before and how life now is changed for the better. This has most to do with the decrease in labour and time consumption which the subsidies has brought about, but also the feeling of being more safe in terms of food security.

The fact that off-farm work is now possible without long-term migration, due to the improved access to urban centres also plays positive role on well-being. Now the wage worker can choose to participate in farming activities during weekends and holidays, as it is seen in San Pandak. But as mentioned earlier, the perceived benefit of being able to stay in the longhouse close to family and friends and with the comforts this includes is equally important to the inhabitants' well-being.

Although remittances are not characterized as important to the overall income of the household, they were found to cover important expenditures such as medical expenses and special school tuition, which though they might not be essential surely contributes to the well-being of the families.

Reduced Vulnerability

During peaks in prices, production of cash crops has been very profitable for the inhabitants, for instance recently (2010 for rubber and 2012 for pepper) inhabitants generated high income from cash crops that made purchases of luxury commodities such as cars and motorcycles possible. This being said, cash crops are also subject to fluctuations in world market prices (Widdle & Cramb 1997), creating times of "drought" of income, as it is seen at the moment in San Pandak with rubber. When prices are low, income diversification becomes important to reduce the impact of this. The inhabitants will reduce their tending and time spend on the particular cash crop, and put efforts elsewhere, which is easily done with rubber as it only requires very low maintenance. This creates a buffer that minimizes vulnerability (likewise to what was found in e.g. Wadley & Mertz 2005).

Another trend recently starting to affect the vulnerability of San Pandak is the change in migration, going from the traditional circular labour migration to out-migration, where the migrant is accompanied by his wife and children. Lack of labour is coped with by using *beduruk*, but if out-migration becomes pronounced, *beduruk* will be more difficult to uphold because taking part in *beduruk* also requires some able-bodied workforce. Not being able to use *beduruk* as the important coping strategy that it is, leaves the vulnerability of the inhabitants increased. This is especially notable when seeing how important the subsistence farming is, in relation to food security as well as its buffer function in times of economic shocks. Additionally, the well-being that comes from maintaining their cultural heritage, which is very close connected to the *bilek* and the cultivation of the "padi pun" (the sacred rice of the ancestors of the *bilek*), is in danger of being eradicated.

The positive impact on rural-urban linkages should not be perceived as a panacea to rural development in all circumstances (Tacoli 1998), which is certainly also true in the case of the starting trend of out-migration in San Pandak. Overall, by analyzing the capitals of San Pandak, it is clear how rural-urban linkages has helped to expand the area of these assets, which in turn has had primarily beneficial effect on livelihood outcomes. The Iban are traditional exploitative peoples (Taylor et al. 1994), and as one farmer puts it: "We will take advantage and use the opportunities given to us in order to improve our lives".

7. Conclusion

Based on the case study in San Pandak, most important rural-urban linkages were identified to be government policies, land tenure, market access, infrastructure, off-farm wrok and migration. It was found that these linkages have a significant impact on the land use in the area, in terms of the distribution of land, where cultivation has moved closer to the longhouse, as well as along the road and earlier cultivated fields has been abandoned. This is primarily due to the government subsidized fertilizers and pesticides making sedentary agriculture possible and at the same time result in high yields. The traditional shifting cultivation is therefore almost replaced.

In opposition to surrounding landscape dominated by large scale plantations, San Pandak has maintained small scale fields with a wide diversity of crops, including intercropping with vegetables. The San area has in addition kept much forest area.

With the current land use, land is abundant and negative impacts from farming were not detected on soil and water quality.

The main crops in San Pandak are limited to rice, pepper and rubber, and choice of crop is influenced by market price and available labour. Also, rice cultivation remains considerable because of the significance in the Iban culture and the food security it provides. It also functions as a buffer, when market prices are low.

There has been a long tradition of circular labour migration, which impacts the age distribution and therefore the labour force. A trend towards out-migration is emerging as job opportunities in the urban area are becoming more reliant, which in turn may jeopardize the continued existence of some of the bileks.

Apart from this, the rural-urban linkages and the income diversification it has created have generally improved livelihoods, increased the well-being of the villagers and reduced vulnerability.

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Appendices

Appendix A. Overview of applied methods

Method name	Specification	Amount
Questionnaires		11
San Pandak Headman interview	Initial overview	1
Informal Headman San Panjai interview	Shifting cultivation, pepper, rubber, oil palm	1
SSI with Special officer	Land tenure, government development programmes, subsidies, land scarcity, migration, rural-urban linkages	1
SSI with households	Household (HH) 1-3 + 5-9	8
Group interview	Government development schemes	1
Participatory mapping	PRA group	2
Crop ranking and scoring	PRA group	1
Population timeline		1 HH
Logbook		5 days
Transect walks and guided field tours	From longhouse to river Batang Ai, logged forest and gravity fed water system, agricultural systems.	5 trips
Ethno-botanical transect walk	Old and new forest	2 walks, 48 species
Ranking of most important income	Questionnaire format	9 households
GPS mapping	Continually with other methods	16 tracks, 143 waypoints

Soil samples		28 samples, 3 sites
Water samples		3sites

KØBENHAVNS UNIVERSITET

Synopsis for research proposal

Migration effects on land use and livelihoods in San Pandak, Malaysia

ILUNRM 2015

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Introduction

The case study of *Migration effects on land use and livelihoods* takes place in San Pandak, Sarawak comprising 12 Iban households located 5 km from the town of Lubuk Antu.
The Ibans represent the largest tribal population in Sarawak, who has a long tradition of shifting cultivation and small-scale farming. The Ibans live and rule under adat, a body of beliefs, social norms, customary laws and traditional practices used and recognized in daily issues. Besides the assigned geographical area (categorized as NCR land) the land comprises tales and legends, village histories and important events which link the land to the people and give people a sense of "belonging to the land, just as the land belongs to them" (Colchester et al, 2007: 9).
The hilly terrain district of Sarawak comprise a mosaic of secondary forest of various ages, rice cultivated fields (upland and lowland), rubber and pepper gardens and oil palm plantations. Rice cultivation normally follows a slash-and-burn process of secondary forest, and cash crops may be integrated during or immediately after rice cropping (Ichikawa, 2007). Fallow periods may vary in length depending on population pressure, use of fertilizers and management practices. In the case of San Pandak, the land use pattern does not seem to be intensive in the sense that large patches of old fallow land (temuda) are scattered in the area, where they seem to grow back into forest rather than being recultivated (Field sites, SLUSE 2015).
The observed fallow patterns might be related to changes in migratory patterns and following changes in available labour in the village. In the past 40 years, a migration trend among young Ibans of both genders to urban areas has been found to be increasing (Cramb and Sujang, 2011). This trend of semi-permanent or permanent migration may have several drivers such as government policies, infrastructure, life strategy and available job-opportunities in off-farm activities (Fox et al, 2009). Consequences linked directly to the change of available labour may be found in farming practices, land use intensity and management of resources (Hansen 2005).
These drivers and consequences linked to migration are interdependently connected, and must therefore be investigated with an interdisciplinary and holistic approach. The social structure in the village and their own perception of important livelihood values are crucial measures to understand the drivers of the land use change and migration pattern observed. Similarly, the changing land use strategies may alter the ecology and state of natural resources (ecosystem services) on which the Ibans still heavily rely on. The aspect of sustainability in both livelihood strategy and ecological state is therefore very relevant to evaluate based on a broad variety of social,- and natural-science methods.

Problem framing

The rural-urban migration of Sarawak change socio-economic and demographic characteristics of rural communities. One changing characteristic following from migration is the available labour for farming activities, which may be an explaining factor of land use change (LUC) in combination with other important drivers as e.g. the transforming political system which encourage participation in various land development schemes (e.g. logging activities, oil palm plantations) and promote local economic development.
San Pandak has experienced migration in the later years and is used as a case study to investigate migration effects on livelihood strategies and the following related LUC's.

Problem formulation

How does migration affect livelihood strategies in San Pandak? How may the trend of migration be linked to land use change, and which impacts does it have on the surrounding ecological environment?

Objectives:

- Assess **livelihood strategies** on household and community scale, with focus on human and natural capital.
    - What are their activities?
        - Off-farm (compensation from logging, remittances, Non Timber Forest Products)
        - Farming practices (hill rice, swamp rice, rubber, oil-palm, pepper)
    - What is gained from the activities?
        - income composition
        - living standard level?
    - How do they make their decisions? Decision-making and land tenure
        - How does this relate to neighbouring San Panjai?
        - How is the relation to San Panjai?
        - How does available resources affect their activities?

- Assess use of **land and resources**
    - What is the composition of land cover and land use?
        - How has it changed over time?
        - What are the perceived drivers of change?
    - What is the fertility status of farming land, fallow fields and potential farming land?
    - What are the **environmental effects** of present practices?
        - Water and soil quality?
        - Forest area and biodiversity

- Assess whether **migration** affects the livelihood strategies and land use in San Pandak
    - How can the current labour migration be characterized?
        - What gender and age characterizes the migrants?
        - Is the migration temporary or permanent?
    - Does the out-migration have a significant impact on available labour for farming practises and thereby on land use?
    - Examine if there is a linkage between migration and forest regrowth?

- Analyze the potential for increasing the ‘room for manoeuvre’ in relation to natural capital

Theoretical framework

We are interested in assessing the effects of labour migration on livelihood strategies and ecological environment in San Padak. Building on the Sustainable Livelihood Framework presented by Ellis (2000), we will explore changes in livelihood strategies focusing on the human and natural capital.

By migration, we mean the move of individual(s) from one geographic unit (longhouse) to another (town) in search of employment, as involving a change in usual residence (cf. case description of San Pandak).

Methods

According to the established research questions, several practical field methods are applied in order to collect data that represent the situation in San Pandak. The main aim of using multiple methods for the same research question is to validate obtained knowledge through triangulation and using methods most appropriate for investigation of a given question. The relation between research questions and field methods are outlined in figure 1 (appendix 1), data matrix in appendix 2 and timeline in appendix 3.
In the following section the methods for collecting empirical data is presented.
The outcomes of the headman interview, questionnaires and initial observations will provide focus and be used to prioritise between the methods described below.

Key-Informant Interview (Appendix 4.1)

According to Mikkelsen (2005), the key informant interview aims at obtaining special knowledge from individuals that potentially have broader knowledge about a given topic. The key-informant will be used to test preliminary hypotheses shortly upon arrival and to gain overview. The headman-key informant interview is expected to cover topics related to the first objective including the decision-making process at a community-level and the relationship with neighbouring longhouse (San Panjai). In addition, he is asked to uncover the general topics such as perceived drivers of LUC, historical events (e.g. initiation of logging, migration trends) and their discursive effects, as well as his opinion on ecological state, which all relate to research objective two and three.

Questionnaire

Short questionnaires will be used initially with the double purpose of presenting ourselves to inhabitants and to obtain initial information on households, e.g. amount of household members, any migrants in household, activities practised such as farming and forest-use. These initial informations will be used to guide us when performing semi-structured interviews (SSI).

Semi-structured interview (Appendix 4.3)

In order to obtain in-depth information and understanding Mikkelsen (2005) and Gillham (2000) suggests the use of interviews. The purpose of the semi-structured interviews in the present setting is to understand choices related to livelihood strategies and characteristics on household and community scale, including land use and changes in land-use, perceptions of quantity and quality of available land/natural resources, and effects of migration.

Semi-structured interviews will mainly take place with household (HH) members. The case area has just one longhouse with just 12 households which should make it possible to interview all households. If not possible, interviewees will be chosen to represent different household types (based on household structure, different livelihood strategies and specific purposes) based on information obtained through questionnaires and interview with headman.

Transect walks/ walkabouts

Transect walks are a joint exercise, usually with a local informant, that facilitates observing, discussing and registering the endowments and problems of the area walked through (Mikkelsen 2005).

Empirical data from the walks will be drawings of (present) land cover and written field notes. During walks waypoints will be noted by GPS as will the full length of the walked track.

The main goal of transect walks is to deepen our understanding of topics such as local LUC, and community boundaries. farming practices, labour requirements, perception of soil quality, forest products use, global landscape management decisions.

GPS measurements

The opportunity to map geographic points (5m precision) is very useful to identify plots, areas or location, which easily can be used in spatial analysis.

GPS is primarily used to map the boundaries of territorial units. Certain areas that are reported to have changed cover in recent years might be mapped using GPS and matched to satellite images and participatory map– to improve accuracy.

GPS may also be used in relation to the forest assessment and forest biodiversity assessment, depending on the current spatial attributes of the forests.

Satellite images analysis

In order to estimate land covers over time, satellite images in high resolution serve very well as a component in triangulation with GPS constructed ground truth positioning in the years of available imagery.

Satellite images (Pléiades', resolution 50cm (.un-spider.org)) obtained from Google Earth are available for the area over San Pandak from 2011 (no color) and 2014 (natural color) which can be used for visual comparison in relation to changes in land cover. A time line reference for older land cover changes may also be constructed from satellite imagery from Landsat 7 and 8 (USGS/EROS: https://earthexplorer.usgs.gov)

Imagery is also available at the Sarawak Geoportal (http://www.bmfmaps.ch/EN/composer/#maps/1001)
The imagery will serve as reference to participatory mapping and to check other related information obtained through qualitative methods.

