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Impacts of Agricultural Commercialisation on Land Use and Livelihood in Banteay Chhmar Commune, Cambodia

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Preface

The present report is the result of the field study in Banteay Mancheay province in Cambodia as part of the SLUSE Interdisciplinary Course on Land Use and Natural Resource Management (2009).

The goal of this report is to relate and analyse our findings on impacts of agriculture intensification in Banteay Chhmar commune on local livelihood and environment. It is based on lectures given before departure, data collected during the field trip that took place from the 4th to the 20th of March, as well as relevant literature.

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We also would like to thank our Cambodian counterparts Phanny He, Naluch Lim, Nara Chan, and Sinuoeun Suo as well as our interpretor Virak Gidar, it has been a great experience to share with them the learning, the data, the shelter and the fun.

Last but not least, we are very thankful to all people we have met during our study for their kindness, hospitality, patience and willingness to talk with us for hours.

Abstract

In recent years, there has been a considerable change in the agricultural patterns in north western Cambodia. Due to the increasing demand for energy crops in Thailand, cassava was introduced as a cash crop to the area around Banteay Chhmar. The farmers in the area were already cultivating other types of cash crops along with their subsistence crops, but as commodity prices on the world market went up, the demand and hence the price for cassava skyrocketed. With global financial crises of 2008, the prices on cassava have dropped dramatically. This eventually led to Thailand closing the border to protect Thai farmers.

To characterize the impacts of commercialisation on farmer livelihoods and vulnerability along with the effects on the local environment, a series of interdisciplinary investigations were made in the study area. This included natural science methods such as soil analysis and GPS mapping; and social science methods including interviews and participatory rural appraisal.

The wholesale price increase in 2007 along with the very low input requirements inspired a lot of farmers in the region to invest heavily in cassava, showing a high degree of adaptability to the market. Our research shows that the farmers became less diversified after they adopted cassava because they abandoned a variety of cash crops that they had cultivated before. This led to an increase in vulnerability which resulted in livelihood strategy change – e.g. more people have to go to Thailand as unskilled worker to be able to pay back loans.

The commercialisation also has consequences for the surrounding forest, which is diminishing at an alarming rate due to clearing and logging. But the forest also represents an economic resource for the very farmers that are clearing it, leaving a inherent land-use conflict.

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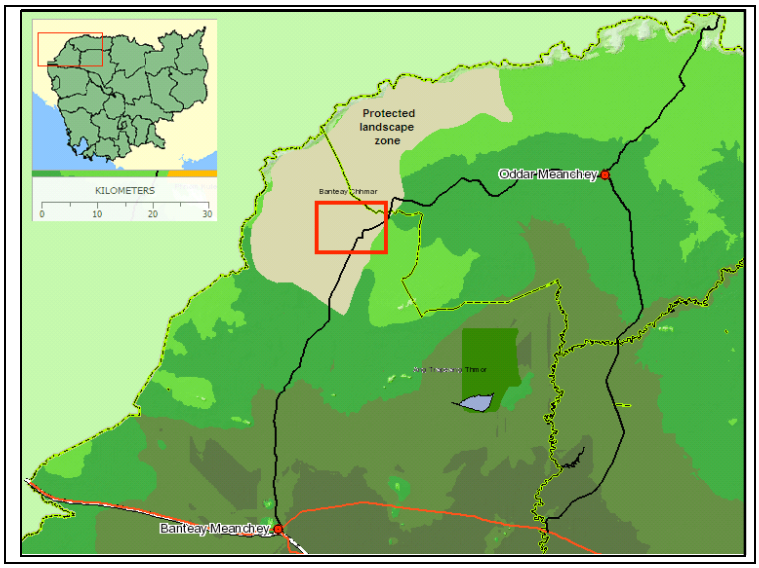
Background on the problem

Cambodia is located in South East Asia, sharing borders with Thailand in North and West, Laos in the North East, and Viet Nam in the East. Cambodia has an area of 181,040 square kilometres, much of which lies at an elevation of less than 100 meters (CIA, 2009). The region of interest in this study lies in the "upland" north-western province of Banteay Meanchey. Upland Cambodia is flatter and more arid than lowland areas fed by the Mekong delta. There is still a prolonged rainy season good for extensive rice growing, from mid-May to early October, and a dry season from early November to mid-April. Temperatures range from 17 ˚C in January to a high of 40 ˚C in April.

The political history of Cambodia in the last several decades has been tremendously destructive of rural ecosystems and rural livelihoods. The aftermath of these detrimental years stretches far in to both present and future, and political and social stability still has a long way to go. Examples of this can be seen anywhere in Cambodia to various degrees, also in our area of interest, the village of Banteay Chhmar (see **Map 1**), where residents experience high levels of poverty, recurrent food insecurity and a complicated land tenure situation (Kusakabe et al., 1995; Sedara and Sophal, 2002) Subsistence is primarily based on mixed agriculture involving rain-fed rice, various degrees of subsistence crops and cash crops and some livestock, but also selling wood and off-farm work.



Map 1: Banteay Meanchey province. Research area marked with red box.

Recently a market has emerged for cassava-based biofuels in neighbouring Thailand, and Cambodian farmers largely abandoned their previous cash crops with cassava to get into the lucrative cassava market. Cassava is a very attractive cash crop for local farmers, as it is easy to propagate and grow, requires little input, and can also thrive on marginal soils. There is almost no history of use of cassava as food in upland Cambodia,

although its leaves are sometimes used for fodder.

In addition to converting other cash crops to cassava, the farmers also clear local forest areas to increase cultivation. In the case of Banteay Chmar, this is problematic since the farming area exists within a so-called "protected landscape" zone, which is under government management (see **Map 1**). The farmers' expansion into the protected forest land creates various challenges since it holds a conflict of interest between the farmers right to improve their livelihood through extensive cash cropping vs. the sustainable use of the forest as a natural resource.

While increasing market integration can benefit the smallholder economy in the near-term, it can also render farmers more vulnerable to other factors. Cambodian cassava farmers in the Banteay Meanchey province wholesale their products predominantly to Thailand, where demand is susceptible to the politics of regional trade (Sambath, 2008) and therefore quite volatile as this study shows. Historically, as smallholders open their livelihoods to trade, they tend to shift their labor away from subsistence crops, and the diversity of agricultural strategies tends to decrease, which in turn exposes households to greater consumption vulnerability (Vadez et al., 2004). Mund and Bunthan (2005) go further and suggest that rather than alleviating poverty, "dependence on cash cropping has been shown to intensify debt and landlessness of the rural poor in almost all of the Asian development countries, along with a negative impact on diet and community healthy in general." This suggests that the very farmers who are drawn to cash-cropping cassava may be rendered more vulnerable in the long-run.

Cash cropping is also obviously attractive as a buffer against the risks to a smallholder economy. It is a common way for a farmer to diversify their livelihood strategies and provide a kind of insurance against variables outside the farmer's control – for example the loss of other subsistence crops, labour shortage due to illness, and the unpredictability of climate (Bentley et al., 1987 as cited in Vadez et al., 2004). But as observed in the study area there are still various risks involved with cash cropping; especially when it is based on one single crop. Agricultural commercialization is viewed by development strategists as crucial for poverty reduction in the tropics, although some recognize that this often involves a tradeoff between immediate income and conserving local resources for other uses (Tomich et al., 2001).

Upland Cambodian smallholders must continually weigh different livelihood strategies in the context of competing needs of other stakeholders (such as other local landowners, livestock owners, and regional forest protection authorities). The long-term sustainability of cassava cropping is also limited by the continued environmental health of local resources. Increasing agricultural commercialization has been linked to long-term environmental degradation, and continuous cassava mono-cropping has been linked to loss of soil fertility and eventually decreased production capacity (Valentin et al., 2008; Tomich et al., 2001).

Objective

In light of the potentials and threats to livelihood posed by increased commercialization based on cassava among Banteay Meanchey farmers, our objective is to understand the dynamics of cassava farming in the community, and analyze the impact cassava growing has on farmer livelihoods as well as the surrounding environment. This leads us to ask four specific questions:

- What characterizes the livelihoods of farmers who grow cassava?
- What are the dynamics of the cassava market and farmers' involvement in it?
- How has cassava farming affected the livelihood of current cassava farmers?
- What are the effects of increased commercialisation on local land use?

What this study will do is explore and map out relationships among different livelihood aspects—such as farming strategies, degree of commercialization—and aspects of status and vulnerability—such as land tenure, amount of land under cultivation, household demographics, and relative food security. This can tell us what the farmer's motivations are, how adaptable they are, and how they conceptualize and assess risks and opportunities.

Next we want to look at the effects cassava farming has had on existing livelihood strategies—for example changes in land use or labor allocation—and explore the impact of these changes on vulnerability and food security. Since the long-term security of smallholders also depends on the condition of the local natural resources, we wish to investigate the biophysical characteristics of cassava cultivation under local conditions. This will require analysis of soil qualities and nutrient balances. The farmer's choice towards extensive agriculture also has consequences for the local interests, namely the forest in the protected landscape zone, which has played an important role in the livelihood of the villagers ever since the village was settled. We will describe and analyze the actors and the different layers of the conflicts.

Methodology

Land use mapping

To assess the land use changes due to agriculture, we had at our disposal satellite data from 2000, 2003 and 2005. We also had some data from the Cambodia atlas regarding the land use in 2000. By extracting the data from each map, we were able to observe general deforestation from 2000 to 2005.

Using field observation by transects walk and GPS tracking and markings, we were able to create a more complete picture, including GIS database on land use in Trapeim Thlok village. We realised 4 transect walks marking with the GPS when land use changed between cassava, cleared forest, fruit trees, and house lots. The last day, we also conducted a transect walk on the northern part of the road, walking along the boundary between forest and cultivated areas.

Household Survey

A household survey was conducted among 36 respondents in two villages, Thma Daekkeh and Trapeim Thlok. In order to explore divergences and convergences in livelihood strategies among cassava farmers, we defined 4 themes on which we collected quantitative data:

- Demographic profile
- Land use information
- Agricultural information
- The cassava market

We used a stratified random sampling strategy, focusing on cassava farmers. We began our sampling with poorer farmers in Trapeim Thlok, where we interviewed 17 respondents, then surveyed additional farmers in Thma Daekkeh to survey wealthier farmers.

Semi-Structured Interview

In order to get answers to more complex and subtle questions, we conducted several semi-structured interviews. These were conducted with farmers from each stratum that were chosen among people we had met during the survey, trying to select the most informative people. We also used this method with key informants with specialized knowledge, such as village chiefs and protected

landscape managers. For additional information we also conducted informal conversations with locals such as our homestay hosts.

Group Interview

In order to get the community perception on the cassava issue and the land use evolution, we conducted a group interview in each village (Thma Daekkeh and Trapeim Thlok). In both villages farmers had been selected by the village chief and were cassava farmers. In conjunction with this we conducted participatory village land use mapping and a participatory seasonal calendar, to observe villagers perceptions of land use and overall agronomic strategies.

Soil Analysis

Figure 1: Naluch and Virak taking soil samples (*Personal source)*

In the field, the ambition was to take out samples from plots with different degrees of cultivation, ranging from newly burnt forest to areas that had been under cultivation for several years (Figure 1). Given the limited time available for soil sampling and testing, an exploratory approach was taken to obtain a rapid general appraisal of the area. We chose to conduct the soil samples in the village of Trapeim Thlok where we did most of our quantitative data collection. Three sites were selected for sampling: a recently burned area and two areas with different degrees of cultivation. In each specific sample location, three soil samples were selected representatively and collected from a depth of approximately 20 cm and then mixed to correspond to the in-field variation.

Results: Dynamics of cassava farming

Origins of the cassava market in Bancheay Chmar

The story of cassava cultivation in Southeast Asia began in the 1970s, when Thailand first began producing cassava pellets to meet heavy demand in Europe for cheap animal fodder. Following changes in the EU's agricultural policies in 1993, however, the demand for cassava fell sharply on European markets, effectively drying up the export market in Thailand. The Thai government tried to help farmers regain their livelihoods by shifting away from cassava and into other crops, but they found that cassava was the best-suited crop for marginal soils and weather conditions in Thailand. Still faced with a surplus of more than 25 millions tons of cassava annually, the Thais tried a different strategy: instead of pellets for animal feed, they began producing raw starch. Here they tapped into a bourgeoning market in China, and subsequently developed a domestic market as well (Howeler 2007).

Bancheay Chhmar villagers who had experience working in factories in Thailand, as well as Cassava traders with direct contacts with buyers, confirmed that raw cassava starch (or "flour" as it was translated) was used in the manufacture of a variety of goods, from baked goods, to shampoo—and, increasingly, as a raw material in the production of biofuel. Anticipating a rise in global oil prices, Thailand was one of the first countries in Asia in 2000 to initiate a "gasohol" program, aiming to replace 10% of their gasoline with fuel-ethanol. Cassava has received a great deal of attention as a source of biofuel: it has also been shown to be better than other biofuel materials (corn, soy), and because it is already domestically produced and does not require the fossil fuel inputs that many other crops do, it could reduce reliance on oil imports. Hence, national demand for cassava has increased, cassava prices doubled from 2003 to 2007, and a number of ethanol production factories in Thailand have been built (Howeler 2007).