Participatory mapping (Appendix 4.4)

A participatory mapping exercise can provide quick and reliable spatial information to limited physical space and settlements. It is done in a group to incorporate a corrective function (Mikkelsen 2005)._The method is applied in relation to the second research objective regarding land use. We expect to perform two sessions, one with presently active farmers to get the best description of present uses, and one with elders that may inform us on changes in relation to past uses. However, it is likely and potentially beneficial that these two groups of participants will overlap, and thereby only one session will be relevant. In that case, we will take care to distinguish the two purposes: present use and past use/changes in use. When discussing changes over time, the timeline created in the key informant interview will be used to differentiate between "earlier" and "later" times and we will include discussions on perceptions of "under-" and "over-utilized" land. The map and following discussion can be used for a trend analysis.

Focus group with migrants

Focus group interviews are a useful method to establish a dynamic conversation about a certain topic (Mikkelsen, 2005).
The focus is dedicated to collect information on migration trends and drivers. We will, if possible, conduct two focus group sessions: one with 4-5 active migrants identifying the reasons and personal values behind their decision to leave the community, and one with non-migrants of the same age on reasons for their different choice. This will give us an understanding of drivers of migration as well as future trends. We are aware that it may not be possible to conduct the focus groups sessions as migrants may not be present in the longhouse, however we hope for them to be present in weekends and possibly evenings.

Ranking and scoring (Appendix 4.5)

Ranking and scoring can be useful for generating information on people's priorities, and are good at covering sensitive issues such as wealth, because the participants are only asked to provide relative measures rather than absolute measures (Mikkelsen 2005). Another important outcome of ranking and scoring exercises is additional and often interesting information from discussions during the exercise (Ibid.).

In the present study, ranking exercises would be relevant in terms of evaluating the importance of migration as a driver of land use change in comparison with other drivers such as e.g. infrastructure and policy changes. Ranking may also be performed in relation to wealth-assessment to investigate whether differences in livelihood strategies are related to wealth. Local measures, judgements and materials will be used for the exercises, as they sometimes help to demystify the exercise (Mikkelsen 2005).

Direct observation

The main purpose of observations is to provide important information for posing central questions (Mikkelsen 2005). Observation will also be used to gain an overall understanding of the community which will be helpful for adjusting and answering research questions. Field observation takes place at all times during the stay, but also with specific attention in some situations (estimate present land cover, difference in wealth between different households, large presence of sediment in the river, community cohesiveness, quality of crops, presence of earthworms in fields and forest biodiversity).

Soil quality tests (Appendix 4.6)

Soil quality indicators are useful to assess environmental characteristics. In relation to our second research objective, soil samples on quality (fertility, degradation) are collected for different farming activities and management practices to examine effects from different practices.
According to the second and third research objective, we will investigate whether some land undergo a possible "extensification" in terms of longer - or even permanent fallow periods and specific lands are being intensified. The reason is to conduct a series of soil samples which indicate the level of recovering/exhaustion. Conducted field investigations will base on locations in different stages of fallow, succession stages in the growing secondary forest and in the more intensively cultivated fields. The locations must be identified carefully with respect to prior land use and topography, and will be analyzed in a spatial context that may reveal certain trends.

Water samples (Appendix 4.7)

According to the third research objective water samples are used to examine water quality in terms of environmental impact of various land uses. Logging and agricultural practises may lead to silting, chemical pollution and detrimental changes in pH that may harm the local ecosystem as well as ecosystems downstream. This is especially relevant for the inhabitants in San Pandak, if fish species of use react negatively to the changes or if substantial pollution occurs with e.g. pesticides. We expect water sampling to be especially relevant in relation to environmental assessment of logging practises, as these have been stated in the case description to lead to silting.

Forest assessment (Appendix 4.8)

The forest assessment includes mapping of actual accessible resources in both secondary and primary forest as well as identifying which products are valued.
The forest assessment also aims to measure standing biomass (in terms of basal area using relascope and clinometer) and forest (re)growth rate. Making a biodiversity assessment, i.e. the UNA-index, will easily helps identify structural features that can be converted into a measure for biodiversity (see appendix 4.9, GEUS skovstrukturindex). If logging activity is derived to be valued highly from the first interviews with the headman, both the pace of logging and information regarding the management will be investigated through SSI.

Delineation

Our experimental investigations will be geographically delineated to San Pandak, however we will compare research with literature from other places (Sarawak, Borneo/Malaysia and world). Our experimental period in the field is 10 days, which put clear delineations on feasible sampling, and sampling according to obtaining statistical significance may not be possible. Technical delineation will be according to available equipment.

Collaboration with counterparts and interpreters

We are in contact with our Malaysian counterpart regarding research question and methods, and our proposals are very much in accord at present. Details on methods will be finalised upon meeting the 27th February. In the cooperative work we will put attention on making use of individual skills, on keeping an open and including atmosphere and on doing daily debriefings.

We will take care to include the interpreters and learn from experiences expressed in Kerani (n.d.).

All methods will be corrected upon meeting with counterparts and social science methods will be tested with interpreter before implementation in field.

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web-sites

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Appendix 1. Flow-chart

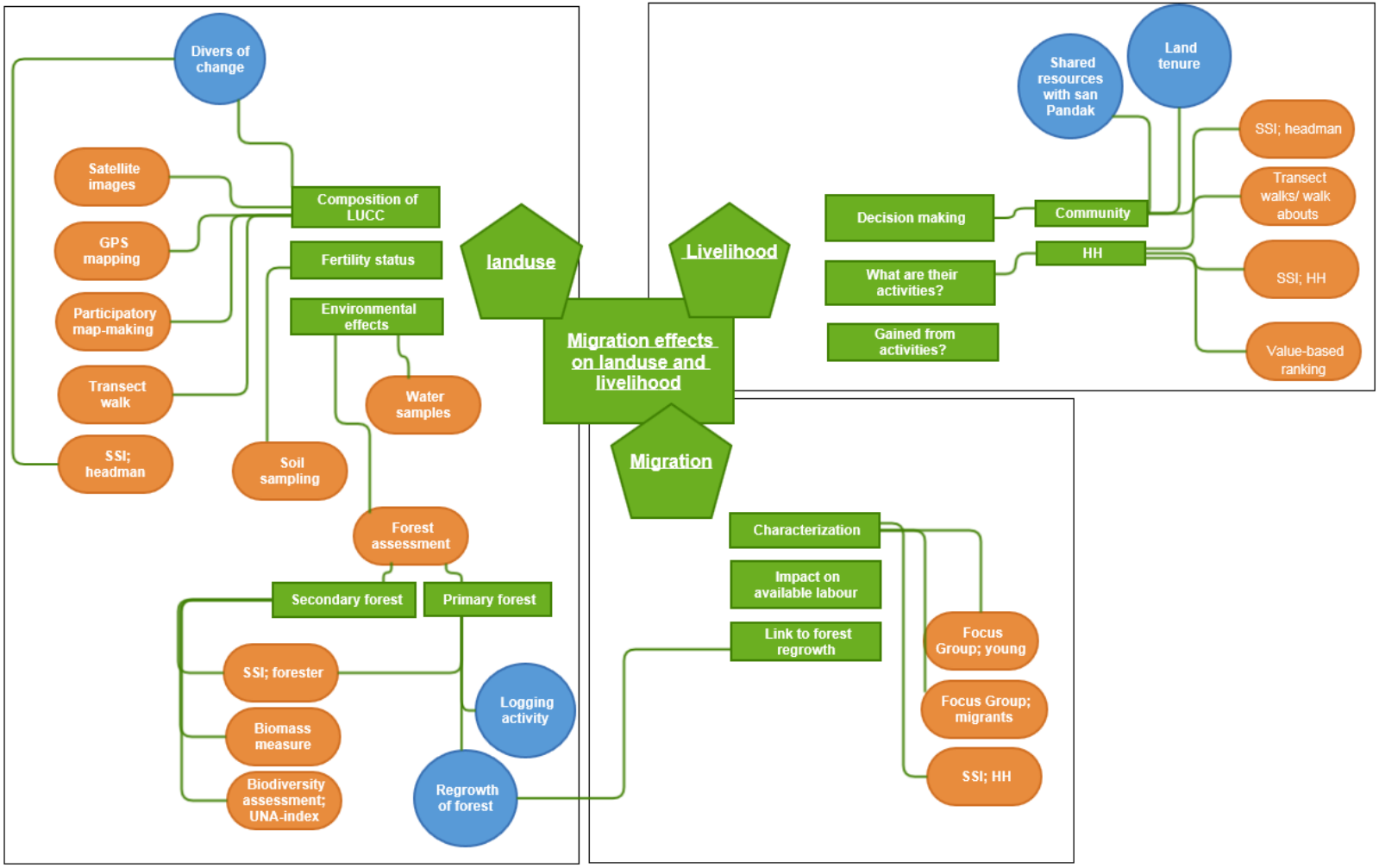

Figure 1: The flow-chart is a graphical presentation of how the different methods are connected to the research objectives stated in the problem formulation.

Appendix 2. Data matrix

Research Questions	Task/ Sub-questions	Data Needed	Methods	Equipment needed/Input
Assess livelihood strategies	Describe the livelihood portfolio..., 	- Listing of activities per household (HH) - Composition of household income	- Household questionnaire - Observations*	- Stationery* - Interpreters* - Key-informant - HH residents
	... the use of natural and human capital assets,	- HH demographics and characteristics - Labour and land availability - Factors limiting access to resources (policies, land rights, regulations, social norms, power relations, etc) - Allocation of resources per activity	- HH survey - Semi-Structured Interviews (SSI) with selected HH - Focus-group discussions - Scoring limiting factors	- HH members - observations - Ranking exercise
	...and the livelihood outcomes as related to risk mitigation	- Food self-sufficiency/surplus - Cash-income level and stability - Other benefits and priorities	- HH survey - SSI	- HH members
Asses land and resources	Describe land use and its change (LUC) over 20 years	- Aerial photos - Satellite images - Participative map	- GPS mapping - Remote Sensing classification - Participatory mapping	- GPS - Secondary sources - Large papers, pens
	Evaluate natural resources at community level	- Soil quality (fertility) - Water resources and quality - Forest resources	- Soil sampling - Key-informant interviews, SSI -Water sampling - Forest resource assessment (relascope and	- Topsoil sampling material - Water quality assessment equipment - Relascope,

			sample plot measurements) - Transect walk	clinometer, tape measure - Weight-scale
	Assess the environmental impact of the current land use	- Soil and water quality (degradation and pollution) - Forest biodiversity - Other important ecological services/functions	- Soil/Water sampling - Species counting on transect/sample plot	- Water quality analyses material
Assess the effect of labour migration on livelihood and LUC	Describe how labour migration affect livelihood (decisions)	- Village history: progression of migration rate/tendency - Historical changes in livelihood strategies	- Historical mapping - Focus-group discussions with elders	- Elders
	Analyze relations between labour migration and LUC	- Decisions made over land use at household and community levels	- SSI - Focus-group discussions	- Migrants, HH permanent residents, headman, community authorities
	Identify other drives of LUC	- Individual and household motives	- SSI	- HH members

*applies to most/all methods

Appendix 3: Time Table

Activity	Day 1 27-Feb			Day 2 28-Feb			Day 3 1-Mar			Day 4 2-Mar			Day 5 3-Mar			Day 6 4-Mar			Day 7 5-Mar			Day 8 6-Mar			Day 9 7-Mar			Day 10 8-Mar			Day 11 9-Mar		
	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E	M	A	E
Finalizing proposal																																	
Finalizing of survey and interview questions, PRA with Malaysian counterparts (Kutching)																																	
Evaluation of progess and results within research group - assess need for modifications																																	
Preparation of presentation																																	
Presentation of modified synopsis to teachers																																	
Presentation of priliminary results to village people and local officials																																	
Social events																																	
Transport																																	
Understanding of setting (social, land use and natural ressource availability)																																	
Observations																																	
Semistructured interview with village headman																																	
Semi-structured interview with village households																																	
"walkabouts" (potentially with GPS)																																	
Surveys																																	
PRA: Participatory map making																																	
PRA: Ranking																																	
PRA: Transsect walking																																	
GPS mapping with village ressource person (determined the day before)																																	
Natural science methods																																	
Water sampling																																	
Biodiversity (two stages of fallow + primary forest + cultivated field)																																	
Assessment of standind trees																																	
Soil sampling (fallow + primary forest + cultivated fields)																																	

M= Morning
A= Afternoon
E= Evening

Potentially longer time for understanding of setting. Depends on when we are to present to fellow students.

Appendix 4. Methods Appendix

The following outlines drafts of method approaches and execution, as well as agreed-upon guidelines for execution of methods.

Appendix 4.1. Interview with key informant: Headman

Interviewee: Headman (and Household heads/Elders if present)
Objective: Getting **overview** of history, strategies, land use, migration extent and impact, logging in primary forest, drivers of change.

The themes are topics that we would like to cover in the interview. However, the idea is to have a loosely structured interview that covers topics that are important to the community. So all topics that are mentioned here might not be covered.
Primary and secondary questions are meant as probing questions that we can ask if we need to steer the interview in a certain direction.

Bring: Gifts, paper, pens

Theme	Primary question	Secondary question	Notes	Expected outcome
Introduction of us, aim with fieldwork and interview	Is it okay if we take notes and use this information in the report? -Permission to use dictaphone		Bring notebook and gift Start with "Thanks for having us and taking time to meet with us"	Introduction
Personal information	Tell us something about yourself	How did you become a headman?		Introduction
Community structure and village description	Describe the village	How many live in the village? What are the family relations between people?	Draw in who lives where, if mentioned.	Overview
	Daily life in the village	When do people get up? Go farming? Go to work?		Practical information
History	When did the community move here? Why? What are the major events of the community for the last 10 years?		Draw timeline?	Overview
	What is the relation	How has land been		Overview

	now with San Panjai?	redistributed since you left them? What is shared and how is the relationships?		
Village activities	What are the activities of the community?	The overall community? The individual households?	Refer the map above (Livelihood)	Overview, Livelihood assessment
	How have the activities changed the last 10/20 years? What do you think the reasons are of these changes?	E.g. less farming? E.g. migration, infrastructure, internet (...)?		(Drivers of change)
Income	What are the major sources of income for the community as whole?	Logging? Remittances?		(Livelihood)
Migration	Describe the migration that is occurring	How many? Who (young, males etc.)? Development over time? Has migration increased in later years?	Draw on timeline	Assessing relevance of migration
	How has the migration affected the community?	Less dependent on farming? Better living standards?		
Farming	What are the changes in farming now compared with for XX years ago	Less land farmed? More intensive farming close to the longhouse? Less labour intensive farming? More logging? Are fields allowed to lie fallow more now than previously?	Know year to refer to from timeline: when migration were substantially less (Land use)	Assessing whether we should focus on farming in later research
	Are you experiencing a change in fertility over time?	E.g. near to longhouse, on rice fields?		
	Whom would it be best for us to talk with to know more about the community farming practises?			Practical
Logging	How far away is the primary forest where logging occurs?	5 km? 10 km?	Bring map so that headman may show location	Assessing whether we shall focus on logging in later

	Did people from the longhouse use the forest before?	E.g. for collecting NTFP?		research
	Is logging an important income for the community?	Compared to..		
	How is it shared among members of the community?	Do all households get some money? Is it used on community level and not divided?		
	What was the decision-making process before agreeing on the logging?	Who decided? Did you talk about it in the whole community first?		
	Are you content with the practise? Are the people of the longhouse?	Is anyone not content? E.g. someone using the river for fishing? Are you experiencing any bad effects, e.g. silting of the river or problems with the logging company?		
Decision-making	Can you describe the decision-making process in the village?	Is it consensus? Is it only males/ females? E.g. when deciding on logging		Livelihood strategies
	Are any local institutions affecting your decisions?			
	Any policies	E.g.		
Wishes regarding improvements	Which improvements would you like to see in your village?	E.g. other crops, more palm oil, more rice? Better drinking water? Less silt in river? More/ less logging?	Relating to objective 4	Assessing potential for development
	Has there any development organisations working here? Which development schemes have you been applying for?			Assessing potential for development
Closing	Thank you for your time and for sharing			

	your information. Is there anything you would like to add? Terima Kasih (Thanks)			

Appendix 4.2 Questionnaires for Households

Date:
Household Head:
Informant:

Introduction:
Hello,
We are (say names)
We are 9 students from Malaysia and Denmark who have come here to San Pandak to do a study in the village for our university. We will be here for 10 days. Today, we are asking households about their household activities.
We would be very grateful if we can ask you some questions about your household?

Who belongs to this household?

Name	Family relation	Age	Main Occupation	Does this person still live in San Pandak?*

*A)Full time, B) part time (specify, e.g. weekends), C) moved out

Activities and income composition

If farming is done, which crops are grown by the household?

- Hill rice
- Swamp rice
- Pepper
- Oil palm
- Rubber

Others _____

Please tick off the household's sources of income (subsistence and monetary)

- Farming
- Fishing
- Remittances
- Logging compensation
- Employed job as _____
- Other 1 _____

- Other 2_____
- Other 3_____

Which of the above is most important to you? Please rank

1. _____
2. _____
3. _____

Resource Use

Do you use the river?

- for fishing
- Swimming
- Other 1 _____
- Other 2_____

Did you use to use the primary forest, where there now is logging? (collecting timber, fruits or other things)

- Yes
- No

If yes, for what? (timber, fruits, other?) _____

Do you experience any negative effects from the logging?

- Yes, which: _____
- No
- Don't know

Thank you very much. Could we please come back and talk to you another time?
Do you have any questions for us?

Any notes about the informant/the interview:

_____
_____
_____

Appendix 4.3. Guidelines for Semi-Structured Interviews

People we want to conduct semi structured interviews with:

- Headman (follow up interview)
- Households (some or all)
- People relating to the logging, e.g. company, NGO, officials.

Interviewee: Headman (Specific on logging if decided relevant from first interview)
Objective: **Specifics** on primary forest use and agreement on forest logging (Ask *italic* questions and follow up if relevant):

- *What were the common uses of the forest before?* What products were derived and what level of dependency where there, e.g. was it only used in times of hardships? Is there any current use of the primary forest and what type of access do the villagers have if any? Is there any conflict generated by logging (you <-> community member <-> company <-> forest officer, traders), complaints received or heard about (from any of these stakeholders, other community, state officers)
- *Process of establishment* (who initiate when, how it goes, role shared by stakeholders that is who did what when, where and why, shared values/views, any misunderstandings, negotiations about what, equity and fairness, who has a say, who leads discussions), form of agreement, stakes, content, responsibilities, benefits for the chief-the community-specific groups, ambiguities, disputes solving clauses, feed-back and household involvement...
- *How is it implemented?* how often are you consulted on an initiative or a problem faced by the company? what do they require from you? Do you perceive any distortion from the agreement statement?
- *Transparency and Accountability*: are periodic reports of activities made, to whom? Are there any mechanism to check (company -> community representants -> larger community)
- *How were decisions made about redistribution of benefits?* Under which circumstances, what rules can be changed? *How much has been paid* (cash and kind) since the beginning (as far as they can track back), how was it redistributed? how much was used for any common projects ?

Interviewee: Household residents (available)
Section1: Understanding the livelihood portfolio

- Rank the income giving activities (both subsistence cash giving) and of your HH by importance and say why you think it is important

No	Activity	Reasons	'10 Stones' Score
1			
2			
3			
4			
5			

_____
_____
_____
_____
_____

- (For the 3 main ones) How long does the specific activity occupy the HH member/Describe a typical day? (workload on daily basis and seasonality)

Activity 1:

	Low intensity		Medium		High intensity		Observations
Seasonality	from…. to….		from…. to….		from…. to….		
Who participates?	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	
1……..							
2							
3							
4							
5							

Activity 2:

	Low intensity		Medium		High intensity		Observations
Seasonality	from…. to….		from…. to….		from…. to….		
Who participates?	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	
1……..							
2							
3							
4							
5							

Activity 3:

	Low intensity		Medium		High intensity		Observations
Seasonality	from…. to….		from…. to….		from…. to….		
Who participates?	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	Time spent (hours/week)	Tasks	
1……..							
2							
3							
4							
5							

Comments:_____
_____
_____
_____
_____

- What do you get from nature, without buying? *Follow-up question*

Comments:_____
_____
_____
_____
_____

- How would you compare the importance of having food stock / money / stuff ready to sell?

Comments:_____
_____
_____
_____
_____

- What staple food do you think are essential for your household survival? Do you get them around the year, quantities and period of shortage? Where do you get/sell the difference?

Comments:_____
_____
_____
_____
_____

Labour availability and land use

- How do you decide to put more or less effort in a specific activity, how do you balance between all the activities?

Comments:_____
_____
_____
_____
_____

- What were the main activities, 10-20 years ago? What has changed and why?

Comments:_____
_____
_____
_____
_____

- Do you face any shortage in labour? If so, when and how much? How do you cope with it?

Comments:_____
_____
_____
_____
_____

- How much land do you need to cultivate in a year to meet your basic needs? What can you say about the fertility status of the pieces of land you are using?

Comments:_____
_____
_____
_____
_____

- How do you manage fertility?

Comments:_____
_____
_____
_____
_____

- How do you get access to the land? What are the rules related to the land access? What is permitted, encouraged, discouraged, forbidden.

Comments:_____
_____
_____
_____
_____

- How easy/difficult is it to get land to cultivate, what are the opportunities/barriers if any? How do you use/overcome them?

Comments:_____
_____
_____

- What are the main constraints, when growing your crops? How do you deal with them?

Comments:

Section 2: Relation with migration

- How many members of the family have left the household since 1990? Who are they, when did they leave, in what circumstances? Where are they? What do they do? How often do they come back?

No	Name	Departure time	Location	Occupation (s)	Frequency of return	Observations

Comments:

- How do they participate in the life of the household? What do they take from the household? Who is now in charge of what they were doing before leaving? What do people say in the longhouse about them?

Comments:

- What has changed since their departure (living standard, behaviours, food source, farming size, crops, techniques, alternative livelihood activities)? What are their interest regarding to the longhouse?

Comments:_____

- Who else is planning to leave? Why? What do you advise them? What issues do you discuss with them?

Comments:_____

- What are you relations with the other migrants of the longhouse? Do you see any changes in the living standard of the remaining kins?

Comments:_____

Interviewee: Migrants
Objective: Information on migration status and drivers (push-pull)

- What were you doing before leaving the longhouse?

Comments:

- Why did you choose to migrate?

Comments:

- How did you manage to make it happen? What have you been doing (jobs) since then?

Comments:

- How do you secure your position in town? How do you partition your income?

Comments:

- In what forms do you save money?

Comments:

- What do you send/get from the household?

Comments:

- What are the benefits, the constraints as compared to life in longhouse? What did you lose, when leaving the longhouse? What are your achievements?

Comments:

- What are the pressures faced?

Comments:

- Do you foresee any opportunity, threat? What are your plans? What are your current and future interests in the longhouse?

Comments:

- What are the expectations of your family, the other members of the longhouse?

Comments:

- Would you bring your relatives with you in town, why? What could make you return to the longhouse?

Comments:

- What would you like to share from your experience? What kind of advice would you provide?

Comments:

Interviewee: Residents who could potentially migrate, but do not
Objective: Understand the barriers to migration

- What do you do here? What do you like/dislike in it? How often do you go to town(s)?

Comments:

- What do you want to do in future? What are your challenges to achieve your dreams? How do you try to overcome them?

Comments:

- What do you know about the life in town (positive and negative)? How do you know it?

Comments:

- How do you perceive migrants, non-migrants around you? Can you imagine your household in your absence?

Comments:

- If you are to stay here in the longhouse in your old days, what would be your occupations? What would you do differently from the last generation?

Comments:

- What if the forest was entirely logged? if the land becomes less fertile?

Comments:

Interviewee: Forester from countergroup/Forest officer/Representative from logging company carried out as a walk-about, with questions probed from observations.
Objective: Forest assessment and knowledge about forest management

Potential questions

- Degree of (risk of) illegal logging

Comments:

- How are forest laws enforced, who is in charge? What are the relations to San Padak people?

Comments:

_____
_____
_____
_____

Extras

Interviewee: Other key-informants (NGO, SALCRA representent, Forest officer in Lubok Antu, probably more diverse actors)
Objective:
Gaining information on management of the forest

Interviewee: Women (to some extent same as household residents)
Objective: Stress on specific interests

Appendix 4.4. Guidelines for Participatory Map Making

Reminders to us/researchers:

- As you want to stimulate participation, you should limit your information giving
- Mark space for legend in bottom right corner.
- Ask participants to draw markers upon mentioning, eg. if participants say 'the field is behind the big hill', we shall ask them to drawn the hill as well.
- Be prepared that the participants may have problems with representation and abstraction. Therefore, make it as concrete as possible.
- Be aware never to break confidence. E.g. not show privately

Objective: Land Use
Setting: Group of farmers
Guidelines specific for group setting: Only one person should be drawing (to have same use of symbols), but he may only draw when people agree. It's best if not the most educated person is the drawer, because this person might contest what others draw, while others will not contest him. Therefore, to get participation by (and inputs from) all, not the leader nor the most educated one should draw.
Guidelines specific for individual setting: ...

Specific questions for drawing process:

1. Please draw your house in the centre of the drawing.
2. Please draw where you have fields?
3. Who have fields next to you fields? What are on these fields?
4. How do you go there from your house? Can you draw in the path? What do you pass on the way to your fields? Do you pass any bridge? Any water? What fields are next to the road?

Appendix 4.5. Guidelines for Ranking and scoring

Who and what we could use the method of ranking with/for (initial ideas):

Who	What
Migrators	Drivers of migration and their importance (Obj. 3)
Households	Drivers of migration could also be determined by the households, as they might know and have been part of the decision about off-farm work (Obj. 3). Wealth-ranking with members (random) of the longhouse. Can be used for further reflections if e.i. livelihood strategies (Obj. 1) is affected by wealth.
Farmers	Determine indicators for drivers of land use change and rank them according to importance. This exercise will give us an additional idea of what drivers are the most important in the village.
All	During all exercises, discussion can provide additional and important information, which can be included as results or help the research process forward.