Banteay Chhmar province lies on the border with Thailand, and there is a flow of goods between both. Vegetables, processed foods, and hard goods are regularly found in markets in Banteay

Chhmar; and cambodian farmers have a steady export market for their agricultural goods in Thailand, where they have an advantage over Thai farmers as they sell for less.

The first residents in the study area to cultivate cassava for the Thai market did so in the spring (wet season) of 2006. Many had learned of the lucrative cassava market from cassava traders who came from across the border in Thailand, where market demand was quickly heating up. Others had worked in cassava fields in Thailand and had first-hand experience in cultivating it. Cassava has been the darling of agricultural developers in southeast Asia for some time (Howeler 2007), and although there are no agricultural NGOs working in this particular area, local microfinance banks were instrumental in financing villagers' investment in the 2007 crop. From key informant interviews it appears that cassava traders were the closest thing villagers had to agricultural advisors.

Residents quickly learned how to propagate and grow cassava from one another, abandoning other cash crops and clearing more forest for cultivation. By the spring of 2008, based on our sample data, the majority of households that had land at their disposal had cassava in it (32 out of 35 households. Villagers were perfectly positioned to reap the benefits of the skyrocketing cassava market, and reaped huge profits from their harvests in 2008.

Unfortunately, in late 2008 (October-November), cassava producers in Banteay Chhmar found themselves with field upon field of mature cassava, and a sudden absence of anyone to buy it.

Worldwide, the prices of energy crops fell drastically the last half of the year 2008, closely coinciding with the fall in agricultural commodity prices (Biopact 2008). This crash naturally also affected the prices of cassava (Figure 3). According to one source, "poor ethanol returns, combined with lower crude oil prices in recent months, have depressed cassava utilization in energy production, thereby accelerating the general price decline" (bioenergysite 2008b). In addition to the reduced demand for their products, farmers in Thma Daekkeh and Trapeim Thlok are also suffering from protectionism from the Thai side of the border. Economic and political tensions between Thailand and Cambodia have seen a resurgence since the global economic crisis, with the Thai government closing the border to Cambodian-grown rice and cassava, in the interests of protecting their own farmers (phnompenhpost 2008).

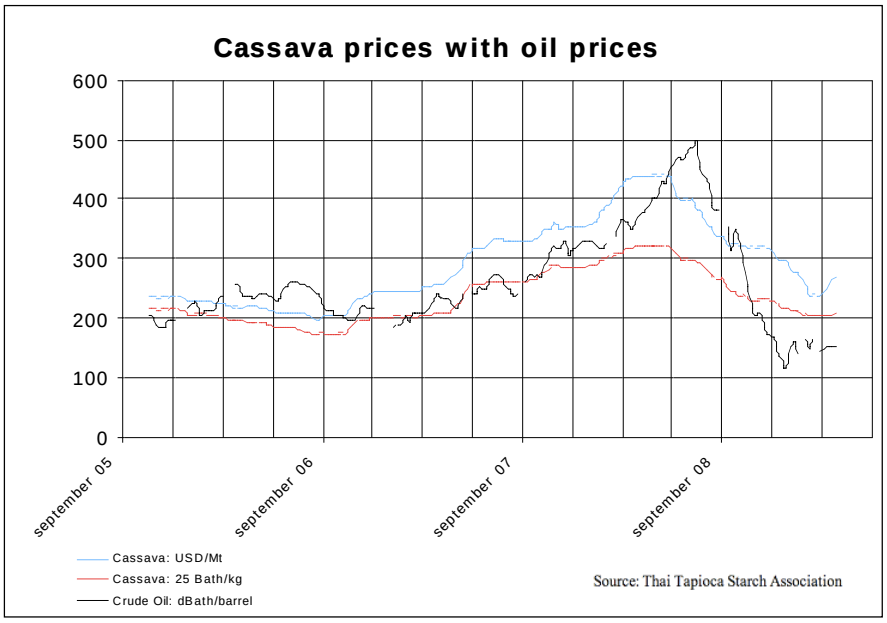


Figure 2: Showing the fluctuation in the cassava prices. The black line indicates the price of crude oil on the world market. The blue line illustrates the extort prices and the red the domestic prices. The prices decline in august 2008. Current prices are still higher than they were before the crash, and before villagers began to invest. Source for oil data: *US ENERGY INFORMATION ADMINISTRATION*

There *is* a domestic market for raw cassava in biofuels emerging in Cambodia, but as yet it cannot benefit farmers in Banteay Chhmar. In November 2008 the first ethanol plant was constructed by Bioenergy Group in Kandal province, just outside Phnom Penh (bioenergysite 2008a). It has an output capacity of 36.000 tonnes ethanol per year, and is mainly supplied by large cassava plantations in Kampong Cham and Battam Bong provinces (ibid; personal communication, Naluch Lim). This plant has limited capacity, is currently well-supplied, and is a great distance (km app. 500) from the study site. Far from its vicinity, the farmers in Banteay Chhmar's only existing option is to sell to the market in Thailand.

Cassava production in an agro-ecological context

Arriving in Bancheay Chhmar by car for the first time, one is struck by the sheer number of cassava fields. Plots of the spindly, 2-meter high plants are tucked between stands of palm and banana trees; they line the roadside, encroach on house lots, and spread in flat planes to the horizon. The situation is not unique to the region: by 2007, a World Bank report estimates that by 2007, three percent of total land in Cambodia was under cassava cultivation (phnompenhpost, 2009). But the

overwhelming adoption of cassava, from our data, has some basis in the history of the villages' development and aspects of the local landscape.

When the area was first settled in the early 1990s (see also our land use discussion), villagers' main occupations were based on extracting and selling resources from the local landscape. The Trapeim Thlok village chief recalled that the men earned their livings cutting and selling timber, while the women sold roofs made of thatch. Within a few years, villagers had broken ground in suitable lowland areas and began cultivating rice for their own consumption. Many began to sell their rice surplus domestically; they also sold many varieties of native fruits (banana, jackfruit, coconut, mango, lichees, and others), and cash crops specifically for export to Thailand (including maize, soybeans, mung beans, and watermelon).

The Trapeim Thlok village chief stated that cash crop cultivation was the main reason for deforestation prior to cassava. Indeed, satellite evidence of land use change [see section on land use for further discussion] shows that the rate of forest clearing was at its highest between 2003 to 2005; cassava was therefore preceded by substantial commercialization.

The most common previous crops, mung bean (*Vigna radiata*) and watermelon (*Citrullus lanatus*), are grown during the dry season as secondary crops before and after rice cultivation. Both are well-suited to rain-fed subtropical conditions and are important cash crops throughout Cambodia. They have been implicated in heavy deforestation in other provinces, and are associated with somewhat indiscriminate use of pesticides and herbicides (Gray, 2003). Key informants reported that mung bean yields typically declined within two harvests; given that mung beans are not terribly hard on the soil (Praveen-Kumar 2002) this suggests that little fertility replacement is taking place. In hindsight it would have been useful to ask farmers how they managed these crops in order to better assess their overall agronomic approach. Villagers have no access to agricultural services or education, and displayed limited interest in enhancing or preserving soil fertility. From the survey there was no evidence of crop rotations, fallow, or green manuring to enhance yields, and few farmers used any treatments on cassava. If this approach continues they may encounter yield problems with cassava as well. "Continuous cultivation of cassava does not appear sustainable on this land because of the depletion of nutrients and soil organic matter," according to Tomich et al. (2001). "On these soils, marginal revenues from fertilizer application to cassava do not cover

fertilizer costs at current prices." For a detailed discussion of our results on soil quality in the area, see the soil results later in this report.

In some ways villagers here didn't fit the definition of subsistence-based smallholders that we were anticipating. They could be described as settlers, more than farmers; having suffered through decades of war, the loss of family members, and extreme displacement, it is possible what we are seeing is some disruption of the typical features of smallholder households. Whether they once belonged to farming families is unknown; their record here appears to be of farming not so much for subsistence, but for cash income. From this perspective, tilling the soil could be the latest in a pattern of simple resource extraction. However, local informants stated that farmers in the region were typical Cambodian agriculturalists.

Many mechanisms/aspects that operate in smallholder economies are not in play here, possibly due to increased reliance on cash crops. For example, household members either worked as agricultural labourers or hired labour to manage large areas, whereas in a true smallholder economy labour is a limit on production, and household size is often correlated with size of landholdings (Netting 1993). Had they had the [culture] of subsistence farmers, would they have allowed themselves to be exposed to such a catastrophic loss? According to Netting (1993), "the integration of smallholders into the economy is never so complete that they are fully dependent on it" (p83). Smallholders often consider multi-year risk, and find it better to "reduce the risk of hunger or starvation by producing a number of different crops for home consumption" (ibid., p84). Cash crops can of course be used as a hedge against the failure of subsistence crops (Maxwell and Fernando, 1989), but they certainly were not in this case—According to farmers interviews, villagers used the profits from the 2008 harvest to pay back loans and to invest in further cultivation. Although this is extremely difficult to ascertain, there was no evidence from the survey that the returns from the boom harvest were saved, or allocated to other household needs, or otherwise added to household security in the poorest households.

However, it may be that another, more practical factor has shaped resource use in the area: the lack of consistent access to water and good soil. Villagers in Bancheay Chhmar have few options for extracting a livelihood from their dry upland areas, called *chamkas*, and can only grow rice and garden vegetables during the rainy season. Soils from these areas are not of good quality (see

discussion later in report), and throughout the war regional irrigation systems were destroyed or badly neglected. Farmers in both villages complained that only a few drought-tolerant crops can survive here during the dry season; previously villagers grew mung beans, root crops, and watermelon with reasonable success. 13 out of 16 respondents in Trapeim Thlok had no access to rice land at all, and had only cash cropping at their disposal.

Figure 3 **Cassava field**

Cassava thrives in exactly the type of marginal, sandy soils these farmers use. Despite the harsh heat and dryness of the upland Cambodian climate, the cassava plant can produce thick, starch-rich tubers in just 6 months even in nutrient-deficient soils (CGIAR 2005). Compared to many other crops, far less skill, labour and inputs are needed when propagating, planting, and harvesting. To ready the field, farmers first plough the soil into 8”-high ridges, then place a ft-long stem cutting upright into the soil, approximately 2ft apart. (Figure 3 **Cassava field**) (beginning of wet season) Farmers reported that they only need to weed once or twice in the spring, and most do not apply herbicides or pesticides. Less than 20% of farmers interviewed applied any additional nutrients. Despite this minimum of effort, yields in Trapeim Thlok for the 2007 harvest were approximately 30t/ha. A cassava trader reported to us that area yields range from 20t/ha to, rarely, 50t/ha. This is high compared to 23t/ha average yields reported by the World Bank for the same year (phnompenhpost, 2009) and therefore somewhat questionable.

In sum, there are several factors that may have contributed to the cassava boom and bust in Bancheay Chhmar. The fact that cassava so easily does so well in the local soil, together with a history of farming for cash, a spike in market prices, and low transaction costs (Makhura, 2001), may explain why farmers so completely abandoned other cash crops.

Farmers in our sample are overwhelmingly growing the same type of cassava, a white-stalked variety, which matures in 12 months and can stay in the ground for up to 2 years without a loss of starch quality. Two farmers however cultivate a red-stalked variety, which matures more quickly (6 months), but must be harvested soon or else quality will be lost. It seems that farmers are willing to

wait until the use-by date as the investment they put into cassava is too high to enable them to lose it.

Market Investment and Returns

According to the commune vice-chief almost everyone in the area, rich or poor, borrowed money in order to invest in cassava production. Household loan amounts in the survey ranged anywhere from 1.200 to 70.000 baht, with an average of around 20.000 baht. The majority used the local microfinance NGO; others borrowed money from neighbours, other banks, or relatives. Interest rates are from 2.5 - 3%. 84% of the respondents borrowed money for the spring 2008 planting; their loans are due in Spring 2009. Over half of the respondents stated that they will not be able to repay their loan this year.

Data on investments varied considerably among respondents, but ranged from 12.000 to 40.000 bath/ha. For typical costs associated with cultivating and harvest, see Box 1 at right. This is a substantial amount considering many have not yet received any returns. Even one of the most resource poor we interviewed estimates she spent 8,000 baht for the establishment of her cassava plots.

BOX 1: Investment case study

The head of household is a single woman with 7 ha. She doesn't use any inputs or machines. Below are her investment costs for 2008:

Preparing the field: labor 200 baht/day. For the 7 ha she needs labor for 10 days and 10 liters of gasoline at 500 riel/liter.
Propagation material: 10.00 baht.
Sowing: 100 baht/day. Needs 15 persons for one day.
Weeding: 100 bath/day. It takes 30 persons 2 days to weed 1 ha. This is done two times.
Harvest: 10-15 persons for 100 bath/day. Last year it took 10 persons 12 days to harvest 2.5 ha.
Transportation: She has her own truck, which she uses to transport the cassava to the border. 1 ton costs 50 baht from field to house.
Drying: takes 3 days. Cassava can be dried on the field, but this is risky so close to the rainy season. She can sell the dried cassava for 2,7 bath /kg at the border, but this price is still to low, also compared with the risk of drying.