Matrix Scoring 1-5

	Respondent A	Respondent B	Respondent C	Score
Indicator 1				
Indicator 2				
Indicator 3				
Reasons				

Preference ranking exercise

1.				Score for each item:	1. 2. 3.	4. 5. 6.
2.						
3.						
4.						
5.						
6.						

Comments:_____
_____
_____
_____
_____

Appendix 4.6. Guidelines for Soil Quality Assessment

Soil tests will be taken from fields at different "stages of use". The purpose is to investigate effects of the land use practices on soil quality parameters.
At least two different set-ups can be chosen from:

1) Comparing soil qualities of shifting-cultivation fields with permanent fields
This scenario looks to see if soil quality is affected by permanent cropping, which might be a result of labour shortage.

2) Comparing effects of different fallow periods
In many areas –especially where there is shortage of land – fallow periods have decreased. This could mean that shorter fallow periods leads to less nutrient content in fields when these are re-farmed. Comparing fields that were recently cleared and which had different fallow lengths is one way to test the hypothesis. Alternatively, two newly established fields that came from plots of different fallow lengths can be tested, or finally new secondary forest can be compared with old secondary forest.

The comparison of fields is based on the "space-for-time" method. When choosing fields, we will search for fields that have the same inherent characteristics, most notably same topographical placement in the landscape.
For internal reference a minimum of 3 profiles will be dug at each field and samples will be taken at the topsoil level and just below topsoil level.
Sampling plots will be chosen at locations in the field that are found to be most representable of the overall field. This means that if a small corner looks different from the main parts of the field, this is not the area that will be sampled.
Community farmers will be consulted in the process of choosing fields.

In the field, soil samples will be sampled in plastic bags noting; date, field, profile number, depth and, if applicable, replicate no. In the village soil samples will be sun dried on paper.

Testing Soil Qualities:
Soil texture will be roughly estimated in field using the FAO 2006 guideline (see table below)
pH: pH will be tested in the laboratory
• SOC: SOC will be tested using the Permanganate Oxidizable SOC method
• Total N content will be sent to laboratory technicians for testing

Equipment needed in the field:
Soil metal rings, markers, Plastic bags, FAO Soil texture sheet, notebook

TABLE 25

Key to the soil textural classes

				~% clay
1	Not possible to roll a wire of about 7 mm in diameter (about the diameter of a pencil)			
1.1	not dirty, not floury, no fine material in the finger rills:	sand	S	< 5
	• if grain sizes are mixed:	unsorted sand	US	< 5
	• if most grains are very coarse (> 0.6 mm):	very coarse and coarse sand	CS	< 5
	• if most grains are of medium size (0.2–0.6 mm):	medium sand	MS	< 5
	• if most grains are of fine size (< 0.2 mm) but still grainy:	fine sand	FS	< 5
	• if most grains are of very fine size (< 0.12 mm), tending to be floury:	very fine sand	VFS	< 5
1.2	not floury, grainy, scarcely fine material in the finger rills, weakly shapeable, adheres slightly to the fingers:	loamy sand	LS	< 12
1.3	similar to 1.2 but moderately floury:	sandy loam	SL (clay-poor)	< 10
2	Possible to roll a wire of about 3–7 mm in diameter (about half the diameter of a pencil) but breaks when trying to form the wire to a ring of about 2–3 cm in diameter, moderately cohesive, adheres to the fingers			
2.1	very floury and not cohesive			
	• some grains to feel:	silt loam	SiL (clay-poor)	< 10
	• no grains to feel:	silt	Si	< 12
2.2	moderately cohesive, adheres to the fingers, has a rough and ripped surface after squeezing between fingers and			
	• very grainy and not sticky:	sandy loam	SL (clay-rich)	10–25
	• moderate sand grains:	loam	L	8–27
	• not grainy but distinctly floury and somewhat sticky:	silt loam	SiL (clay-rich)	10–27
2.3	rough and moderate shiny surface after squeezing between fingers and is sticky and grainy to very grainy:	sandy clay loam	SCL	20–35
3	Possible to roll a wire of about 3 mm in diameter (less than half the diameter of a pencil) and to form the wire to a ring of about 2–3 cm in diameter, cohesive, sticky, gnashes between teeth, has a moderately shiny to shiny surface after squeezing between fingers			
3.1	very grainy:	sandy clay	SC	35–55
3.2	some grains to see and to feel, gnashes between teeth			
	• moderate plasticity, moderately shiny surfaces:	clay loam	CL	25–40
	• high plasticity, shiny surfaces:	clay	C	40–60
3.3	no grains to see and to feel, does not gnash between teeth			
	• low plasticity:	silty clay loam	SiCL	25–40
	• high plasticity, moderately shiny surfaces:	silty clay	SiC	40–60
	• high plasticity, shiny surfaces:	heavy clay	HC	> 60

Note: Field texture determination may depend on clay mineralogical composition. The above key works mainly for soils having illite, chlorite and/or vermiculite composition. Smectite clays are more plastic, and kaolinitic clays are stickier. Thus, clay content can be overestimated for the former, and underestimated for the latter.

Source: Adapted from Schlichting, Blume and Stahr, 1995.

Table from: Guidelines for soil description, FAO, 2006

Appendix 4.7. Guidelines for Environmental Water Quality Assessment

Pollution of the water resource may be a problem for the local community (San Pandak) as well as communities downstream of San Pandak and ecosystems at large including the coral reef surrounding Borneo as the final recipient (Oney et al. 2011; Jinggut et al. 2012). Pollution in terms of both sediments, chemicals and variations in pH and temperature may arise from activities such as logging and farming (rice, palm oil etc.). Available parameters that may be investigated include the following:

- Water temperature
- **Dissolved oxygen**
- **pH**
- Salinity (analyses 1- 4 is measured using Hydrolab Multiprob)
- **Biochemical oxygen demand (BOD)**
- **Chemical oxygen demand (COD) (using Merck Environmental Kit, Model SQ118)**
- **Nutrients (ammonium-N, phosphorus, nitrate); measured using Hach Kit, model DR700**
- **Total suspended solids (TSS)**
- Microbial level in water (Faecal coliform count (FCC) and total coliform count (TCC) using Paqualab system)

For the purpose of assessing environmental impacts of present land use (objective B) the highlighted parameters are expected to be of most importance. Sampling will be conducted upstream and downstream of potential pollution site.
Especially silting may be a problem as a consequence of logging activities (Field Site Maps and Descriptions). An evaluation of this problem can be done through TSS measurements.

Appendix 4.7 Forest Assessment and Forest Biodiversity Assessment

First and foremost, the current condition of the forest should be revised simply by going and start observing. This will give a clearer picture on how to assess the forest.
For instance, a high level of fragmentation will have a huge impact on how to go about the measurements, and so forth, so it will be crucial to go and get an overview. After this, more specific methods on how to assess measurements will be decided, e.g. whether GPS should be used. Another unknown variable is how much already existing data can be accessed through for instance the forest department or even the logging company. When this is established, methods can be specified as to fill out the gaps of data.

It is highly possible though that an assessment of both basal area and volume will be carried out.
Also, an assessment of the forest biodiversity will be carried out. This should be executed although existing data is accessed as both the forest department and/or the logging firm could have hidden agendas so triangulation will be prioritized.
First of all when assessing the biodiversity of the forest, one should look to identify type of forest and type of forest management. It is often most easy to look for "problems", such as signs of heavy machinery, high-volume harvesting, eroded areas and so on.
A set of variables will also be used in the assessment:

- Forest area by type and successional stage
- Degree of fragmentation
- Rate of conversion of forest cover
- Forest composition (hopefully from forest inventory)
- Percentage of forest affected by anthropogenic and natural disturbance
- Complexity and heterogeneity of forest structure
- Number of forest-dependent species

Indicators should always be specified in relation to the objective of the assessment, so they might be altered.

Luckily, a forester is part of our counter group from Malaysia, and we are hoping he will be able to provide us with some knowledge about the characteristics of the forest, help us identify the forest management if not obvious and point out possible "problem areas". This could be documented as a key informant interview, which possibly will be quite unstructured.

Bilag 8 Skema, Geus Skovstrukturindeks Version 5.0

GEUS SKOVSTRUKTURINDEKS VURDERING AF STRUKTUREL DIVERSITET I SKOV			Version 5.0 April 2005
Lokalitet:	**Løbenr:**	**Dato:**	
Afdeling, litra:	**Areal:**	**Start kl.:**	**Slut kl.:**
Undersøger:			
		Kryds af	**FELTNOTER** (valgfri)
Nr	**Areal**		
1	Areal > 1 ha		
2	Areal >10 ha		
3	Indgår i skov med sammenhængende areal > 100 ha		
4	Grænser op mod anden skov eller naturarealer (fx mose, sø, hede, klit men ikke mark, by og vej) langs mindst 80% af randlængden		
5	Afstand til dyrket mark, by, svinefarme, større veje o.l. >100 m for mindst 95% af arealet		
	Bevoksning		
6	Fleretageret struktur (min. 3 lag) i bevoksningerne på min. 10% af det bevoksede areal		
7	Holmevis højdevariation i bevoksningerne på mindst 10% af det bevoksede areal (min. 3 holme á 400-1000 m^2 /ha)		
8	Naturlige smålysninger (> 100 m^2). Fx vådområder, stormhuller o.l.		
9	Ingen synlige tegn på at bevoksningen er kunstigt anlagt (helt eller delvis plantet). Dvs. ingen planterækker o.l.. (Indtil 5% indplantning er i orden)		
	Træarter		
10	Bøg, stilkeg eller vintereg; dbh ≥ 10 cm		
11	Ask; dbh ≥ 10 cm		
12	Rødel; dbh ≥ 10 cm		
13	Småbl. lind; dbh ≥ 10 cm		
14	Småbl. lind; dbh ≥ 25 cm		
15	Avnbøg; dbh ≥ 10 cm		
16	Elm; dbh ≥ 10 cm		
17	Navr, løn; dbh ≥ 10 cm		
18	Bævreasp, birk, røn, fuglekirsebær, abild eller hassel; dbh ≥ 10 cm; Kristtorn; dbh > 5 cm.		
19	Ingen større forekomst af glansbladet hæg, sitkagran eller andre invasive træarter eller forekomst af kæmpebjørneklo.		
	Træer; uanset træart		
20	Stortræer; dbh ≥ 50 cm tilstede		
21	Stortræer; dbh ≥ 50 cm ≥ 5 stk/ha		
22	Stortræer; dbh ≥ 50 cm ≥ 10 stk/ha		
23	Stortræer; dbh ≥ 75cm tilstede		
24	Stortræer; dbh ≥ 75cm ≥ 1/ha		
25	Stortræer; dbh ≥ 75cm ≥ 5/ha		
26	Megatræer (dbh ≥ 100 cm) tilstede		
27	Megatræer (dbh ≥ 100 cm); ≥ 1/ha		
28	Megatræer (dbh ≥ 100 cm); ≥ 5/ha		
29	Levende træer med større huller, skader o.l.; dbh >25 cm; ≥ 1 træ/ha		
30	Levende træer med større huller, skader o.l.; dbh >50 cm, ≥ 1 træ/ha		
31	Levende rodvæltere el. hængere, dbh ≥ 25		
32	Levende rodvæltere el. hængere, dbh ≥ 50		
	DELSUM 1		

Lokalitet:	Løbenr:	Kryds af	FELTNOTER (valgfri)
Nr.	**Kronelag (det øverste kronetag uanset træhøjden)**		
33	Stort diameterspand hos træer i kronelag (minimum ½ m)		
34	Stort aldersspand hos træer i kronelag (min. 100 år)		
35	Stor formvariation hos træer i kronelag		
36	Mindst 4 træarter i kronelag		
37	Mindst 3 hjemmehørende arter udgør hver mindst 25% af kronetaget		
	Underskov/opvækst (Vedplanter > ½ m og < 5 m)		
38	Opvækst/underskov (af træarter inkl. Hassel, men ikke buske) tilstede på 10-35 % af fladen		
39	Opvækst aldersvarieret; aldersspand minimum 50 år		
40	Opvækst holmevist fordelt		
41	Mindst 1 hjemmehørende træart i underskov/opvækst		
42	>5 hjemmehørende træarter i underskov/opvækst		
43	≥10 hjemmehørende træarter i underskov/opvækst		
44	>5 hjemmehørende buskarter i underskov		
45	≥10 hjemmehørende buskarter i underskov		
	Dødt ved; Uopsavede træer, uanset træart dbh= dbh i opret stilling		
46	Døde el. døende træer, dbh10-24 cm		
47	Døde el. døende træer, dbh 25-49 cm		
48	Døde el. døende træer, dbh 50-74 cm		
49	Døde el. døende træer, dbh 75- 99 cm		
50	Døde el. døende træer, dbh ≥ 100 cm (megatræer)		
51	Døde træer dbh ≥ 25 cm, flere (≥ 5/ha)		
52	Døde træer dbh ≥ 25 cm, mange (>10/ha)		
53	Døde stortræer dbh ≥ 50 cm; mange (≥ 5/ha)		
54	Døde stortræer dbh ≥ 50 cm; >10/ha		
55	Døde stortræer dbh ≥ 75 cm; ≥ 5/ha		
56	Døde stortræer dbh ≥ 75 cm; >10/ha		
57	Stående døde træer ≥ 8 m høje; dbh 10-24 cm		
58	Stående døde træer ≥ 8 m høje; dbh 25-49 cm		
59	Stående døde træer ≥ 8 m høje; dbh ≥ 50 cm		
60	Døde rodvæltere, dbh ≥ 25cm		
61	Døde rodvæltere, dbh ≥ 50 cm		
62	Døde rodvæltere, dbh ≥ 75 cm		
63	Døde rodvæltere, dbh ≥ 100 cm		
64	Solbeskinnede døde stammer, dbh ≥ 25 cm		
65	Solbeskinnede døde stammer, dbh ≥ 50 cm		
66	Levende el. døde knækkere/stabbe > 2m høje, dbh >25 cm		
67	Levende el. døde knækkere/stabbe > 2m høje, dbh >50 cm		
68	Døde stammer dbh ≥ 25 cm, mindst 3 arter		
69	Døde stammer dbh ≥ 25 cm, mindst 5 arter		
70	Døde stammer dbh ≥ 25 cm, **Rådklasse 1** (Frisk, ved hårdt, bark intakt. Uforandret (rundt) tværsnit)		
71	Døde stammer dbh ≥ 25 cm, **Rådklasse 2** (Overfladisk blød (indtil ca. 1 cm); bark løs eller delvis affaldet; uforandret (rundt) tværsnit.)		
72	Døde stammer dbh ≥ 25 cm, **Rådklasse 3** (stammeved blødt flere cm i dybden. Bark væk (med undtagelse af de arter som formulder indenfor barken (fx kristtorn, *Ilex* og birk, *Betula*)).		
73	Døde stammer dbh ≥ 25 cm, **Rådklasse 4** (Stamme gennemrådden, hullet, går let sønder. Ovalt tværsnit.)		
74	Døde stammer dbh ≥ 25 cm, **Rådklasse 5** (Stammeved delvist til næsten helt formuldet; ses på bunden som grovførn eller i afvigende vegetation.)		
	DELSUM 2		

GEUS SKOVSTRUKTURINDEKS VURDERING AF "STRUKTUREL DIVERSITET I SKOV			Version 5.0 April 2005
Lokalitet:	**Løbenr:**	**Kryds af**	**FELTNOTER** (valgfri)
	Flora		
75	Bundvegetation af sommergrønne karplanter (skovarter) til stede på min. 10 % af arealet.		
76	Levende stammer rige på mosser. Over 25% dækning op til 3 meter.		
77	Levende stammer rige på løv- eller skorpelaver. Over 25 % dækning op til 3 meter.		
	Topografi og jordbund		
78	Stor makrotopografisk variation (>20 meters højdeforskel indenfor 1 ha)		
79	Stor mikrotopografisk variation (>1m/100m^2)		
80	Store rodkager fra stormfald tilstede		
81	Store sten/blokke/klipper; min. 1 x 1 meter; naturlige forekomster i overfladen.		
82	Muldbund tilstede på min. 5% af arealet		
83	Morbund tilstede på min. 5% af arealet		
84	Humuslag (mor el. tørv), tykkelse ≥ 5 cm. På min 5% af arealet.		
85	Fri kalk i øverste jordsmon. Synlig kalk/kridt i jordoverfladen.		
86	Pletter med solekspo neret, naturligt blotlagt jordflade (skred, klit o.l.)		
	Vandstand		
87	Åbne vådområder, dvs. uden træbevoksning tilstede; min 5% af areal		
88	Sumpskov tilstede (fx ellesump, birkesump, blandet sumpskov); min 5% af areal		
89	Sig, temporære vande (områder med vandspejl kun en del af året)		
90	Fugtige lavninger tilstede (min 100 m^2)		
91	Væld, kilder tilstede		
92	Naturlige, uregulerede vandløb		
93	Vådområder uden grøfter eller grøfter lukket effektivt		
94	Våd el. fugtigbund fremherskende på min. 25% af arealet		
	Driftpåvirkninger m.v.		
95	Ingen tegn på jordbearbejdning, harvning o.l.		
96	Ingen grøfter tilstede eller grøfter effektivt lukkede		
97	Ingen nyoprensede (indenfor 10 år) grøfter		
98	Ingen tydelige spor af kørsel i bevoksningen (dybe hjulspor)		
99	Ingen hugstspor (stød) tilstede		
100	Ingen nyere hugstspor (stød) (< ca. 10 år)		
	DELSUM 3		
	Delsum 1 (overført)		
	Delsum 2 (overført)		
TOTALSUM (Indeksværdi)			

KOMMENTARER:

Bilag 9 Vejledning, Geus Skovstrukturindeks Version 5.0

GEUS SKOVSTRUKTURINDEKS version 5.0

Vejledning og forklaring til feltskemaet

Dbh = Diameter i brysthøjde (1,3 m over terræn). Ved ved væltede træer o.l. menes dbh, da træet endnu stod.
Det bevoksede areal = det træbevoksede areal; for at udskille naturligt ubevoksede arealer som fx åbne vådområder o.l. af beregningen.
Fladen = det undersøgte område.

GEUS SKOVSTRUKTURINDEKS (UNA-INDEKS)		**NATURKVALITETSVURDERING I SKOV** Version 5.0 April 2005	
Lokalitet: **Afdeling, litra:** **Areal:** **Undersøger:** **Dato/tider:**		**FORKLARING/BEGRUNDELSE** <Basale oplysninger om det undersøgte areal, undersøger, tidspunkt m.v.>	**VEJLEDNING** **Lokalitet: <skovnavn m.m.>** **Afdeling, litra: <på undersøgte flade>** **Areal: <det undersøgte areal i ha>** **Undersøger: <navn> Dato: <> Start/slut:<>**
Nr	**Areal**		
1	Areal > 1 ha	Arealet har stor betydning for et områdes artsindhold og funktion og stabilitet som system.	Arealet af det undersøgte område (fladen). Findes i bevoksningslister o.l. eller måles/skønnes på kort. Et areal på fx 12 ha vil således få 2 krydser.
2	Areal >10 ha		
3	Indgår i skov med sammenhængende areal > 100 ha		
4	Grænser op mod anden skov eller naturarealer langs mindst 80% af randlængden	Betydning i forhold til naturindhold og negative påvirkninger som luftforurening o.l.	Naturarealer er fx strand, hav, kyst, sø, mose, vandløb, klit, hede o.l., men ikke have, by, mark, o.a. arealer i omdrift. Hvis der ligger en større vej (som beskrevet i pkt 5) mellem skoven og et naturareal tælles det som grænsende til ikke-naturareal. Vurderes i felten eller på aktuelle kort.
5	Afstand til dyrket mark, by, vej o.l. >100 m for mindst 95% af arealet	Betydning i forhold til negative påvirkninger som luftforurening o.l.	Måles på kort. Omfatter også fx svinefarme, industrier, forbrændingsanlæg o.l. Med vej menes større veje som landeveje, hovedveje, motorveje, men ikke småveje (kommuneveje), skovveje o.l.. Som bagatelgrænse regnes med 5%, dvs. at mindst 95% af det samlede, undersøgte areal skal ligge udenfor denne afstand.
	Bevoksning	Makrostrukturel variation i bestand	
6	Fleretageret struktur i bevoksningerne på min. 10% af det bevoksede areal	Indikation af makrostrukturel variation i bestand.	Tilstedeværelse af mindst 3 højdelag (etager) over fladen i bevoksningerne på min. 10% af det bevoksede areal, ikke blot forekomst af flere forskellige bevoksninger eller fx spredt opvækst eller to etager.
7	Holmevis højdevariation i bevoksningerne på mindst 10% af det bevoksede areal	Udpræget holmevis (gruppevis) variation, fx på grund af forskellige aldre. Af betydning for den strukturelle variation.	En holm er på 400-1000 m^2. Der skal være mindst 3 holme/ha i bevoksningerne på mindst 10% af det bevoksede areal. Vurderes under gennemgang.
8	Naturlige smålysninger (> 100 m^2)	Indikation af makrostrukturel variation i bestand. Lysninger er af stor betydning for variationen og for en lang række arter.	Forekomst af flere, naturlige, ubevoksede lysninger, pgr. af vådområder, træers død, stormfald - ikke hugsthuller, pladser, veje,hustomter o.l. Registreres ved gennemgang. Størrelsen kan vurderes ved fx afskridtning (10 x 10 m = 100 m^2).
9	Ingen synlige tegn på at bevoksningen er kunstigt anlagt (helt eller delvis plantet)	Dvs. ikke noget umiddelbart synligt uniformt "plantningspræg" der antyder stærkt brud i kontinuiteten.	Ingen umiddelbare, synlige tegn på planterækker, indplantninger, plantehuller o.l.. Som bagatel-grænse regnes mindre indplantninger på højst 5% af det bevoksede areal. Dokumentation for ældre bevoksninger ville kræve en større, skovhistorisk udredning som ikke kan rummes i denne vurdering.

	Træarter	Forekomst af fortrinsvis hjemmehørende træarter. Indikation af trærtsmæssig variation og diversitet	Forekomst af levende individer af disse arter af minimum den nævnte dimension på den undersøgte flade. Optegnes under gennemgang af arealet.
10	Bøg, stilkeg eller vintereg; dbh ≥ 10 cm		Afkrydsning hvis blot en af arterne findes.
11	Ask; dbh ≥ 10 cm	Hjemmehørende, fugtigbundsindikerende arter	
12	Rødel; dbh ≥ 10 cm		
13	Småbl. lind; dbh ≥10 cm	Naturlige lindeforekomster indikerer lang skovvedvarighed.	
14	Småbl. lind; dbh ≥25 cm		
15	Avnbøg; dbh ≥ 10 cm	Forekomst kan indikere højere grad af naturlighed.	
16	Elm; dbh ≥ 10 cm		
17	Navr, løn; dbh ≥ 10 cm		
18	Bævreasp, birk, røn, fuglekirsebær, abild eller hassel; dbh ≥ 10cm Kristtorn; dbh > 5 cm		
19	Ingen større forekomst af glansbladet hæg, sitkagran el. andre agressive træarter eller forekomst af kæmpe-bjørneklo	Ingen større forekomst (< 5% af arealet) af stærktspredende, "aggressive" træarter, dvs min. 95% af det bevoksede areal skal være uden disse træarter.	Forekomster af disse arter registreres under gennemgang. Samlet arealandel skønnes. Kun hvis 95% af det bevoksede areal er uden disse arter foretages afkrydsning. Ær regnes ikke som aggressiv træart. Bjørneklo er negativ uanset areal.
	Træer		
20	Stortræer; dbh ≥ 50 cm tilstede	Store træer har særlig stor betydning for en række arter. Store træer er i sig selv indikation af en vis kontinuitet.	Forekomst af levende individer af træer uanset art og oprindelse af minimum den nævnte dimension på den undersøgte flade. Udregnes i forhold til hele det undersøgte område, også selvom stortræerne er koncentreret i mindre områder.
21	" ≥ 5/ha		
22	" ≥ 10/ha		
23	Stortræer; dbh ≥ 75cm tilstede		
24	" ≥ 1/ha		
25	" ≥ 5/ha		
26	Megatræer tilstede (dbh ≥ 100 cm)		
27	" ≥ 1/ha		
28	" ≥ 5/ha		
29	Levende træer med huller, skader o.l.; dbh ≥25; ≥ 1 træ/ha	Indikation af af strukturel variation, ekstensiv udnyttelse - og levesteder.	Med huller menes større huller – mindst som spættehuller. Med skader menes større flæk- og rådpartier, hulheder o.l. Afkrydses hvis der findes mindst et sådant træ /ha.
30	" ; dbh ≥50, ≥ 1 træ/ha		
31	Levende rodvæltere el. hængere, dbh ≥ 25	Indikation af strukturel variation og ekstensiv udnyttelse.	Levende, helt eller delvis rodvæltede træer. Afkrydses hvis der findes mindst et sådant træ /ha.
32	", dbh ≥ 50		
	DELSUM 1		