The simplest way to sell a harvest, and what many farmers do, is sell the whole field outright to the middleman, who incurs expenses for harvest and transport. Farmers receive slightly less return this way, but also avoid paying the costs of transportation and drying, which many lack the means for. The alternative is to pay for labour to harvest the fresh or dried root and transport it to the buyer themselves, avoiding the cost of the middleman. In 2008 a farmer could get 220 riel/kg, or 240riel/kg if they drive it directly to the plant in Thailand, but this also entails border taxes; most prefer to sell at a discreet location "in the forest" before the border, and pay an "informal tax" instead. Today this price is only 80 riel/kg. Just under half our respondents hired labour for the harvest; 1/3 harvested it themselves, and the remainder sold the entire field to the middleman to

harvest and sell. Most villagers do not have the means to transport or sell their product themselves; having traders come "take it off their hands" is very convenient, but obviously leaves them high and dry when those buyers aren't around. Occasionally the raw cassava is chipped and dried before export, but this is cost-intensive and is not done by most farmers.

For many villagers, there are very few transaction costs associated with participating in the cassava market. Two-thirds of farmers in our study delegated the harvest to laborers or middlemen. The majority of villagers have no direct access to current market information and rely on middlemen or the village chief to provide it. Villagers' somewhat distant relationship with the market may explain why they seemed passive in terms of their knowledge of the market, their consideration of market risk, and their expectations of the future (saying for example, "we just want the market to go back up," or "we want the government to find someone else to buy the harvest"). Most villagers have no strategy for their cassava problem except to wait.

LIVELIHOOD

From the survey we see that the livelihood has changed since the settlement of the village. In the beginning livelihoods were based primarily on the forest resources, then it changed more towards agriculture with an increasing degree of commercialisation. Through cash cropping they depend on the market, which – if that was the only source of income – would make them very vulnerable to market fluctuation. To measure the vulnerability we have assessed the different sources of income in each household, dividing the respondents in 4 strata based on land size:

1. stratum: [0-3] ha 11 households
2. stratum: [3-7,5] ha 11 households
3. stratum: [7,5-15] ha 11 households
4. stratum: [30-31] ha 2 households

As we see in the 4 charts below (Figure 4), there is a clear distinction between how the farmers in the different strata differentiate their sources of income.

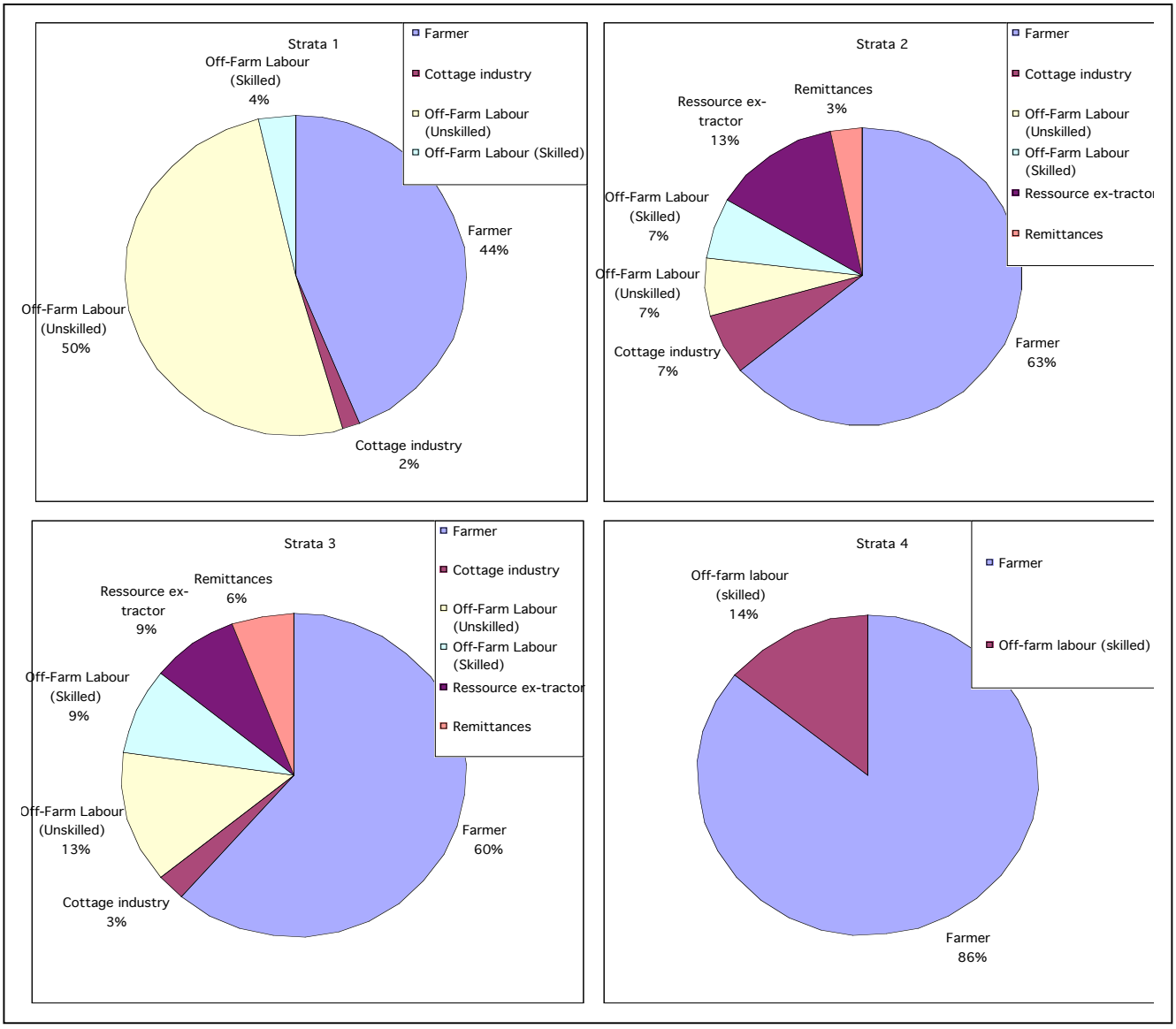


Figure 4: Sources of income divided by strata. Other household occupations include home making, student and persons under/over the working age

Strata 1 shows that 50 % of the households income is based on unskilled off-farm labour, whereas the other strata have little to no income from this source. We also detect an increase in the number of people that list their main occupation as farmer as the land size increases. There is also a clear tendency towards more skilled labour from stratum 1 with 0 % to stratum 4 with 14 % (bearing in mind that stratum 4 only holds 2 households). Stratum 2 and 3 shows a multifaceted picture with income-diversification ranging from cottage industry to resource extraction from the forest. There is

a trend towards more skilled work from stratum 2 to 4, and stratum 2 and 3 also gets income from remittances, which corresponds with more general resource-fullness.

Based on the different diagrams we find that the people in stratum 1 are more vulnerable due to their limited span of income sources. One question arises when discussing the conclusions based on the chart: Are we seeing the consequences of the current financial situation, or is this the general picture? Based on the interviews we saw a tendency towards more people going to Thailand to work in order to meet the household debt, which could imply that the composition of the household income has changed somewhat due to the collapsed cassava market. Regardless of the situation, we see a more widespread and diversified approach to income generation in stratum 2 and 3, which leaves them less vulnerable to loss of single income sources.

Another relevant consideration related to the division of household occupations in the survey is that a person can have different jobs throughout the year as the agricultural workload changes with the seasons. Stratum 4 only holds two respondents which means than it cannot be compared directly with the other strata. However, it does give an indication of the strategies of the wealthier farmers.

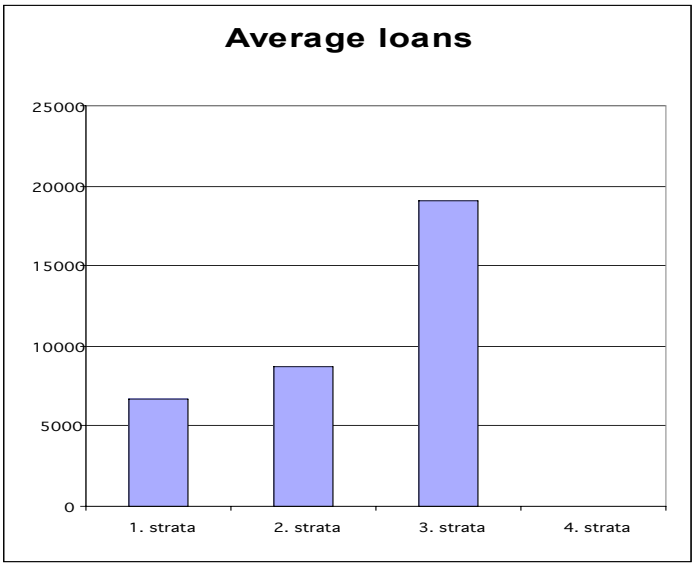


Figure 5: **Average loans divided by strata**

Half of the respondent in the survey took out loans in 2008. The majority of the loaners stated that they borrowed the money to invest in cassava (Figure 5: **Average loans divided by strata**). Data shows that the loan size increased with the land size, showing that either the larger landowners were less risk averse than the small ones, or it could indicate that the farmers – regardless of strata – took out loans relative to their land size. The latter would indicate that they all were risk-willing to the same extent, but subsequently had different ability to pay back the loans. It is noteworthy that the respondents in stratum 4 did not take out loans, even though they are very involved in cassava cultivation. This suggests that they are

resource strong, and – based on interviews – that they made money from last year's harvest which they reinvested.

Another aspect of farmer vulnerability relates to crop diversification, which from a theoretical point of view increases the livelihood risk (Ha 2004). As we see in Figure 6, there is a clear difference in the diversification strategy between the strata. The farmers in stratum 1 have cassava on the majority of their land, whereas the tendency for the other strata is that only half or less of their land is cultivated with cassava. This indicates that the farmers from stratum 1 are more susceptible to market changes as they have "put all their eggs in one basket", since the actual size of their rice field and other fields are very small. However, a study by Ha (2004) shows that the reason for low crop diversification is due to small landholdings which act as a constraint. The fast adaptation to the market demands undermines the idea of the "conservative farmer".

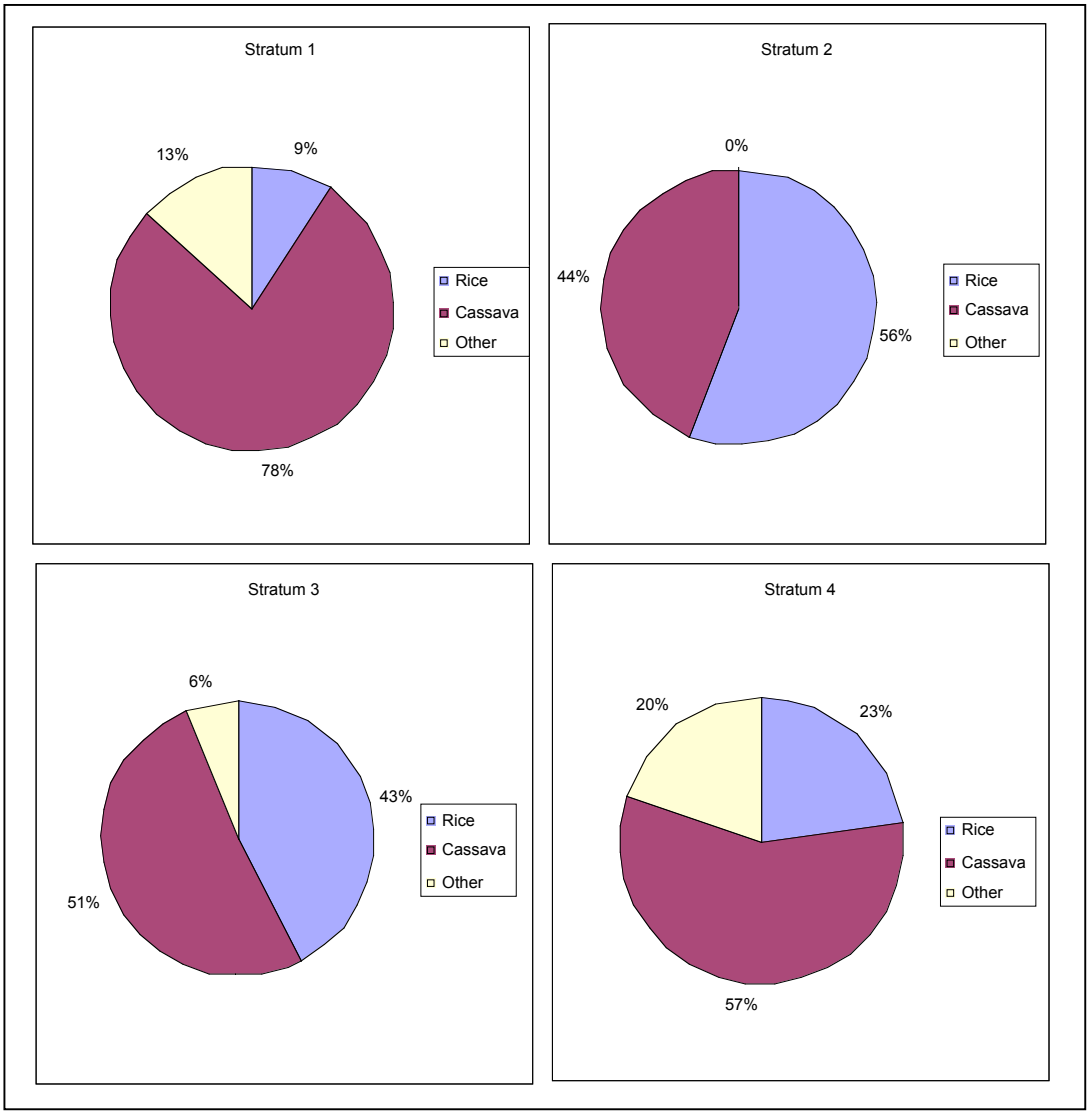


Figure 6: ***Land use diversification***

When looking at the land use, the percentage of rice fields is an important indicator of wealth and household security. According to the commune vice-chief in Banteay Chhmar "people that have a lot of rice paddies are better off". From a vulnerability point of view, rice has an important buffer capacity because is both used for consumption and sale. Additionally, the rice market is perceived as more stabile compared to the cassava market since it is a home market with a continuous demand.

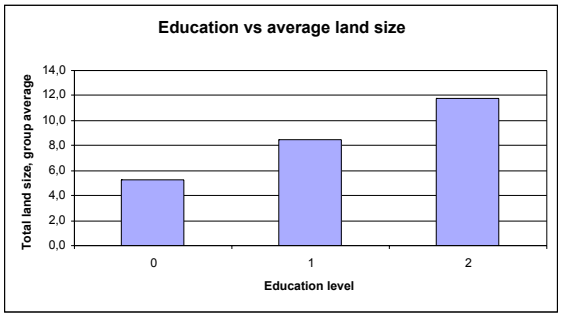


Figure 7: Land size sorted by educational level.

0: no education. 1: Primary school. 2: Secondary school and above

The survey shows a strong link between land size and educational level as can be seen on the Figure 7: Land size sorted by educational level.. Correlated with the stratification, the conclusion is that the farmers are better educated in the strata with more land, leading to the deduction that the better educated farmers have a more diversified cultivation strategy and a more diverse income pattern.

From our survey we learned that regarding the farmer's current livelihood situation, most of the farmers from the resource poor village of Traepeng Thlok stated that their biggest concern is food security, whereas the farmers from Thma Dekkeah are generally more concerned about the cassava market. Both concerns relate to financial matters, but the villagers of Thma Dekkaeh have various other possibilities for cash income leaving them less prone to immediate food shortage.
One of the important other sources of income is the forest. Especially in Thma Dekkeah it is an important part of the villagers earnings, and it appears that the forest acts as an economic buffer. This, however, collides with their perception of the forest as a part of the protected landscape zone and the subsequent protective regulations, because when asked about their opinion they focus only on their claim for more agricultural land. In this way it seems that cassava competes with their own most important income sources.

Land use conflicts in the area

In 2003, ten years after the settlement of Trapeim Thlok, the king of Cambodia declared the surrounding forested area a "protected landscape," effectively encasing the villages inside an 48,320 ha zone of restricted use. Within Bancheay Chhmar are the ruins of several 13th century Angkor Temples and, according to informants, the area was declared in order to provide a buffer for them against the effects of increasing population. Other protected landscape areas have been designated in areas with other temples (e.g. Siam Reap) (SCW 2006). According to the forest administrator, if

the forest around the temples disappears, the temples would be "like stones in the desert". He believes that preserving the forest will enhance tourism in the future.

Under the decree, village residents are allowed unrestricted access to the forest and its resources, but only for private consumption and logging of dead trees. All commercial use – for example selling firewood or growing crops for sale – is illegal (see Appendix 2).

It was not until 2007, however, that an office of landscape protection was established and began to enforce the law. These authorities designated six separate community forests and allocated them to the villages, and village chiefs were given responsibility for their protection (see map and legislation in the Appendix 2 and 4). "The people can protect the forest better than we can," said our informant. They also worked with an NGO called VSG to provide several training sessions, educating villagers about the area's legal status and promoting the forest as a long-term, renewable resource. However, our survey showed very little understanding of the protected area. When asked about their perception of the protected area, villagers responded in several ways: they either showed no awareness of the law, they acknowledged the law but stated they did not use it for commercially (even if evidence of timber for sale was in the yard, for example), or they complained strongly that the law was unfair and restricted their livelihoods. Often the forest administration is seen as being at odds with the people: as Thma Daekkeh village chief said: "keep forest, kill people". Of 24 people that have answered the question about their opinion on the protected landscape, 13 were able to give their point of view — only two villagers declared having a positive opinion — whereas 11 did not know it or had no opinion.

Box 2: Renewable Use of the Protected Landscape

Households reported they used the forest for many things

- Frogs and lizards for consumption/sale
- Herbs for medicine
- Trees for firewood and charcoal
- Grass for building construction
- Vegetables
- Grazing and shelter for cattle

Whatever the level of awareness and enforcement, clearing of the forest seems to be a common practise. During transect walks, we documented fields in various stages of land clearing

Box 3: Not only village people

Residents are not the only ones responsible for clearing forest in the protected area. Nonresidents were not included in our survey, but villagers stated that a fair amount of the land in the area is owned by outsiders. The former village chief of Thma Daekkeh estimated that 10% of the total land under cultivation in Thma Daekkeh is owned by outsiders. They are often "high ranking people" who come from the bigger cities in the province; for example, one 100-ha cassava plot is owned by the Tamar Po police chief.

Villagers reported that rich farmers who do not live in their commune have more means to clear land and have been clearing large amounts in the last few years in order to grow cassava. Small farmers feel they

and cultivation – some still smouldering, some blackened and re-growing with grass, some freshly ploughed into high ridges ready for cassava sticks, some previously cleared and abandoned again to forest shrubs (Figure 8: different stages of land clearing:). Survey analysis shows that virtually every farmer has cleared some piece of land for cultivation, while forest authorities estimated a 1-2 ha expansion per household.

Figure 8: different stages of land clearing:
a. burning forest, b. clearedforest regrowing with shrubs, c. tilled field ready for cultivation

Clearing the forest for cassava is not the only 'illegal' activity in the area. Timber and non-timber forest products still constitute an important cash income for many households, especially this year as they cannot sell their cassava yields. On the 18 people we surveyed in Thma Daekkeh, 6 reported making additional cash incomes on forest resources, especially timber products. When forest is cleared, large timber is harvested first before the vegetation is burned. Hirsch (1999) concludes that poorly controlled logging has been the main culprit in deforestation over the past decade in Cambodia. It is a common sight to see villagers selling firewood along the road, for which they can earn 390-400 baht/month. Timber is also sold on the black market, where it fetches much higher prices (up to 600 baht/month), but this entails paying "informal taxes" to authorities. The continued commercial use of forest resources is not surprising given the history of development the area: our survey results showed that early settlers made their livings from the sale of forest resources before moving into cash crop cultivation.

Figure 10: confiscated tools in the protected landscape office

Since the new commune chief has been elected and the administrative office has been created, villagers sense that their access rights to the forest are more restricted. If people are caught in the act of clearing forest, they may be charged with a fine or have their tools confiscated as evidence (Figure 10: confiscated tools in the protected landscape office

Figure 10: confiscated tools in the protected landscape office). Of the 50 farmers who were brought to court because of clearing activities since 2007, only 3 did not agree with the sentence and kept using the cleared land; the others had the fields taken away to allow forest to re-grow. Forest authorities said that they would like to be able to put more violators in jail as a deterrent – wealthier farmers can afford to simply pay the fine, while others may consider the fine an acceptable cost compared to the sale of their harvest.

Enforcement of the protected landscape area is still quite inefficient. Forest authorities lack means to manage the area: There only 8 poorly-paid men responsible for 48,000 ha; they have to use their own motorbikes and pay for their own fuel when they patrol. They are also implicated themselves in small-scale corruption: respondents in our household survey mentioned an "informal tax" villagers can pay to administrators if they are caught.

In 2008, the commune filed a request with the king for rights to part of the protected area, including some fields already under cultivation as well as additional forest. They asked for 12,313 ha, forest, or what amounts to 25% of the total protected area. They are only seeking access to the land, not

ownership. Informants suggested that the king and prime minister have approved the request; it is now up to the environment ministry, represented by the local administrators, to decide.

Property rights in the Cambodian context

Exactly what property rights do villagers have in this case? To outsiders, the picture of land tenure in Bancheay Chhmar commune can seem a bit complicated and incoherent. According to different informants the government in collaboration with UNESCO originally gave every newly settled household 1 ha dryland (*chamka*), 1 ha lowland and 25x70m for a house lot. This is the only land the villagers have legal documentation on. Subsequently the government gave the village chief the authority to delegate user rights to additional land to the other villagers. This explains why many villagers have a paper on land signed by the village chief. This is an informal paper, therefore only giving informal property rights over a piece of land. Any forest land that households had already cleared by 2003, when the protected landscape area was defined, they were granted legal access to; any further expansion was considered illegal. The legal validity of this process is difficult to confirm, and data from the survey are not consistent.

The situation in our study area also reflects the complex story of land use in Cambodia. Even though the state has historically claimed sovereign property rights, by custom "the land belonged to the tiller" (Kusakabe et al., 1995). Private property ownership went in and out of fashion beginning in French colonial times, through the civil war and finally to the period of the Khmer Rouge (1975-1979), when the Khmer population was violently resettled to farm "communal" lands (ibid). Then in 1989, the Cambodian government instituted various schemes to redistribute land back to private individuals. Generally land was apportioned according to the size of the household, the population density and the amount of land available in an area. The process was mainly implemented by the local authorities, and enforcement has been inconsistent (Sik, 2000).

Deforestation

Cambodia's population is in flux, with high rates of migration to rural areas. From Dasgupta *et al.* (2004) "overall population pressure is a major determination of deforestation in Cambodia" The increase in population in Bancheay Chhmar has brought with it increasing agricultural commercialization as well as alarming rates of deforestation. As shown in Figure 11: Overall pace of agricultural expansion into the forest since 2000.10, in 2000, the earliest year for which there is

clear spatial data, human activity is concentrated in small village areas. By 2003, there is evidence of expansion concentrated along the road going north, while only few fields were cleared deep in the forest. From 2003 to 2005 an explosion of development occurred, not only in Trapeim Thlok, but in the eastern part of the forest. We calculate the general deforestation rate to be almost 8 times higher in 2005 than it was in 2003 (55ha/year in 2003 vs. 432ha/year in 2005).

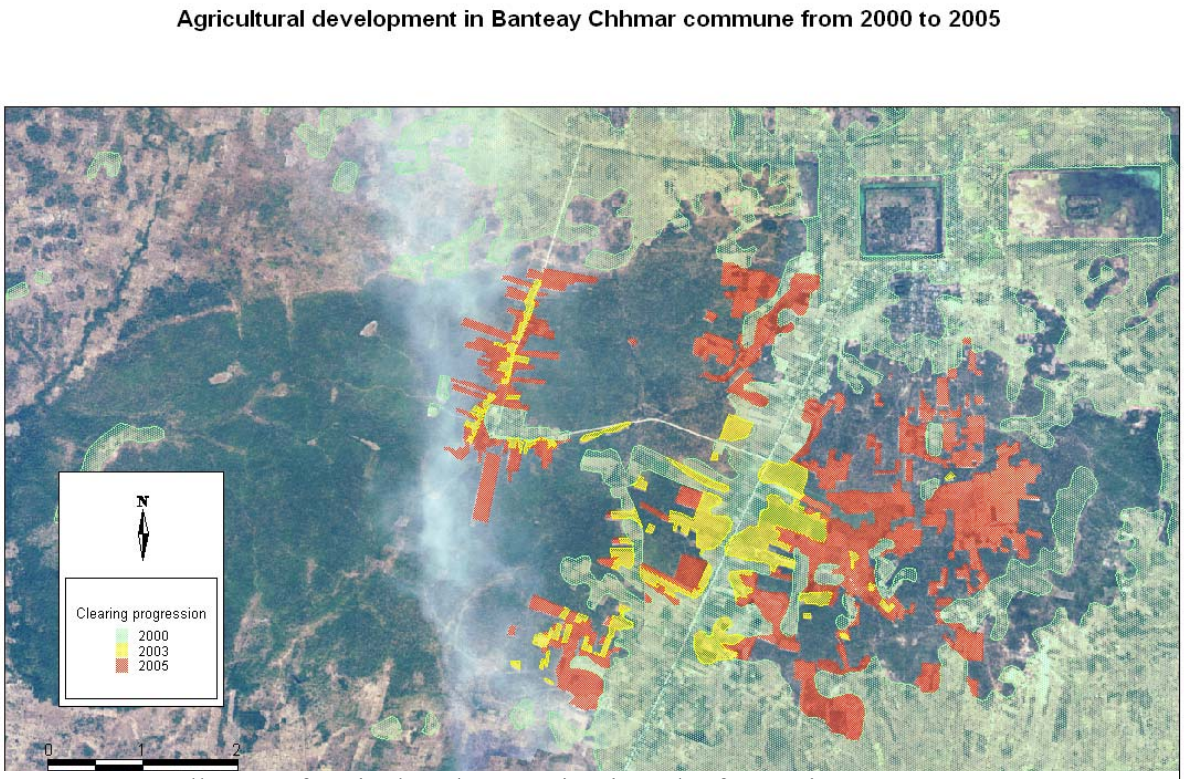


Figure 11: Overall pace of agricultural expansion into the forest since 2000.