Nr	Kronelag	Variation i kronelaget	Kronelaget er de træer hvis kroner danner det øverste lag.
33	Stort diameterspand i kronelag (minimum ½ m)	Indikation af struktural variation.	Variationen i brysthøjdediameteren på de træer, der danner kronetag skal være ≥ ½ m.
34	Stort aldersspand i kronetag (min. 100 år)	Indikation af (aldersbetinget) strukturel variation.	Variationen i alderen på de træer, der danner kronetag skal være ≥ 100 år. Dvs. at der fx skal forekomme væsentlig ældre overstandere, indblandede enkelttræer o.l.
35	Stor formvarians hos kronelagstræer	Indikation af struktural variation, større levestedsudbud og ekstensiv forstlig drift.	I stammeform. Dvs. en bred variation af krogede, flerstammede, tvegede, vanrisede træer i kronelaget.
36	Mindst 4 arter i kronelag	Indikation af artsmæssig og som regel også strukturel diversitet.	Mindst 4 forskellige træarter (uanset art) i kronelaget. Blot en mindre del af kronen er i kronetag, regnes en art med.
37	Mindst 3 hjemmehørende arter udgør hver mindst 25% af kronetaget		≥ 25% af kronetaget. Ang. hjemmehørende: se vejledningens pkt. 41.
	Underskov/ opvækst (Vedplanter >½ m og < 5 m)	Forekomst af en vis foryngelse. Naturmæssigt og strukturelt er det at foretrække at foryngelsen ikke bliver kohortepræget, men strækker sig over tiden.	
38	Opvækst/undersko v (af træarter inkl. hassel, men ikke buske) tilstede på 10-35 % af fladen	Indikation af en vis, men ikke totalt dominerende foryngelse samt af strukturel variation tilstede.	Skønnes ved gennemgang af arealet. Dækningsgraden skønnes efter undervækstens kroneprojektion. Hvis en højere andel er dækket af tæt opvækst afkrydses *ikke.*
39	Opvækst aldersvarieret; aldersspand mindst 50 år	Indikation af (aldersbetinget) strukturel variation.	Alder skønnes ved gennemgang af arealet.
40	Opvækst holmevist fordelt	Indikation af en vis, men ikke totalt dominerende foryngelse samt af strukturel variation tilstede.	Opvækst i større grupper (holme). Afkrydses også selvom der tillige er lidt spredt opvækst.
41	Mindst 1 hjemmehørende træart i underskov/opvækst	Indikation af variation og diversitet og mulighed for fremtidig træartsvariation.	Hjemmehørende træarter er bl.a. ask, bøg, stilkeg, vintereg, rødel, alm. røn, småbl. lind, vortebirk, dunbirk, bævreasp, storbl. elm, skærmelm, småbl. elm, avnbøg, fuglekirsebær, taks, skovfyr. Ikke-hjemmehørende træarter er bl.a. hvidel, ær, rødeg, hestekastanie, alle poppelarter pånær bævreasp og alle nåletræarter pånær taks og skovfyr. Optegnes under gennemgang af arealet.
42	>5 hjemmehørende træarter i underskov/opvækst		
43	≥10 hjemmehørende træarter i underskov/opvækst		
44	>5 hjemmehørende buskarter i underskov	Indikation af diversitet.	Hjemmehørende buskarter er bl.a. hassel, tørst, kvalkved, ene, alm. hvidtjørn, engriflet hvidtjørn (inkl. koral-hvidtjørn og krydsninger hermed), kristtorn, pors, gråpil, seljepil Ikke-hjemmehørende buskarter er bl.a. glans-hæg, snebær, druehyld, bærmispel. Dværgbuske som fx hedelyng og revling medregnes ikke. Lianer som vedbend og vedvindel medregnes kun hvis de forefindes i kronerne, ikke hvis de blot kryber på jorden eller i få meters højde. Optegnes under gennemgang af arealet.
45	≥10 hjemmehørende buskarter i underskov		

	Dødt ved	Uopsavede træer, uanset træart. Dbh = dbh i opret stilling	Bemærk at der kun regnes med stammer/træer. Stød og grene tæller ikke.
46	Døde el. døende træer, dbh 10-24 cm	Dødt ved er en helt fundamental faktor i naturlige skovøkosystemer. De forskellige former for forekomster giver flere forskellige levesteder og forskellige muligheder.	Registrering af den blotte forekomst af døde eller døende træer på fladen som sådan i de nævnte diameterklasser, uanset art, position og tilstand (stående, liggende, hængende, flækkede, splintrede osv), bortset fra opsavet træ. Med døende menes træer hvor min. 25 % af kronen er død og træet i øvrigt virker stærkt svækket. Træer der ellers er nogenlunde sunde, men fx har mistet kronedele i storm og ser ud til at gendanne krone er ikke omfattet.
47	" , dbh 25-49 cm		
48	" , dbh 50-74 cm		
49	" , dbh 75-99 cm		
50	" , dbh ≥100 cm (megatræer)		
51	Døde træer dbh >25 cm, ≥ 5/ha		Registrering af den blotte forekomst af døde træer på fladen som sådan. Antallet skønnes/opgøres i forhold til hele den undersøgte flades areal uanset hvordan de er fordelt og omfatter alle former for døde træer på fladen som sådan i de nævnte diameterklasser, uanset position og tilstand (stående, liggende, hængende, flækkede, splintrede osv), bortset fra opsavet træ.
52	Døde træer dbh >25 cm, >10/ha		
53	Døde stortræer >50 cm; ≥ 5/ha		
54	Døde stortræer dbh >50 cm; >10/ha		
55	Døde stortræer dbh >75 cm; ≥ 5/ha		
56	Døde stortræer dbh >75 cm; >10/ha		
57	Stående døde træer ≥ 8 m høje; dbh 10-24 cm		Forekomst af stående, døde træer. Træer henregnes til denne kategori så længe mindst 8 meter af stammen er stående.
58	Stående døde træer ≥ 8 m høje; dbh 25-49 cm		
59	Stående døde træer ≥ 8 m høje; dbh ≥50 cm		
60	Døde rodvæltere, dbh ≥ 25cm	Forekomster af hele, rodvæltede træer; dvs træer hvor en større eller mindre del af rodkagen er vippet op.	Forekomst af hele, intakte, rodvæltede træer. Dvs. som ikke er savet op el. lign. Kun træer i rådklasse 1-4 (se pkt. 70-74).
61	Døde rodvæltere, dbh ≥ 50 cm		
62	Døde rodvæltere, dbh ≥ 75 cm		
63	Døde rodvæltere, dbh ≥ 100 cm		
64	Solbeskinnede døde stammer, dbh ≥ 25 cm	Lys og varme er af stor betydning for en række dødtvedsarter.	Stående eller liggende, døde stammer, udsat for direkte solbelysning i nogle timer dagligt ved sommertide (fuld løvsætning). Kun hele, dvs. ikke-opskårne stammer.
65	Solbeskinnede døde stammer, dbh ≥ 50 cm		
66	Levende el. døde stabbe/ knækkere, dbh >25 cm	Indikerer potentiale for bl.a. hulrugende fugle.	Levende eller døde, knækkede træer af mindst 2 meters højde.
67	" , dbh > 50 cm		
68	Døde stammer dbh ≥ 25cm, mindst 3 arter	Dødt ved af forskellige træarter indikerer levestedsmuligheder for flere forskellige arter.	Mindst tre hhv. fem forskellige træarter, uanset art. Kun hele, dvs. ikke-opskårne stammer.
69	Døde stammer dbh ≥ 25cm, mindst 5 arter		
70	Døde stammer dbh ≥ 25cm, **Rådklasse 1** (Frisk, ved hårdt, bark intakt. Uforandret (rundt) tværsnit)	Dødt ved tilstede i alle nedbrydningsklasser indikerer høj grad af urørthed og et kontinuum af levesteder for tilknyttede arter og stor variation i levestederne.	Rådklasser. Den anførte diameter er i forhold til hvad der skønsvis svarede til dbh på det stående træ (Det er vanskeligt at vurdere for klasse 4 og 5). Afkrydsning kun hvis der er/har været tale om hele stammer (dog evt flækkede, brækkede o.l.) - ikke blot stød eller rester fra hugst.
71	Døde stammer dbh ≥ 25cm, **Rådklasse 2** (Overfladisk blød (1 cm); bark løs eller delvis affaldet; uforandret (rundt) tværsnit.)		
72	Døde stammer dbh ≥ 25cm, **Rådklasse 3** (Stammeved blødt flere cm i dybden. Bark væk (med undtagelse af arter som formulder indenfor barken (fx kristtorn og birk)).		
73	Døde stammer dbh ≥ 25cm, **Rådklasse 4** (Stamme gennemrådden, hullet, går let sønder. Ovalt tværsnit.)		
74	Døde stammer dbh ≥ 25cm, **Rådklasse 5** (Stammeved delvist til næsten helt formuldet; ses på skovbunden som grovførn eller i afvigende vegetation.)		
	DELSUM 2		

	Flora		
75	Bundvegetation af sommergrønne karplanter (skovarter) til stede på min. 10 % af arealet.	Indikation af lys til skovbunden på grund af strukturel variation.	Bundflora af karplantearter (græs, urter og halvbuske, men ikke træopvækst) der forekommer naturligt i skov. Med sommergrønne arter menes arter der er grønne i det tidsrum hvor træerne er beløvede, i modsætning til forårsfloraen (fx anemoner og lærkesporer der visner efter løvspring). Det kan være arter som fx blåbær, majblomst, kohvede, skovmærke, knoldet brunrod, skovstar, bingelurt, arter af græsser osv. Vegetationen behøver ikke at være grøn på registreringstidspunktet (fx ved reg. om vinteren). Nedvisnet, men friskt plantemateriale er tilstrækkelig indikation.
76	Levende stammer rige på mosser	Indikation af høj luftfugtighed. Kan, afhængig af hvilke arter der er tale om, også indikere lav forureningsgrad (især arter af laver). Begge artsgrupper byder på store muligheder for detailindikationer vedr. bl.a. forureningsgrader og kontinuitet, men der er af operationelle grunde valgt ikke at gå dybere end dette niveau.	Over 25% dækning domineret af mosser på stammer i op til mindst 3 meters højde. Behøver ikke at gælde alle stammer i området (fx unge el. undertrykte), men skal være fremherskende.
77	Levende stammer rige på laver		Løv- eller skorpedannende laver, men ikke pulverlaver, på stammer i op til mindst 2 meters højde. Behøver ikke at gælde alle stammer i området (fx unge el. undertrykte), men skal være fremherskende.
	Topografi og jordbund	Variation i jordbund, topografi og eksponeringer forøger udbuddet af levesteder.	
78	Stor makrotopografisk variation (>20 meters højdeforskel indenfor 1 ha)	Indikation af stor strukturel variation.	Bedømmes i skoven eller på kort med højdekurver.
79	Stor mikrotopografisk variation (>1m/100m^2)	Indikation af stor strukturel variation i lille skala.	Variation i lille skala, fx som følge af stormfald, fortidig sandflugt o.l. Bedømmes i skoven.
80	Store rodkager tilstede	Vigtig strukturel parameter.	Rodkager/rodhuller fra rodvæltede (stormfaldne) træer mindst 1 m høje.
81	Store sten/ blokke/ klipper; min. 1 x 1 m; naturlige forekomster i overfladen.	Vigtig strukturel variation af særlig betydning for bl.a. mosser, bregner og grupper af leddyr.	Forekomst af klipper, store enkeltsten (ca. 1x1 m) eller større stenkoncentrationer. Stenene skal være naturligt forekommende eller have henligget på positionen i mindst 100 år. Dvs. at nyligt udkørte marksten, rydningssten o.l. ikke tæller.
82	Muldbund tilstede på min 5% af arealet.	Jordbundsmæssig variation i området.	Bedømmes efter jordbundsstruktur eller flora. Typiske muldbundsarter er fx bingelurt, lungeurt, sanikel, skovmærke, skovstar.
83	Morbund tilstede på min 5% af arealet.		Min. 5% af arealet. Bedømmes efter struktur eller flora. Typiske morbundsarter er fx blåbær, bølget bunke, majblomst, skovstjerne.
84	Humuslag (mor el. tørv), tykkelse ≥ 5 cm		Min. 5% af arealet med humuslag af denne tykkelse. Humuslagene kan enten være mor eller tørv, dvs. bestå af brune eller brunsorte lag af svagt omsatte planterester.
85	Fri kalk i øverste jordsmon		Forekomst af synlig kalk/kridt i fx muldskud o.l. i området.
86	Pletter med soleksponeret, naturligt blotlagt jordflade.		Pletter med soleksponeret, naturligt blotlagt jordflade, fx skred, klit o.l.