To understand this expansion in more depth, we focused our fieldwork on the village of Trapeim Thlok. Combining satellite data with observations in the field, we were able to zoom in on the village and create the following map (Figure 11) showing deforestation evolution from the main road westward into the forest. By 2009, the forest boundary had been pushed back to 535m from the road on average. The present GIS enabled us to calculate deforestation rates and total cleared area for this particular part of the village. Therefore, data are not representative of the whole commune nor the whole village, however, they give a quite good example of the deforestation dynamics.

Deforestation evolution on the western part of the road in Trapeim Thlok

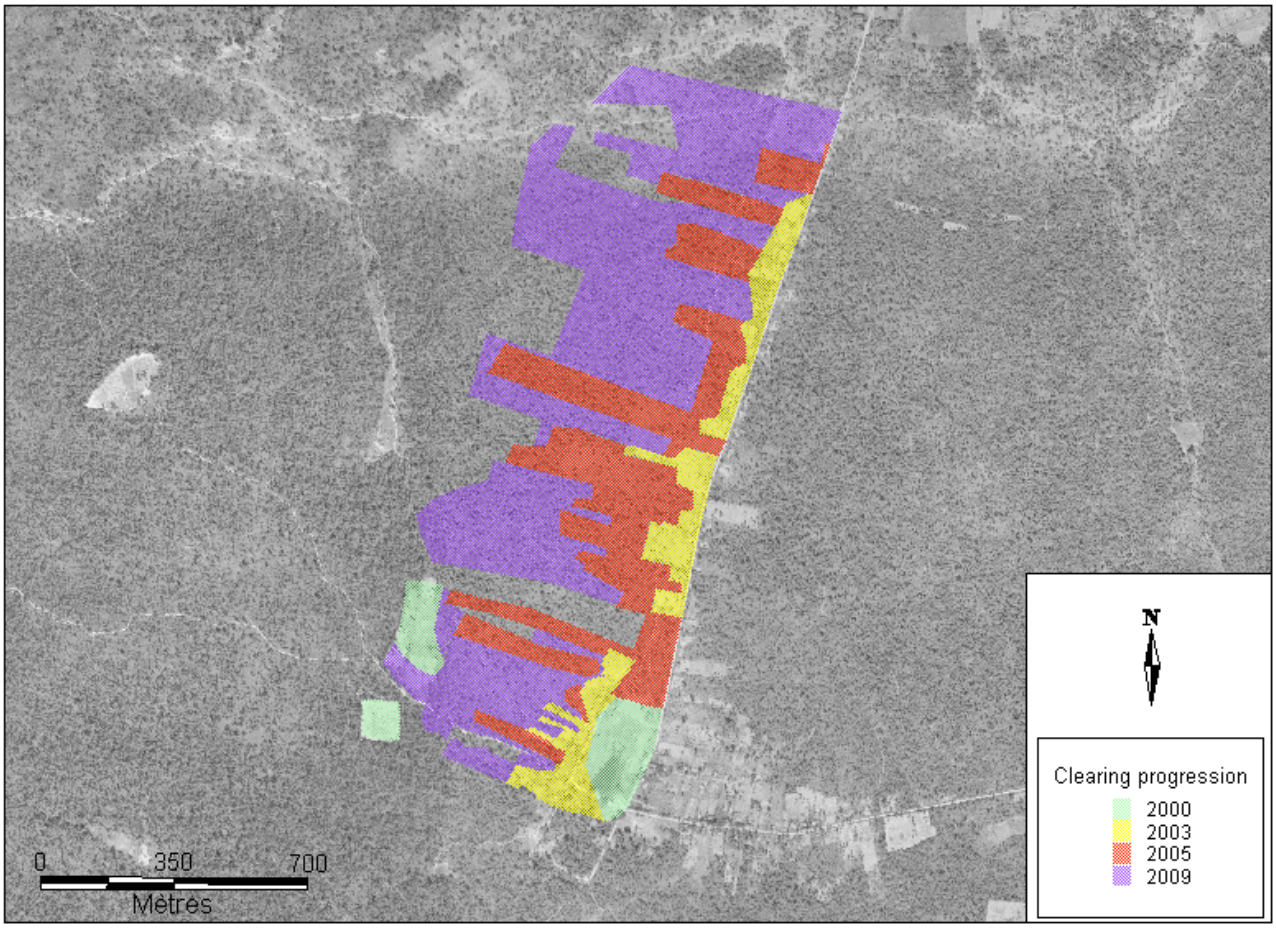


Figure 12: In 2000 only a small fraction of the total area was cleared, which corresponded mostly to the houses and rice fields (respectively east and west green parts of the map). In 2003 the village had developed along the road. Then, 2005 and 2009, show two big stages of agriculture development.

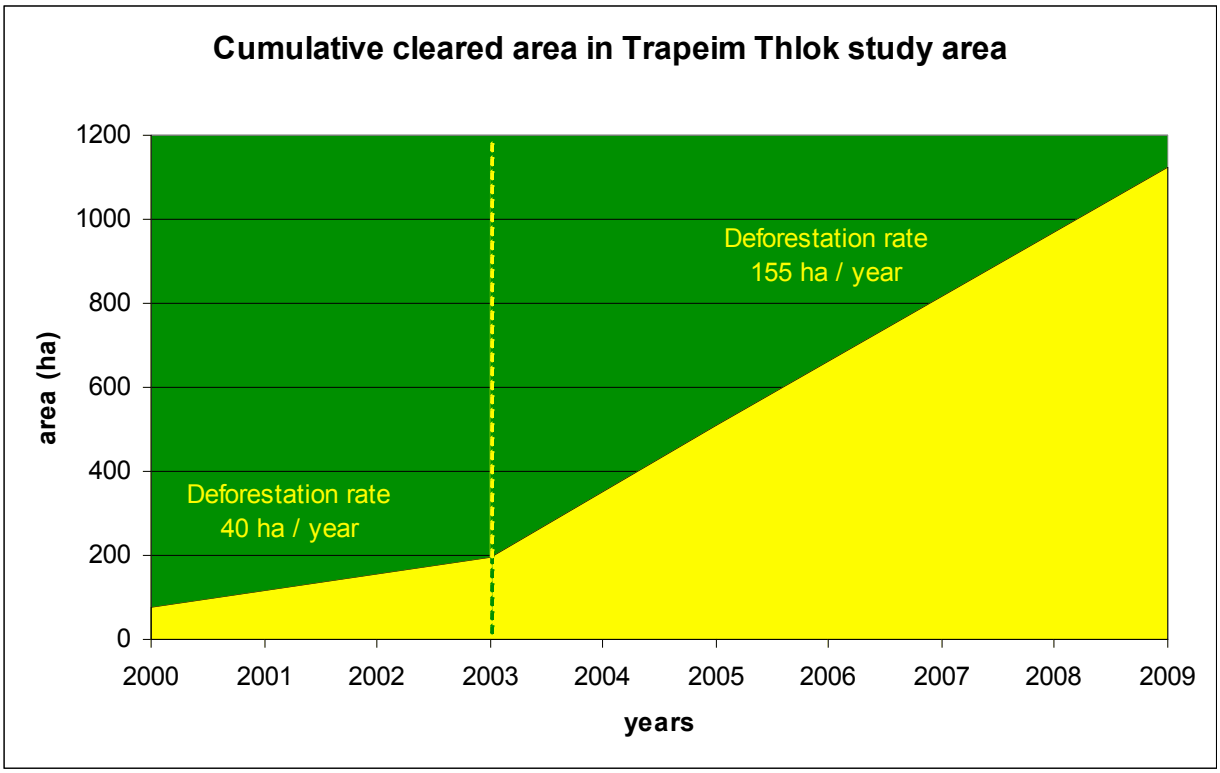


Figure 13: Data extracted from GIS: The total cleared area was 74ha in 2000; 194ha in 2003; 510ha in 2005, and it is now 1122ha in 2009. Until 2003 the deforestation rate remained low; after 2003 it increased to a rate of 155ha/year.

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Figure 12 documents the progressive increase in total cleared land. Between 2003 and 2005, deforestation rate reached a very high rate which has remained fairly constant. We know from our field work that cassava cultivation started only in 2006 and reached its peak in 2008. Therefore we can assume agriculture expansion observed in 2005 relates to other crops than cassava.

Figure 14: *Intentional fire Trapeim*

Regarding the situation in 2009, field observations showed a lot of recently cleared forest, we even saw some intentional fires in progress (figure 13). If current trends continue, there will be little left of the forest very soon, regardless of the protected landscape law. Villagers are seeing a decline in forest resources, for instance they cannot find straw-grass (they use for grass roof) as easily as they used to. One of the farmers we interviewed said

that 10 years from now he doesn't expect to see much forest left in the landscape; if it is not cassava it will be something else. Dasgupta *et al.* (2004) conclude that deforestation stands for the decrease of biodiversity and threatening ot ecosystems

Land Use Change Associated With Cassava

Continuing our land use observations in the village of Trapeim Thlok, we mapped the extent of cassava compared to cleared forest, and other land uses (see Figure 14). Cassava, shown in red, seems to have overtaken cultivation in the area. We observed no evidence of any other crops, with the small exception of rice paddies and fruit trees (shown in yellow). Forest areas that have obviously been cleared (either burned for future cultivation or logged) is also extensive. According to local informants that accompanied us during the transect walks, much of the clearing is very recent.

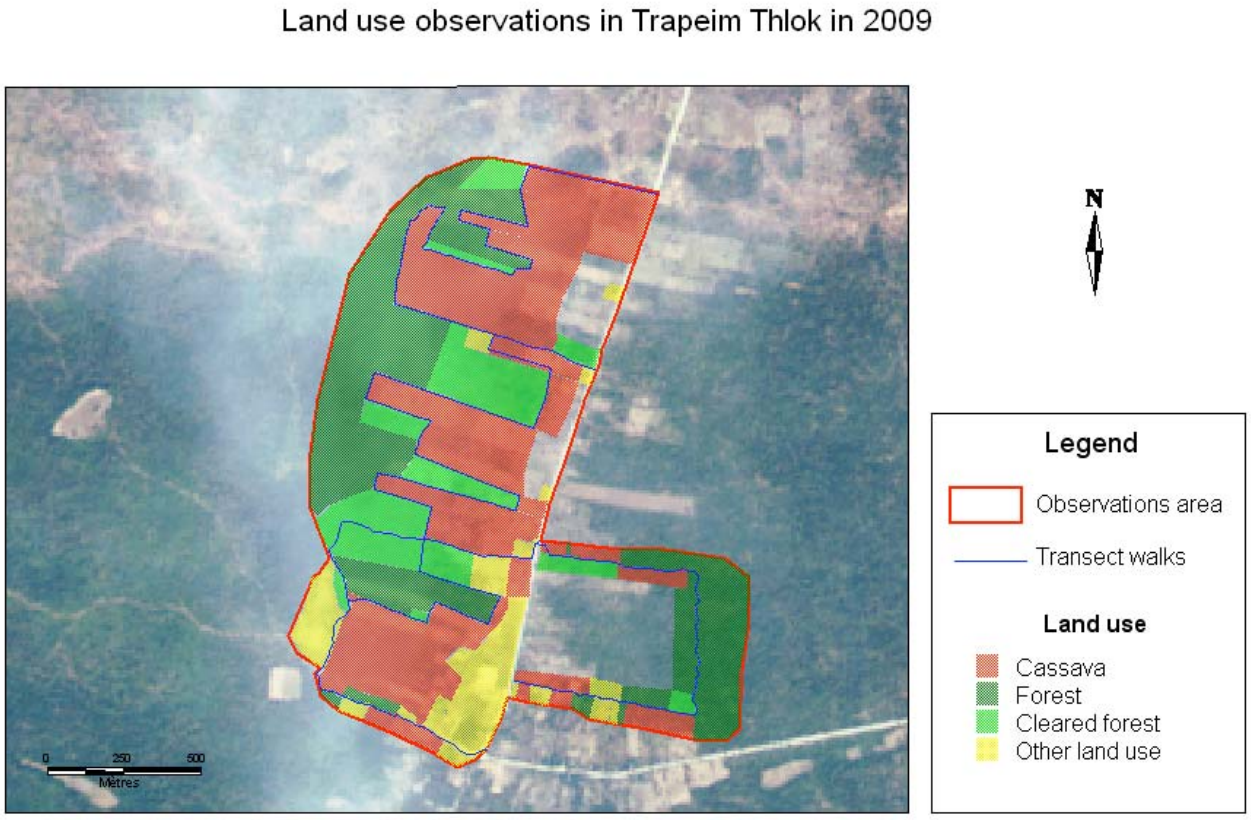

Figure 15: Compiled from data collected during transect walks.. Cleared area = 260ha, cassava =678ha, other land use