	Vandstand	Naturlige vandstandsforhold er særdeles vigtigt for et naturligt økosystem og for variation og udbud af levesteder.	
87	Åbne vådområder, dvs. uden træbevoksning. På min 5% af arealet.	Indikation af uforstyrrede vandstands-forhold og heraf betinget strukturel variation.	Forekomst af naturlige, åbne vådområder. Forekomst af rørsump, enkelte pilebuske o.l. diskvalificerer ikke.
88	Sumpskov tilstede på min 5% af arealet		Forekomst af levende sumpskov, fx ellesump, birkesump el. blandskovsump.
89	Sig, temporære vande (områder med vandspejl kun en del af året)	Indikation af uforstyrrede eller svagt forstyrrede vandstandsforhold.	Forekomst af våde lavninger, hvor der de fleste år står eller flyder vand i vinterhalvåret. Kan om sommeren vurderes udfra floraen og jordbunden.
90	Fugtige lavninger tilstede (min. 100 m^2)	Indikation af uforstyrrede eller svagt forstyrrede vandstandsforhold.	
91	Væld, kilder tilstede	Indikation af uforstyrrede vandstandsforhold.	Naturlige, udrænede væld (kilder).
92	Naturlige vandløb, uregulerede	Indikation af uforstyrrede eller svagt forstyrrede vandstandsforhold.	Forekomst af vandløb, der ikke har karakter af grøfter.
93	Vådområder uden grøfter eller grøfter lukket effektivt	Indikation af uforstyrrede eller svagt forstyrrede vandstandsforhold.	Udrænede vådområder eller genetableret vandstand.
94	Våd el. fugtig bund på min 25% af arealet	Indikation af uforstyrrede eller svagt forstyrrede vandstandsforhold.	Overvejende sump- og vådbundsskov.
	Driftpåvirkninger m.v.		
95	Ingen tegn på jordbearbejdning, harvning o.l.	Indikation af urørthed. Jordbearbejdning, dyrkning, harvning indebærer en stærk forandring i jordbund og et stærkt brud i jordbundskontinuiteten	Forekomst af intakte morlag og uforstyrrede profiler, fravær af harvefurer. Ingen umiddelbare tegn på harvning, opgravning o.l. menneskelig påvirkning. Naturlige forstyrrelser som følge af fx stormfald o.l. er i orden. Det kan erfaringsmæssigt være meget svært at se gamle spor heraf ved en oversigtlig gennemgang som denne.
96	Ingen grøfter tilstede eller alle grøfter effektivt lukkede	Mulig indikation af høj grad af naturlige vandstandsforhold.	Vurderes uanset om der er tale om rent højbunds-areal eller ej. Afkrydses kun hvis der slet ikke findes grøfter el. rørlagte grøfter på fladen eller hvis alle grøfter er lukket effektivt (kastet til el lign.).
97	Ingen nyoprensede grøfter (indenfor 10 år)	Indikation af aftagende påvirkning af vandstandsforhold.	Dvs. at eventuelle grøfter ikke har været renset op i de sidste ca. 10 år.
98	Ingen spor af kørsel i bevoksningen (dybe hjulspor)	Indikation af urørthed.	Ingen tegn på hjulspor o.l. fra traktorer, biler m.v. i selve bevoksningen. Skovveje undtaget.
99	Ingen hugstspor (stød) tilstede	Indikation af urørthed. Store stød af bøg kan holde i op mod 50 år og egestød i 100 år.	Ingen spor af hugst. Det gælder også af stadig synlige spor af oparbejdet stormfald o.l.
100	Ingen nyere hugstspor (stød) (< ca. 10 år)	Indikation af ekstensivitet.	Ingen unge spor efter hugst eller oparbejdning af stormfald o.l.
	DELSUM 3		
	Delsum 1 (overført)		<sumcelle til praktisk brug - kan udelades>
	Delsum 2 (overført)		<sumcelle til praktisk brug - kan udelades>
TOTALSUM		<Antallet af afkrydsninger tælles sammen. Resultatet er indeksværdien>	

Appendix C. Updated and additional interview guides

C.1. Updated questionnaire guideline

Date:

Informant:

Household name:

Introduction:

Hello,

We are (say names)

We are 9 students from Malaysia and Denmark who have come here to San Pandak to do a study in the village for our university. We will be here for 10 days. Today, we are asking households about their household activities.

We would be very grateful if we can ask you some questions about your household?

Who lives in this bilik?

Name	Family relation*	Age	Main occupation?	Location of work?/ Distance to work?	Notes

***f**rom the point of the informant

Who with close relation to the household have migrated?

Name/ person nr.	Family relation	Age when migrated	Location	How often did (s)he come home the last year?	Does (s)he help with the farm work when at home?	Notes

What are the household's activities/sources of income (subsistence and monetary)

	Yes	No	Don't know/ don't understand the question
Crop farming			

Live stock			
Fishing			
Collection of other river products (e.g. snails, turtles)			
Aquaculture			
Collecting forest products			
Remittances			
Logging compensation			
Employed job			
Government subsidies (fertilisers, pesticides, seeds, cash)			
Loan			
Other 1			
Other 2			

If farming is done, which crops are grown by the household?

- Hill rice (paddy bukit)
- Swamp rice (paddy paya)
- "Beach" rice (paddy pantai)
- Pepper
- Oil palm
- Rubber
- Cassava
- Vegetables
- Fruit
- Cacao

Others _____

Which of these to you spend the most time on? _____

Which of your crops do you earn most money on? _____

Thank you very much. Could we please come back and talk to you another time?

Do you have any questions for us?

Any notes about the informant/the interview:

_____

_____

_____

C.2. Zainie's interview

Introduction

Purpose: Understanding rural-urban linkages

Theme 1: Who is the interviewee, his job

Theme 2: Government policies

- Programs for farmers,

- Extension (subsidies, distribution, technology, credit…)

- What is the process, from application to reception?

Theme 3: Market

- Urban demand for rural products
- Market organization
- Market information

Theme 4: Migration.

- So, it seems as though migration is a bit of an issue in San Pandak, is it a general trend?
- Are there any policies directed to manage constraints of migration on rural areas and urban areas?

Theme 5: Land tenure

- What is the relationship between the land tenure and the schemes/Distribution of subsidies?
- Conditions to consider a land as a State Land?
- What is the regulation on fallow land? How is it enforced?

Theme 6: Rural-Urban linkages

- What are the main concerns of people in this area, as you hear them?
- Are there any other issue that we have forgotten, that you think are important?

Appendix D. Ethnozoological assessment

Table D.1. List of animal used by villagers (obtained through interview)

Animal	English	Parts and uses
Pelanduk	Bornoan yellow muntjac	Meat; the calf caught on Friday can be put together with liquor to improve blood circulation.
Kijang	Barking Deer	
Babi hutan	Wild boar	Meat;
Munsang	Civet	Meat
Entambah	Flying fox	Meat; used to cure asthma
Landak	Common Porcupine	Meat; Geliga (Bezoar stone); spike used to protect against the illness caused by Giant's Arrow
Angkis	Long Tailed Porcupine	Meat; Geliga (Bezoar stone)
Rusa	Deer	Meat
Tupai	Treeshrew (Tupaia sp.)	Meat, Geliga (Bezoar stone)
Tenggiling	Pangolin	Scales for sale; Geliga
Bear		Meat, empedu to cure gastric
Sawa	Phyton	Meat, fat used to treat burns, empedu for gastric & asthma
Bayak	Monitor lizard	Meat, fat used for massage & burns
Tekura	Tortise	Empedu (bile) used to treat asthma and cough
Lelabi	Softshell turtle	Meat, seseingat – ingat consumed raw to improve memory; empedu for gastric
Engkarung	Skink/gecko (mabuya sp)	Cure for growth retardation

Kenyalang	Horbill	Tangkung (horns) – used to cure sting and snakebite
Enturun	Bear cat	Empedu (bile) for body pains after an accident
Raong		Cure for cough
Semalau (Bird)		Cure for growth retardation
Empitu (Bird)		Empedu (bile) for medicine
Ruai (Bird)	Peacock	Fur for ornament

Table D.2. Mystical use for animal parts; especially for pengaroh (talisman)

Parts		Uses
Boar's Canine		Used for Pengaroh Kebal (talisman for invincibility) especially when its whispered in the dream.
Deer's horns		Used for Pengaroh Kebal (talisman for invincibility)
Cat's horns		Used for prosperity and good fortune
Cock's horns		Used for gaining high ranks and influence
Pangolin Tooth		Talisman for war (head hunting)
Tortoise's hornless		Penunduk (Submissive power)

Appendix E. Ethnobotanical assessment

Table E.1. Species inventory new forest: 2 years old fallow, new vegetation

wpt#	Vernacular name	Scientific name	Usage	Status
1	Engkerebai	Psychotria sp.	Leaf is used to sooth a wound. Boil and squeeze.	Wild
2	Tubu Hutan	Pycharrhena sp.	For headeache	Wild
3	Asam Kechala	Etlingera elatoir	Ingredient for fish soup	Wild
4	Tekalong	Atrocarpus elasticus	String and rope, clothes	Wild
5	Lengkan	Ficus grossularioides	For fruit and leaf for food	Wild
6	Kemunting	Melastoma malabathricum	Edible berries, leaf used to stop bleeding	Wild
7	Manang Padi	Dianella ansifolia	Planted in padi field to protect the padi	Wild
8	Paku Uban/ Kubuk	Nephrorepis acutifolia	Shoot eaten during confinement	Wild
9	Lemiding	Steanocleana palustis	Edible shoot	Wild
10	Jambu air/Kera	Plethiandra sp.	Fruits	Wild
11	Kemibit	Mikania sp.	Encourage flow of Ijok	Wild
12	Dadak	Annona sp.	Fruits	Wild
13	Letup	Passiflora foetida	Fruits (candy#1)	Wild
14	Empasa	Manihot esculenta	Cassava, edible leaf	Wild
15	Lemba	Cicculigo sp.	Berries edible; whitish ends of the leaf provide water, Tuchung cake wrap (candy #2)	Wild
16	Resam	Dacranopteris linearis	Stem is used to tie the bamboo fish trap	Wild
17	Kelindang	Blechnum oriantale	Shoot can be crushed and put on boil.	Wild

Table E.2. Species inventory Old forest/ primery forest

N1	Orchid	Flower used for adornment	Wild
N2	Nyatoh Marapulut	Timber for construction	Wild
N3	Kayu Ubah	Timber for construction	Wild
N4	Geresang	Plant used to create kertupat (miniature basket)	Wild
N5	Empili	Timber used for construction and fruits	Wild
N6	Pinang	Flower used for adornment	Wild

	Kampung		
N7	Kelasan	Timber for construction	Wild
N8	Sikup	Timber for construction	Wild
N9	Melaban	Timber for construction	Wild
N10	Salak	Timber for construction	Wild

Table E.3. Additional findings in rubber forest (R) and agroforest of approximate 40-50 years(A) (non-systematic)

R1	Senggang	Hornstedtia sp.	mats, edible fruits	Wild
R2	Bemban Batu	Donex sp.	Mats and baskets, fish basket	Planted
R3	Lalis	Plectocomiopsis geminiflora	Edible core	Planted
R4	Sabong	Gnatum gnemon	Edible fruits, leaf used to make soup	Wild
R5	Bungkang	Syzygium fragrans	Mix leaf with chicken soup	Wild
R6	Tubu Rumah	Pycharrhena sp.	Leaf for soup	Planted
A1	Temedak/Jackfruit	Atrocarpus integer	fruits	Planted
A2	Kayu malam	Diospyros sp.	Ward off evil spirit	Wild
A3	Engkabang	Shorea macrophylla	Fruit to make white chocolate/ make butter (apply on rice)	Planted
A4	Durian	Durio zibenthinus	Fruits	Planted
A1	Lumuk/ Terap	Atocarpus odoratissimus	Fruits	Planted
A2	Rambutan	Nephellium sp.	Fruits	Planted
	Ruan	Upuna bornensis	Timber	Wild
A3	Empit	Pentaspadon montleyii	Fruits	Wild
A4	Uchung	Baccaurea angulata	Fruits	Planted
A5	Keranji	Dialium sp.	Fruits	Planted
A6	Ijuk	Arenga pinnata	Beverage (alcoholic)	Planted
A7	Buluh Betong	Bambusa giganthocloa	Construction, floor, walls, edible shoots, fish trap	Planted
A8	Tegelam	Shorea Seminis	Fruits used for white chocolate	Wild
A9	Kemali	Leea Indica	Planted with padi to prevent bugs	Wild
A10	AsamEmpelam	Mangifera sp.	Fruits (mango)	Planted
A11	Rengas	-	Poisonous –used for anything??	Wild

Appendix F. Soil quality data

Name	depth	Weight entire sample (g)	Notes	pH	POX	Pox C calculated	Pox calculated % weight	C %	N %
SO1PO1	5	118.02		4.85	0.013	504	0.0504	4.05	0.28
SO1PO1	17	134.58		5.03	0.019	72	0.0072	1.5	0.13
SO1PO1	35	151.79		5.23	0.02	0	0	0.6	0.07
SO1PO2	5	137.89		4.7	0.018	144	0.0144		
SO1PO2	16	146.07		5.36	0.02	0	0		
SO1PO2	35	149.68		5.13	0.02	0	0		
SO1PO3	5	150.18		4.19	0.019	72	0.0072		
SO1PO3	13	147.56		4.64	0.019	72	0.0072		
SO1PO3	35	148.86		5.02	0.02	0	0		
SO2PO1	5	106.22	dry	4.31	0.015	360	0.036	3.46	0.24
SO2PO1	16	131.81		4.89	0.018	144	0.0144	2.99	0.16
SO2PO1	35	160.61		5.07	0.02	0	0	0.58	0.06
SO2PO2	5	127.28	wet and with a little bit of visible charcoal	4.98					
SO2PO2	15	128.24	visible charcoal pieces	4.92	0.018	144	0.0144		
SO2PO2	35	159.71	wet	4.25					
SO2PO3	5	148.51		5.15	0.016	288	0.0288		
SO2PO3	14	147.03	Roots: 7,11 g, and wet	4.7	0.019	72	0.0072		