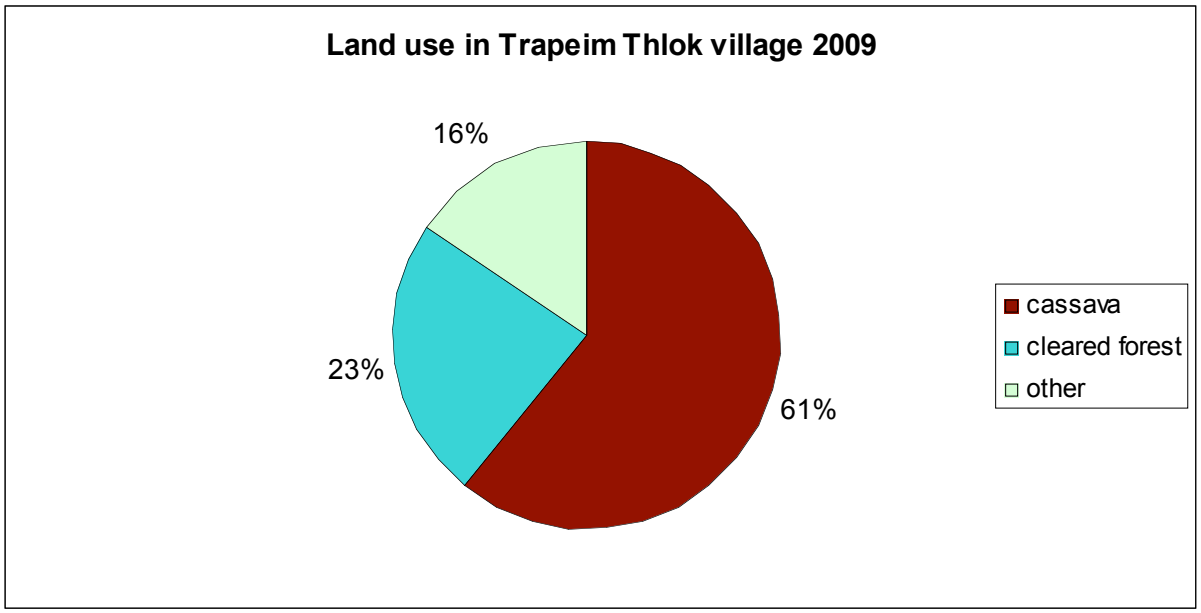

Figure 16: *Data extracted from GIS using current land use observations from transect walks. "Other" stands for all other kinds of crops and land use than cassava, forest or cleared forest*

The amount of cleared area is very high in proportion to the rest of the village land use, Indeed, the land use "other" has a very low percentage: village ground is overwhelmingly either already cassava, or intended for cassava (figure15). Agriculture is endlessly continuing its development. It shows the recent dynamics of deforestation due to cassava fever and its impacts on the local landscape. The study site shows the intersection of what Valentin *et al.* 2008 stated are the three main forces that drive deforestation: population pressure, government policy and market demand. The more people, the less forest, the more pressure.

Effects of Cassava on agronomic diversity

The entire village was outside the scope of this study, but we did get a representative and detailed view of the impact of cassava on village cropping strategy. GPS and satellite data confirm field observations that cassava is dominant cultivated crop, accounting for a full 60% of the total non-forested area. Although there is a strong history of agricultural commercialization in the area (see section on land use history), the arrival of cassava has meant an even more severe decline in diversification.

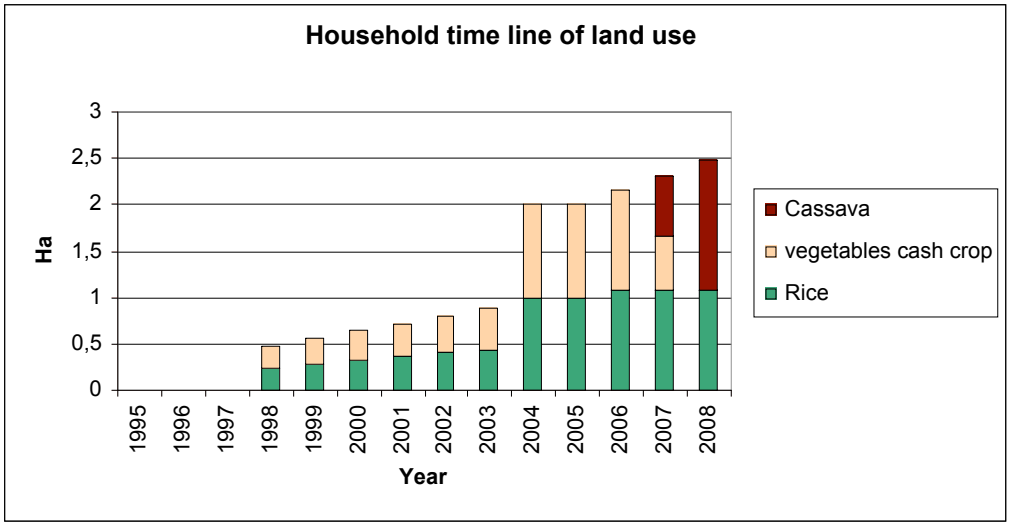

Figure 17: This timeline shows the land use history of the former village chief of Trapeim Thlok. He arrived in 1995 in Trapeim Thlok but started cultivating in 1998 with less than 0,5ha, then he gradually expanded his crops with both rice and vegetables. Vegetables can be soybeans, mung beans, watermelon, etc. In 2004, he doubled his land under cultivation (from 0,9ha in 2003 to 2ha in 2004). Then in 2007 he reduced his vegetables cash crop to start cassava instead. The next year he totally abandoned vegetables and switched to cassava (1.4ha).

Figure 16 shows that clearing is not necessarily due to cassava, it started before around 2004 when farmers were cultivating different kind of crops. Then around 2007 we observe another deforestation wave, this time due to cassava market. In general, our results show a trend toward reduction in crop diversity, that makes farmers very dependant to the market and more vulnerable as discussed previously.

Soil Quality Analysis

From our observations and literature, the dominant soil type in the surroundings of Banteay Chhmar is plinthite podzols. This type of soil has a low agricultural potential and is often covered by forest or used for grazing land (Cam gov 2008). Podzole has a "bleached-out layer from which clay and iron oxides have been leached, leaving a layer of coarse-textured material containing primary minerals and little organic matter" (Encyclopædia Britannica 2009b), and it is typical of upland well-drained soils (Borggaard 2008). Based on the typical slash and burn cropping methods in the region, we expect to see the effects of ash amendment on the soil as well. The most abundant element in ash from wood is calcium, which has a liming effect in the soil. Ash also supplies the soil with different nutrients, e.g. potassium and phosphorus, in the ration 0-1-3 (N-P-K). (Risse 2002). Deforestation is normally known to cause sandy and infertile soils, due to the disruption of the ecological balance and removal of the protective forest cover (Coulter 1998).

As described previously, cassava is known for being able to grow in very poor soils due to its low nutrient demands. Nevertheless, continuous cassava monocropping can lead to nutrient depletion. Cassava is a root crop and in addition used as a biofuel crop in the field location, both things implying a total removal of plant biomass returning little amount of nutrient back to the soil, hence depleting the nutrient pool and SOM content. However the short duration of cassava cropping in the area (2-3 years) does not give us the opportunity to investigate the effect of cassava cultivation on the soil. Instead we assessed the state of the soil, with soil fertility soil and cropping opportunities in mind. In order to investigate this, a number of representative soil samples were gathered and processed both in the field (with field test kits) and in the lab at LIFE-KU.

The goal of our tests was to assess selected soil parameters in samples collected from plots under various levels of cultivation, thus determining the difference - if any - between the different soil conditions. The soil nitrogen content was tested because, next after water, nitrogen is primarily the single most limiting factor in tropical agriculture and can cause great yield decreases (Coulter 1998). The C:N ration was determined in an attempt to create a picture of the amount of organic matter and its quality. The soil was also tested of its content of phosphorus, potassium and aluminum. The two first are important plant nutrient and the latter poisonous to plants in high quantities. Furthermore, the soil pH is measured due to its effect on the nutrient availability for plants, and finally the soil conductivity was tested to determine the salinity.

Sampling Strategy

We extracted 7 samples, all in Traepeng Thlok, from 3 different locations: 1 from a recently burned area, 4 from one farmer's adjacent fields, and 2 from another farmers adjacent fields.

Soil nr	Soil specifics	Additional information
1	Burned area	
2	Cleared 10 years ago 2 year Cassava	Before: vegetables (beans, maize, watermelon, sweet potato, sweet cassava
3	Cleared 10 years ago 2 year Cassava	Before: Rice, added NPK Fertilizer Added manure to cassava
4	Cleared 1 year ago First year cassava	
5	Forest area	Burned
6	Cleared 2003 3 year Cassava	Before: Watermelon, groundnut, sweet potato, corn Use Tractor
7	Cleared 1 year ago 1 year Cassava	Use Tractor

Table 1: Description of the seven sample sites from three areas. Colour-code defines the area

Results

The results of all the soil chemistry tests can be seen in Appendix 5, where they are presented through a colour-ranking relating to their relative value. Generally we would observe that the soil was light brown, very sandy and relatively dry at a depth of 20 – 25 cm. There is no consistent difference between soils that have not been cultivated, soils that have been cultivated for a limited number of years and soils that have been cultivated for an extended number of years. Therefore we are not able to draw any valid conclusions for the effects of cultivation with regard to agricultural sustainability. Looking at the parameters separately, there are a number of observations and conclusions that can be extracted from the test-data:

Conductivity:

Conductivity relates to the salinity of the soil. There is no universal interpretation for the effects of salinity, but according to Landon (Landon 1991, chap. 8.2) a conductivity below 1 is considered low, leaving the effects of salinity negligible in the tested soils. This matches the requirements of cassava which has a low salinity tolerance.

pH:

For most commercial crops a neutral pH range (pH 6,3 – 7,5) is most preferred. Cassava is more tolerant to acid soils with a range for satisfactory yield at pH 5,5 – 6,5 (Landon 1991, table F.4). We did two pH-test: one in the field and one in the lab. Comparing the two datasets, there is a clear tendency towards lower pH values in the field, which is mainly attributed to the difference in testing equipment. As mentioned before the

pH value should be higher in the recently burned areas (nr 1 and 5), which only applies to one of our sample sites. Generally, the soil is acidic ranking from 5.0 – 6.5 in the field whereas appears more neutral in the laboratory ranking from 6.02 – 7.20, both of which lies in an acceptable range for cassava cultivation.

Nutrients:

As described the soil samples have been tested for the content of various nutrients both in the field and in the lab. Generally the field tests proved problematic with a resulting low confidence rate. For comparative measures the most reliable data came from the lab, although some of the field data can be used to indicate certain trends.

Aluminum levels reacting 54000 _g/100g can be toxic for many plants (Landon 1991), the tested soils aluminium values lies between 0 and 1000 _g/100g, and must therefore be considered as very low and not exposing any risk for plant aluminium toxicity.

Indications of poor soil come from the nitrate and ammonium tests, which show low values compared to normal crop needs (e.g. nitrate 50 – 150 kg / ha). The nitrate and ammonium levels, though, are very similar which is unusual since ammonium is readily oxidised to nitrate under normal conditions (*personal communication,* De Neergaard). This can be explained by the overall very low nitrogen level, which implies that the oxidization processes in the soil slows down and the difference between nitrate and ammonium decreases.

Looking at the isolated N and C content, these values also indicate a very poor soil. The carbon content lies between 0,2 -0,5 %, which is low compared to Danish standards, but expectable for Cambodian sandy soil. The values rank from a C:N ratio from 14 – 20.5, which is quit high compared to "normal" soil that lies around 10, even slightly lower in tropical zones (Landon 1991, table 7.4). This relatively high C:N ratio could be the result of burning, combined with the low levels of nitrogen. Burning produces charcoal and other recalcitrant carbon forms which are very resistant to decomposition (*personal communication* De Neergaard). This explains the relatively high values of C, since the farmers use periodic burning.

The phosphorous levels are presumed low. Due to a flawed test kit the values in the chart are only given relative to each other. The chart shows "high" phosphorous levels for the burned area (soil 1), which also has the highest carbon-content.

The values for potassium (K) are extremely high compared to the overall poor quality of the soil, which could be attributed to problems with the test kit. Burning, however, add larges amounts of potassium but this can still not explains that the values are around 10 times higher that high standard potassium values.

Variability

The weakest link is often the sampling procedure, since accuracy and reproducibility seems very difficult for this specific set of samples due to the rapid and limited sampling strategy. In this respect, a high inaccuracy of the sample results is expected and only trends can be commented upon, since the representativity of the samples is questionable. Other limiting factors include defective equipment, problematic circumstances and questionable supervision! ☺

Even though it is difficult to compare the soil samples to each other hence rendering it hard to conclude anything on the sustainability of cassava cultivation or the impact on soil fertility, it is still possible for us to describe the results in more universal terms. We saw some connection between samples from burned areas and high carbon, ammonium and phosphorous content which correlates with theory, although it was not consistent. Generally the nutrient level and organic matter level in the samples are low, which limits the crop species that can successfully be cultivated on this type of land.

Conclusion

In the study we set out to describe and analyse the livelihoods of farmers in the Banteay Chhmar area, focusing on the ones that were involved in cassava cultivation. It turned out that a large proportion of the farmers in the study area had converted to cassava cultivation to a considerable extent, ranging from the smallest to the largest landholders.