SO2PO3	35	167.34	moist	4.66					
SO3PO1	5	90.44	Looks like small amount, has some roots, though less than 5 %	5.04	0.015	360	0.036	2.94	0.24
SO3PO1	22	125.24		5.45				1.79	0.15
SO3PO1	35	149.1		4.77	0.02	0	0	1.35	0.13
SO3PO2	5	137.86		5.14	0.017	216	0.0216		
SO3PO2	19	143.15		5.27			0		
SO3PO2	35	162.64		5.13	0.011	648	0.0648		
SO3PO3	5	137.42		4.63	0.018	144	0.0144		
SO3PO3	13	145.7	wet	5.05					
SO3PO3	35	163.3		4.76	0.02	0	0		
Profile Name	Depth (cm)	C %	N %						
SO1PO1	5	4.05	0.28		374.1229744				
SO1PO1	17	1.5	0.13						
SO1PO1	35	0.6	0.07						
SO2PO1	5	3.46	0.24						
SO2PO1	16	2.99	0.16						
SO2PO1	35	0.58	0.06						

SO3PO1	5	2.94	0.24						
SO3PO1	22	1.79	0.15						
SO3PO1	35	1.35	0.13						

Appendix G. Water quality assessment

The overall status of each water body was calculated according to the Water Quality Index (WQI) using the below formula:

$$WQI =$$

$$0.22SIDO + 0.16SICOD + 0.15SIAN + 0.16SISS + 0.12SIpH + 0.19SIBOD,$$

where SIDO, SICOD, SIAN, SISS, SIpH and SIBOD express subindex values of DO, COD, NH_3-N, TSS, pH and BOD calculated based on results (Table G.5-7) and the formulas given in Table G.1 (Guan, 2015). E.g. SIDO (SubIndex for Dissolved Oxygen) is calculated by

$$SIDO = -0.395 + 0.030x^2 - 0.00020x^3$$

$$SIDO_{St.1} = -0.395 + 0.030 * 66.40^2 - 0.00020 * 66.40^3 = 73.32$$

Table G.1. Best-fit equations for the estimation of subindex values (Guan, 2015)

Parameter	Subindex Formula	Condition
DO	SIDO = 0 SIDO = 100 SIDO = -0.395 + 0.030x^2 - 0.00020x^3	for x ≤ 8 for x ≥ 92 for 8 < x < 92
BOD	SIBOD = 100.4 - 4.23x SIBOD = 108e$^{-0.055x}$ - 0.1x	for x ≤ 5 for x > 5
COD	SICOD = -1.33x + 99.1 SICOD = 103e$^{-0.0157x}$ - 0.04x	for x ≤ 20 for x > 20
TSS	SISS = 97.5e$^{-0.00676x}$ + 0.05x SISS = 71e$^{-0.0016x}$ - 0.015x SISS = 0	for x ≤ 100 for 100 < x < 1000 for x ≥ 1000
pH	SIpH = 17.2 - 17.2x + 5.02x^2 SIpH = -242 + 95.5x - 6.67x^2 SIpH = -181 + 82.4x - 6.05x^2 SIpH = 536 - 77.0x + 2.76x^2	for x < 5.5 for 5.5 ≤ x < 7.0 for 7 ≤ x < 8.75 for x ≥ 8.75
NH_3-N	SIAN = 100.5 - 105x SIAN = 94e$^{-0.573x}$ - 5 | x-2 | SIAN = 0	for x ≤ 0.3 for 0.3 < x ≤ 4 for x ≥ 4

The total WQI value was compared to values in Table G.2 to give the overall classification.

Table G.2. Definition of each class of river according to calculated WQI value (mod.e. Guan, 2015)

Class	WQI	Designated Uses
I	>92.7	Excellent quality. Undisturbed.
II	76.5-92.6	Class IIA: Good water quality, suitable for human use. Class IIB: Protect sensitive species.
III	51.9-76.4	Moderate water quality. Protect common and moderately tolerant species. Need extensive treatment for water supply.
IV	31.0-51.8	Poor water quality. For irrigation purposes.
V	<31.0	Very poor water quality. Not suitable for any use.

The Water quality of individual parameters was estimated according to information provided by Dr. Tay Meng Guan (2015) and supplemented with reference values from NREB (2015) and WEPA (2015) (Table G.3).

Table G.3. Reference values for classification according to individual parameters; (a) Guan, 2015 (b) NREB, 2015 and (c) WEPA, 2015.

Parameters	Class I	Class II	Class III	Class IV	Class V
pH[a]	>7	6.0-7.0	5.0-6.0	<5.0	>5.0
Salinity[b] (ppt)	5	10	-	>20	-
Conductivity[b] (µS/cm)	1000	1000	-	<6000	-
DO [a] (mg/l)	>7	5-7	3-5	1-3	<1

BOD[a] (mg/l)	<1	1-3	3-6	6-12	>12
COD[a] (mg/l)	<10	10-25	25-50	50-100	>100
TDS[b] (mg/l)	<500	500-1000	-	1000-4000	>4000
TSS[a] (mg/l)	<25	25-50	50-150	150-300	>300
NH_3-N[a] (mg/l)	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
*NO_3^- [c] (mg/l)	-	<7	-	<2	-
NO_2^- [c] (mg/l)	-	<0.4	<0.4	1	-
*P [c] (mg/l)	-	<0.2	<0.1	-	-
TCC[b] (index count)	<100	100-5000	50000-50000	50000-50000	>50000

*Values are according to reference decreasing with decreasing water quality, which seems implausible.

Complete results can be seen in Table G.4-G.6.

Table G.4. Results from upstream station (station 1). Raw data is highlighted in green.

Upstream station (St. 1)

	St 1, R1	St. 1, R2	St. 1, R3	AVERAGE ST1	STDEV	Class	Subindex formula
pH	6.90	7.25	7.03	7.06	0.18	Class I	99.19
Salinity (ppt)	0.01	0.01	0.01	0.01	0.00		
Temperature (°C)	25.20	25.20	25.20	25.20	0.00		
Conductivity (mS/cm)	0.02	0.02	0.02	0.02	0.00		
Ammoniacal Nitrogen (mg/l)	0.00	0.00		0.00	0.00	Class I	100.50
Nitrate (mg/l)	0.12	0.13		0.13	0.01		
Nitrite (mg/l)	0.00	0.00		0.00	0.00		
Phosphate (mg/l)	0.99	0.99		0.99	0.00		
TDS (mg/l)	9.75	9.75	9.75	9.75	0.00		

TSS (mg/l)	0.00			0.00		Class I	97.50
Dissolved oxygen (%)	68.30	65.00	65.90	66.40	1.71		73.32
Dissolved oxygen (mg/l)	5.60	5.34	5.45	5.46	0.13	Class II	
BOD (mg/l)	0.90	0.91		0.91	0.01	Class I	96.56
COD (mg/l)	104.00	97.00		100.50	4.95	Class IV	17.24
BOD/COD	0.01	0.01		0.01	0.00		5.60
TCC (index count)	1950.00	1650.00		1800.00	212.13		
FCC (index count)	800.00	225.00		512.50	406.59		
WQI value							79.81
WQI Class							Class II

Table G.5. Results from downstream station (station 2). Raw data is highlighted in green. Only two replicates made *in-situ* in accord with uniform readings.

Downstream station (St. 2)

	St 2, R1	St. 2, R2	AVERAGE ST2	STDEV	Class	Subindex formula
pH	7.53	7,10	7,32	0,30	Class I	99,06
Salinity (ppt)	0,01	0,01	0,01	0,00		
Temperature (°C)	25.90	25.90	25.90	0.00		
Conductivity (mS/cm)	0.02	0.02	0.02	0.00		
Ammoniacal Nitrogen (mg/l)	0.00	0.00	0.00	0.00	Class I	100.50
Nitrate (mg/l)	0.13	0.12	0.13	0.01		
Nitrite (mg/l)	0.00	0.00	0.00	0.00		
Phosphate (mg/l)	1.00	0.93	0.97	0.05		
TDS (mg/l)	13.65	14.95	14.30	0.92		
TSS (mg/l)	0.00		0.00		Class I	97.50
Dissolved oxygen (%)	43.00	44.10	43.55	0.78		40.80
Dissolved oxygen (mg/l)	3.50	3.58	3.54	0.06	Class III	
BOD (mg/l)	0.20	0.58	0.39	0.27	Class I	97.95
COD (mg/l)	83.00	78.00	80.50	3.54	Class IV	27.15
BOD/COD	0.00	0.01	0.00			

TCC (index count)	3800.00	4400.00	4100.00	424.26		
FCC (index count)	400.00	6175.00	3287.50	4083.54		
WQI value						74.49
WQI Class						Class II

Table G.6. Results from tap water from gravity fed water system (station 3). Raw data is highlighted in green. Only two replicates made *in-situ* in accord with uniform readings.

	Tap water (St. 3)					
	St 3, R1	St. 3, R2	AVERAGE ST3	STDEV	Class	Subindex formula
pH	7.48	7.48	7.48	0.00	Class I	96.85
Salinity (ppt)	0.00	0.00	0.00	0.00		
Temperature (°C)	28.80	28.90	28.85	0.07		
Conductivity (mS/cm)	0.01	0.01	0.01	0.00		
Ammoniacal Nitrogen (mg/l)	0.60	0.60	0.60	0.00	Class III	37.50
Nitrate (mg/l)	0.13	0.12	0.13	0.01		
Nitrite (mg/l)	0.14	0.01	0.07	0.09		
Phosphate (mg/l)	1.01	1.04	1.03	0.02		
TDS (mg/l)	5.85	6.50	6.18	0.46		
TSS (mg/l)	0.00		0.00		Class I	97.50
Dissolved oxygen (%)	54.80	50.60	52.70	2.97		56.78
Dissolved oxygen (mg/l)	4.23	3.90	4.07	0.23	Class III	
BOD (mg/l)	0.58	0.56	0.57	0.01	Class I	97.95
COD (mg/l)	98.00	102.00	100.00	2.83	Class IV	18.19
BOD/COD			0.01	0.00		5.38
TCC (index count)	300.00	300.00	300.00	0.00		
FCC (index count)	125.00	0.00	62.50	88.39		
WQI value						66.86
WQI Class						Class III

Interestingly, the water quality is actually significantly worse in the tap water – used for drinking – than at the two stations examined for environmental effects from agriculture in terms of NH_3-N (Table G.7). The villagers have been notified of elevated levels of NH_3-N in their drinking water.

Table G.7. Results and classifications including tap water from the gravity fed water system.

Parameters	Tap water	Upstream	Downstream
pH[a]	7.48 (±0.00)	7.06 (±0.18)	7.32 (±0.30)
Salinity[b] (ppt)	0.00 (±0.00)	0.01 (±0.00)	0.01 (±0.00)
Conductivity[b] (mS/cm)	0.01 (±0.00)	0.02 (±0.00)	0.02 (±0.00)
DO [a] (%)	52.70 (±2.97)	66.40 (±1.71)	43.55 (±0.78)
DO [a] (mg/l)	4.07 (±0.23)	5.46 (±0.13)	3.54 (±0.06)
BOD[a] (mg/l)	0.57 (±0.01)	0.91 (±0.01)	0.39 (±0.27)
COD[a] (mg/l)	100.00 (±2.83)	100.50 (±4.95)	80.50 (±3.54)
BOD/COD	0.01	0.01	0.00
TDS[b] (mg/l)	6.18 (±0.46)	9.75 (±0.00)	14.30 (±0.92)
TSS[a] (mg/l)[a]	0.00	0.00	0.00
NH_3-N[a] (mg/l)	0.60 (±0.00)	0.00 (±0.00)	0.00 (±0.00)
NO_3^- [c] (mg/l)	0.13 (±0.01)*	0.13 (±0.01)*	0.13 (±0.01)*
NO_2^- [c] (mg/l)	0.07 (±0.09)	0.00 (±0.00)	0.00 (±0.00)
PO_4^{3-} [c] (mg/l)	1.03 (±0.02)*	0.99 (±0.00)*	0.97 (±0.05)*
TCC[b] (index count)	300.00 (±0.00)	1800.00 (±212.13)	4100.00 (±424.26)
WQI	66.86	79.81	74.49
Class	Class III	Class II	Class II

*Classification not performed cf. Table G.3.

Explanation of results unrelated to research objectives

Figure G.1. Picture taken at upstream station.

The high COD and related low DO may have natural origins: It was noticed in the field that the colour of the water body was reddish-brown, and at a tributary just below sampling station 1 a layer of reddish-brown solids were noticed at the bottom of the water. As the water sampling was conducted in surface water these solids were not measured. They are hypothesed by the group and Dr. Tay to consist of a mixture of organic material and iron, which potentially could give a high COD. The hypothesis of iron content arises from the colour of the solids and the soils surrounding river San, the latter being a mixture of white and red. The field guide and Malaysian counterpart stated that the river and tributaries origins from peatland and one could hypothese organic matter from the peatland to be the cause of the high oxygen demand and the reddish-brown solids. However, this is not supported by the neutral pH (peatlands are acidic) and low BOD. The relatively low FCC and TCC support the claim by field guide that there are no tributaries containing wastewater flowing into river San between the two sampling stations. An increase in TCC were observed however, but this may be due to lower flow velocity allowing the bacteria to multiply at the lower station.

The DO is so low (44% at downstream station) that it can be expected to have a negative impact on the fauna of the stream e.g. invertebrates and fish. This fits with the observations of only a few small fish at the upper location – none at the lower – and no invertebrates. However, we did not conduct systematic investigations of the fauna due to lack of equipment and lack of standardisation in Borneo. The low DO content likely has a negative influence fishing possibilities at the location.