The study was conducted in two villages which showed different aspects of cassava farmer's livelihood. We found a correlation between education and land size, and we also see a clear tendency towards more income diversification from middle range farmers, indicating that the very poor farmers do not have the necessary means or knowledge to seek other income sources than the apparent: farming or unskilled work.
Many of the cassava farmers took out loans last year to invest in cassava; also the resource poor. This was motivated by the very large profit made in 2008 due to the dramatic price increase. We found in the study that the farmers were not subsistence farmers with an increasing commercialisation due to the increasing cassava market as we had expected, but in fact they were already oriented towards cash cropping long before the cassava boom, growing a variety of different cash crops. However, a limiting factor in the area is the soil, which we tested for various parameters and found poor.

This means that only crops with low nutrient demands can grow in the area, which limits the possibilities for the farmers. Cassava is very adaptable to poor soils, and along with low labour input needs it is a very easy crop to manage. Along with the expectations of the high profit rates it is very understandable why the farmers were very keen on converting to cassava. This keenness to convert, however, meant that the agricultural diversification has gone down since cassava entered the stage. And now that the cassava market has crashed, the farmers are forced to seek income elsewhere to pay back the loans. Our study suggests that a larger proportion of the poor farmers seek employment in Thailand, and the forest resources are also seen as an economic buffer for financial instability.

We discovered large expansion rates starting from 2003, implying that agriculture in the area is based on extensification rather than intensification. This has consequences for the local forest, which is rapidly diminishing. The protection program under the Protected Landscape Law has limited resources and is not able to stop the farmers from clearing land. The farmers appear to have some limited awareness of the long-term consequences of the deforestation. They seem to be more concerned about the near future that is to say will or when cassava market is going to go up again? Their willingness to change agricultural practice seems limited. Therefore at the rate things are going the forest might be totally gone in 60 years.

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Appendix 1: Synopsis

Agricultural Commercialization in Banteay Chmar

Synopsis

Prepared for SLUSE course Spring 2009, by

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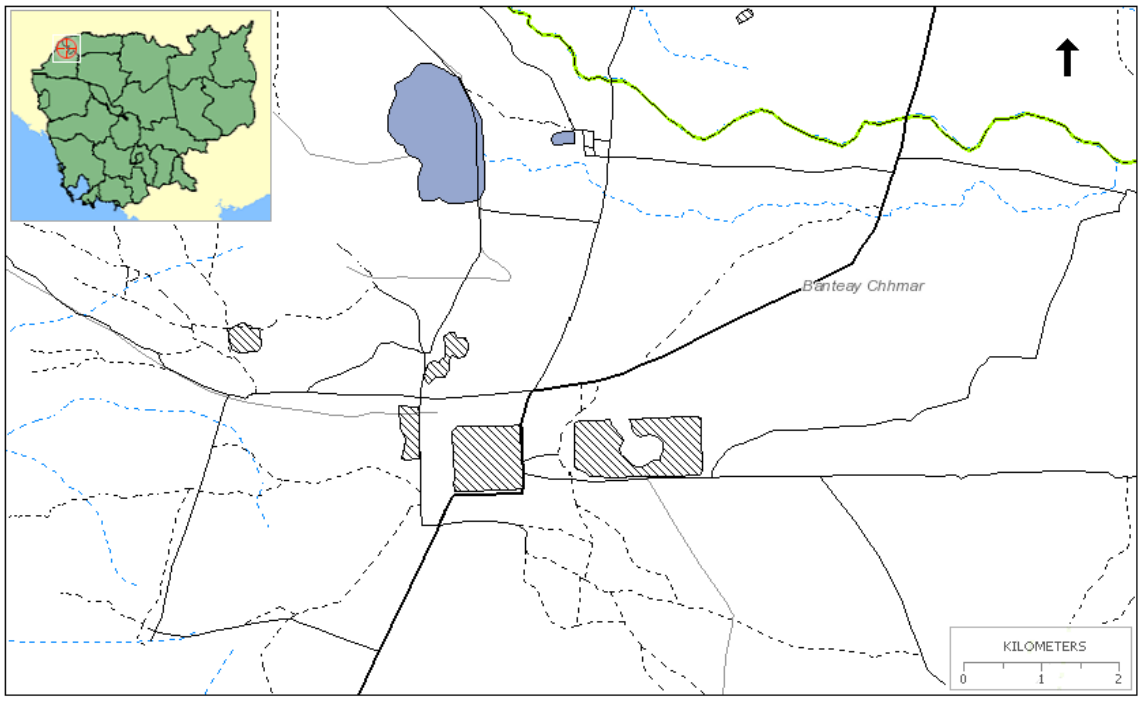
Introduction

Cambodia is located in South East Asia, sharing borders with Thailand in North and West, Laos in the North East, and Viet Nam in the East. Cambodia has an area of 181,040 square kilometers, much of which lies at an elevation of less than 100 meters (CIA, 2009).

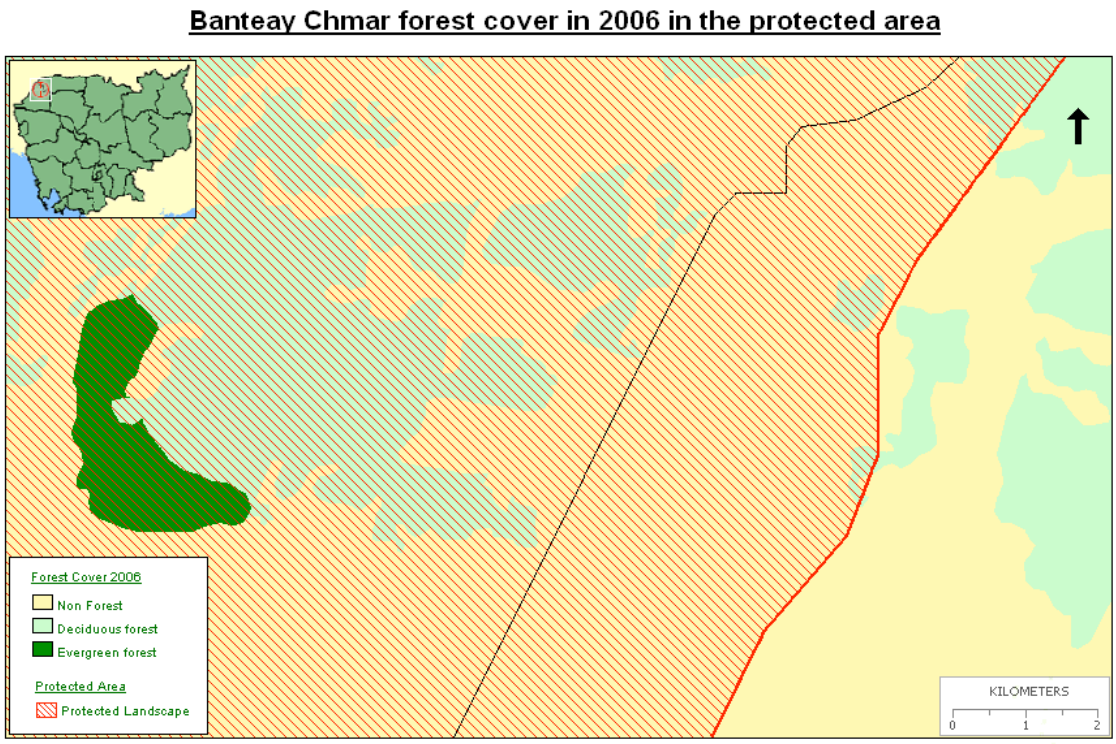
The region of interest in this study lies in the "upland" northwestern province of Banteay Meanchey. Upland Cambodia is flatter and more arid than lowland areas fed by the Mekong delta. There is still a prolonged rainy season good for extensive rice growing, from mid-May to early October, and a dry season from early November to mid-April. Temperatures range from 17 ˚C in January to a high of 40 ˚C in April.

The political history of Cambodia in the last several decades has been tremendously destructive of rural ecosystems and rural livelihoods. In our area of interest, a village called Banteay Chmar (see **Map 1**), residents experience insecure land tenure, high levels of poverty, and recurrent food insecurity (Kusakabe et al., 1995; Sedara and Sophal, 2002) Subsistence is primarily based on mixed agriculture involving rain-fed rice, vegetables, and some livestock. Recently a market has emerged for cassava-based biofuels in neighboring Thailand, and Cambodian farmers have begun to grow cassava in local forests as a cash crop. In the case of Banteay Chmar, this is problematic since the farming area exists within a so-called "protected landscape" zone, which is under government management (see **Map 2**). Farmers' expansion into grazing areas and protected forest land, which is seen as public land, creates a degree of conflict with other villagers who use it for other purposes.

Map 1



Map 2



Background on the Problem

Cassava, or manioc (*manihot esculenta*), is native to South America and is used widely as a staple human food and as livestock fodder in South America and Africa. There is no history of use of cassava as food in upland Cambodia, although its leaves are sometimes used for fodder. Cassava is a very attractive cash crop for local farmers, as it is easy to propagate and grow, requires little input, and can also thrive on marginal soils.

Cash cropping is also obviously attractive as a buffer against the risks to a smallholder economy. It is a common way for a farmer to diversify their livelihood strategies and provide a kind of insurance against variables outside the farmer's control – for example the loss of other subsistence crops, labor shortage due to illness, and the unpredictability of climate (Bentley et al., 1987 as cited in Vadez et al., 2004). Agricultural intensification and commercialization are viewed by development strategists as crucial for poverty reduction in the tropics, although some recognize that this often involves a tradeoff between immediate income and conserving local resources for other uses (Tomich et al., 2001).

While increasing market integration can benefit the smallholder economy in the near-term, it can also render farmers more vulnerable to other factors. Cambodian cassava farmers wholesale their products predominantly to Thailand, where demand is susceptible to the politics of regional trade (Sambath, 2008) and therefore quite volatile. Historically, as smallholders open their livelihoods to trade, they tend to shift their labor away from subsistence crops, and the diversity of agricultural strategies tends to decrease, which in turn exposes households to greater consumption vulnerability (Vadez et al., 2004). Mund and Bunthan (2005) go further and suggest that rather than alleviating poverty, "dependence on cash cropping has been shown to intensify debt and landlessness of the rural poor in almost all of the Asian development countries, along with a negative impact on diet and community healthy in general." This suggests that the very farmers who are drawn to cash-cropping cassava may be rendered more vulnerable in the long-run.

Upland Cambodian smallholders must continually weigh different livelihood strategies in the context of competing needs of other stakeholders (such as other local landowners, livestock owners, and regional forest protection authorities). The long-term sustainability of cassava cropping is also limited by the continued environmental health of local resources. Increasing agricultural commercialization has been linked to long-term environmental degradation, and continuous cassava monocropping has been linked to loss of soil fertility and eventually decreased production capacity (Valentin et al., 2008; Tomich et al., 2001).

Objective

In light of the potentials and threats to livelihood posed by increased commercialization among Banteay Meanchey farmers, our objective is to identify what characterizes farmers in the community who grow cassava, and analyze the impact cassava growing has on farmer vulnerability as well as environmental sustainability. This leads us to ask four specific questions:

- What characterizes the livelihoods of farmers who grow cassava?
- How has cassava farming affected the livelihood of current cassava farmers?
- What are the effects of cassava cultivation on the local environment?
- How does cassava farming conflict with local resource use by other stakeholders?

What this study will do is explore and map out relationships among different livelihood aspects—such as farming strategies, degree of commercialization—and aspects of status and vulnerability—such as land tenure, amount of land under cultivation, household demographics, and relative food security. This should tell us why certain farmers go into cassava farming while others do not, and what their motivations are. Next we want to look at the effects cassava farming has had on existing livelihood strategies—for example changes in land use or labor allocation—and explore the impact of these changes on vulnerability and food security. Since the long-term security of smallholders also depends on the condition of the local natural resources, we need to look at the biophysical effects of cassava cultivation as well. This will require analysis of soil conditions and nutrient balances. Cassava farmers must also coexist and share

resources with other people, with different motivations and different livelihood strategies—such as livestock owners, forest protection officers, and other community members. We will look at the effects of cassava growing on the livelihoods of these stakeholders.

Data Required

In order to situate these questions in a broad and inclusive context, we will approach the study with our complement of skills and perspectives, specifically natural sciences, agronomy, anthropology, and geography. Before starting our field research we plan to meet with our counterparts in Cambodia, come to consensus on our goals and key terms, and also to discuss our individual strengths and interests so that we can allocate tasks efficiently yet still find challenges beyond our personal areas of expertise. During our interviews with local stakeholders' we also want to ask them about their conception of "the problem," to make sure that our research questions are valid and relevant.

To begin to answer our research questions, we want to get a rich picture of what constitutes and differentiates village farmers' livelihoods. This will be done through interviews with village leaders, through household questionnaires, and by participatory rural appraisal methods. We will work with farmers to develop a map of village geography and a seasonal calendar identifying peak periods in the farming year. Once we know which households farm cassava, to what extent, and for how long, we will select a representative sample of farmers for further study. Among these we will conduct more in-depth interviews, and collect soil samples from their areas of cassava cultivation.

For additional perspective on the effects of cassava farming in Banteay Chmar, we also need information from other relevant stakeholders. If feasible we will interview local state and/or NGO representatives, extension officers, livestock owners, community members, and cassava traders; we may also make use of data from other student research groups. Our plans for data collection are described in detail in **Appendix I: Structural Mapping of Data Needed** and **Appendix II: Schedule of Research Activities**.

Description of Research Methods

Village walk

This method is basically exploring the relevant area by walking with a local representative(s), and it will be used to get an overview of the village and the surrounding area. It will be conducted on the first day of research in order get a sense of the land use, area locations and environment. From the village walk we hope to also form a plan for where to collect soil and water samples. A multitude of interesting and unforeseen aspects of village life can come forward through informal conversation while walking.

The village walk will be combined with a preliminary GPS mapping of objects or areas of interest.

Mapping the Area

Using GPS we plan to create a map of area land use and land ownership. We will add this information to data mapped using GIS (ArcView or MapInfo), showing where cassava is cropped, the field sizes, who cultivates which plots, how wealthy the different farmers are, the household demography and other relevant parameters. GPS mapping will also allow us to compare the extent of current cassava plots with satellite images of the area from several years ago, to see if there is evidence of expansion (for example see **Map 3** below). We will also approach questions of land use intensification by interviewing key informants about cassava versus other crops, preferably in a defined area with cleared land.

Map 3

Participatory Mapping and Drawings

Different types of mapping and drawing exercises will be conducted in groups of cassava farmers agreeing on a common visualization and ranking.

- *Participatory village/land use mapping* will be used in order to assess the perception among cassava growers about their village and their land use. The thought behind the implementation of this group exercise is its capacity for revealing different information and observations than obtained by interviewing individual farmers.
- *The income source matrix* will be used to plot the contribution of different types of income to the farm livelihood and how important these attributes are for their livelihood by ranking.

Key Informant Interviews

Short interviews with key informants – such as community leaders or forest protection representatives - will be used to gather preliminary qualitative data. Key informants are important for framing and interpreting field observations, and can offer a context to the motives and behavior of cassava farmers and other stakeholders. They can also suggest other people to be interviewed.

Group Interview

If circumstances allow it, a group interview will be conducted in conjunction with the mapping exercise. This can hopefully inform us about the community perception of cassava growing and may reveal conflicts that we were not aware of.

Smallholder Selection and Sampling

The units of analysis in this survey are smallholders in Banteay Chmar who cultivate cassava as a cash crop. After the first day of exploring the village and cassava-growing areas it will hopefully be possible, together with a local representative, to classify the small-scale cassava farmers into 2 or 3 strata based on household assets (*i.e. socioeconomic sorting*). In this stratified random sampling, 10 -15 households will be selected at random from each stratum to complete the questionnaire and have soil from their cassava plots sampled. We expect our data collection will be limited by realistic factors such as time available, distance and knowledge available in the field. With the aid of key-informants, we will use a purposeful sampling strategy to choose subjects for semi-structured interviews.

Questionnaire

A questionnaire will be used to gather quantitative data on a random sample of smallholder cassava growers. The questionnaire in this study is made up of a mix of closed-ended questions and more open-ended questions. This is an easily comparable method so it will enable us to see divergences in livelihood strategies among cassava farmers.

Semi-Structured Interview

Semi-structured interviews are longer and looser interview conducted from a guide-list of question, which enables the respondents to talk and reflect more freely. This interview form is very flexible and allows new questions and themes to arise. The strengths of this interview type are the more complex; subtle and sensitive topics can be touched upon and the respondents can contribute with their own points of view. Establishment of rapport is crucial for this type of interview. Some of the sensitive and more complex issues related to this report are the land tenure situation facing the farmers in question; wealth compared to other farme rs; and deforestation. Semi-structured interviews will be conducted with cassava farmers as well as relevant stakeholders.

Soil and Water Sampling

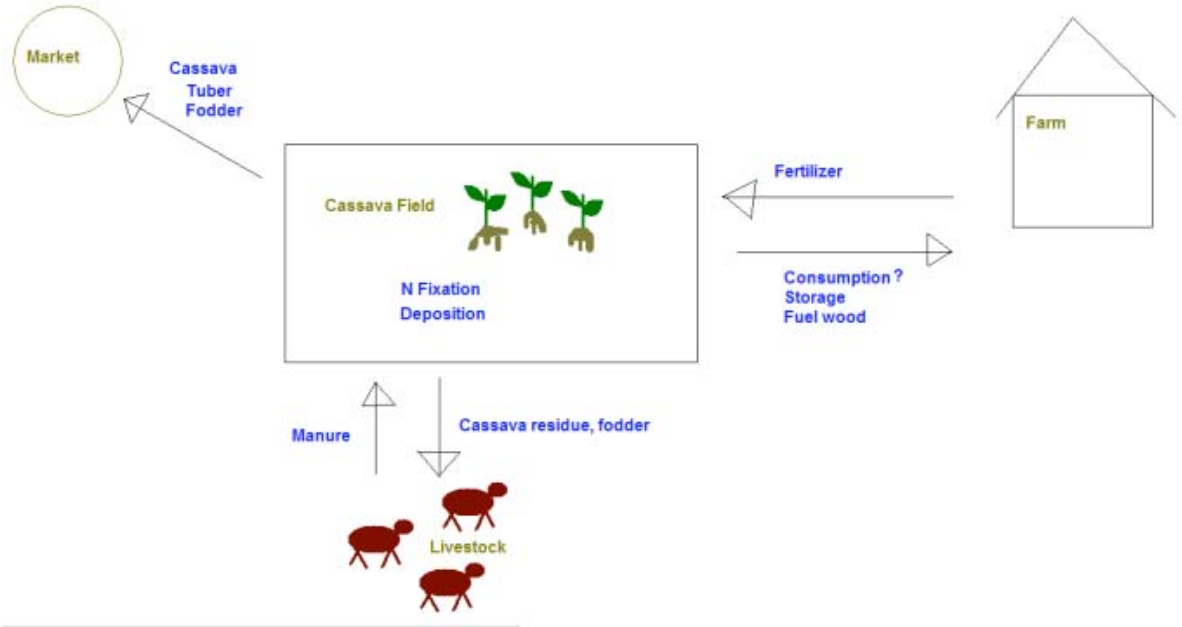
Soils on areas of cassava cultivation will be sampled to get an indication of the soil fertility and to establish a rough estimate of the degree of soil degradation. Soil fertility indicators will be measured biophysical tests including soil

compaction, amount of soil organic matter, carbon content, water infiltration and nutrient status of the soil. Additionally, visual assessment will be used to classify soil types in the study and allow us to detect observable signs of degradation. If circumstances permit, we will compare soil samples taken from cassava fields cultivated for several years with those of newly established cassava plots in an attempt to detect the effects of cultivation on the soil. Composite sampling will be used, taking 15 samples in each of two diagonal lines from corner to corner of the plot. The samples will be thoroughly mixed to form one homogenous mixture, one sample and its replicate will brought home for analysis. To test water infiltration rate and soil compaction, in situ assessment will be necessary.

Due to the dry season, access to water for sampling in Bancheay Chmar might be limited during the study period. If it is feasible, however, water analysis will be conducted in order to detect possible water pollution due to soil degradation. Water samples will be taken near cassava fields in different places as well as in the forest to compare conductivity and pH.

Nutrient Balance Analysis

One way to measure the ecological sustainability of a farming system is to analyze nutrient flows. The fertility store in the soil can be seen as the farm's capital (Defoer et al. 2000), and in the case of the cassava farmers, the farming system should include the cassava fields as part of the total area under cultivation, taking into account all the inputs to and outputs from the field. (This calculation may be affected by the way the land was cleared: it is possible that if the farmers use "slash and burn" methods, they are not using inputs at all but are relying on nutrients from residual ash.) This approach is based on PLAR (Participatory Learning and Action Research), which involves detailed discussions with each farmer. A full analysis is outside the scope of this study, but we intend to gather sufficient data to get a general idea of whether cassava farmers' systems show a surplus or deficit in nutrients.



Alternative Research Methods

As a participatory activity that might supplement our understanding of cassava as well as develop community rapport, we may try to cook cassava and see what it tastes like. Hopefully we will be able to serve cassava to both our fellow students and to local people in order to get some feedback on the use of cassava as food.

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Appendix I: Structural Mapping of Data Needed

Question: What characterizes the livelihoods of farmers who grow cassava?		
Data Needed	**Method**	**Details/Specific Questions**
General vulnerability	Questionnaire SSI - Farmer	What is your biggest concern regarding your livelihood? What are you worried about most?
Tenure status	Questionnaire SSI - Farmer	Where you born in this area? (if not, which part of Cambodia are you from?) Why did you move to this place? How many years have you been farming here? How did you come to be on this land? (inherit, bought, given, other) Do you feel secure on this land/Is your status on it threatened in any way? Do you have plans
Size of landholdings	Questionnaire	How much agricultural land do you have? How much cassava do you farm?
Farming strategy	Questionnaire SSI - Farmer	For how long have you been a farmer? Which crops do you grow, how much? How much of your crops do you eat, how much do you sell, how much is for fodder? Do you own animals, what kind, how many? For sale and/or consumption?
Access to credit	SSI - Farmer	Do you have access to loans if you need it? Have you ever needed a loan before?
Household demographics	Questionnaire SSI - Farmer	How many people live in your household? (children, adults, males/females, etc.)
Health status of household members	SSI - Farmer	Have you or anyone in your household been sick in the last year? Do you have access to health care in the community? Are you worried about your health?
Other status indicators	Observation Questionnaire	Roof type, wall type, generator, furniture Do you own or have access to a tractor or other equipment?
Degree of commercialization	Questionnaire SSI - Farmer	How much of your crop(s) do you sell/eat? How much income do you receive from crop products? Do you receive any income from off-farm work? Is cassava your main cash crop? Have you increased your acreage of cassava?
Food security	SSI - Farmer	Are there times of year when you don't have enough food? What do you do if this happens? Do you have enough money to purchase food if you need to?
Cassava Cultivation	Questionnaire SSI - Farmer	How much cassava (hectares) do you have under cultivation? Where is it? Can you show me? Who in your household is responsible for cassava cultivation? For how long have you been farming it? Why did you decide to grow cassava? Who taught you how to cultivate it? Are you satisfied with yield? Have you noticed changes in yield? Do you work with any other farmers to cultivate/harvest it? Do you think cassava is an easy crop to grow for income? What is the biggest constraint facing your cassava production? (ranking) Do you ever have to hire labor during peak times? Do you need to store the cassava after harvest? How?
	SSI - Extensionist	What has made cassava farming attractive for local farmers? From whom did they learn to grow it? What types of farmers are more interested in it?

	SSI – cassava trader	To whom do you sell the cassava to? How long have you been doing this? What form do you get it in? Are you Thai or Cambodian? What's the high season for selling? Are there any fluctuations? Why are there fluctuations in the wholesale price? What do you do when Thailand closes the border? How do you measure quality? Can you describe the manufacturing process for us?

Question: How has cassava farming affected the livelihood of current cassava farmers?		
Data Needed	**Method**	**Details**
Impact on food security	SSI – Farmer	Do you feel your household security has improved since you began growing cassava?
Impact on land use	SSI – Farmer	Have you changed the way you use your land? (e.g. growing cassava now where there once was rice) How you increased the amount of cassava you grow? How much is grown on your own land? In the forest area? Grazing area?
Impact on labor allocation	SSI – Farmer Quesionnaire	Does cassava ever interfere with working your other crops? Do you have enough labor when you need to harvest cassava? Do you think growing cassava is "easier" than growing rice, other crops?
Impact on overall livelihood strategy	SSI – Farmer Questionnaire	Do you use, or sell, any parts (leaves, stems, root) for fodder? Have you changed the way you use your land? (e.g. growing cassava now where there once was rice) How you increased the amount of cassava you grow?
Vulnerability to market fluctuations	SSI – Farmer Group Interview	Who do you deal with in order to sell your crop? Do you think you get a fair price for your crop? Do you ever have to sell your crop for less than what you expected? Examples? What do you do when there are problems with the market? (e.g. Thailand border closed)
	SSI - Extensionist	What sorts of problems have come up with the cassava market? How do farmers deal with them?

Question: What are the effects of cassava cultivation on the local environment?		
Data Needed *(active cassava cultivation areas)*	Method	Details
Field Management	SSI – Farmer	How do you manage it? (Use of waste, manure, other inputs) Do you use any inputs to enhance fertility? (list) If no, why not? Are you growing cassava by itself, or mixed/rotated with any other crops? Used for grazing? Fallow?
	SSI – Forest authority SSI - extensionist	How would you describe how the farmers are managing cassava fields?
Biophysical Soil Measurements	Physical and chemical soil analysis	SOM Infiltration Bulk density Soil aggregate stability Visual signs of degradation Net carbon analysis

Nutrient Flow Analysis	SSI – Farmer	Estimates of the farmers input to and output from the field Livestock impact on the system - do the livestock graze in the field after harvest? Farmer input: fertilizer (type and amount), manure (type and amount) Farmer output: cassava exported from farming system; residue used for fodder
	Soil tests	N, P, K, SOM (Carbon content and change)
Water Quality *(if feasible)*	Water tests	Conductivity pH
Land Use Changes	GIS	Comparison of satellite data from 2001 vs. present
	SSI – Informant SSI - Farmer	Have you changed the way you use your land? (e.g. growing cassava now where there once was rice) How you increased the amount of cassava you grow? How much is grown on your own land? In the forest area? Grazing area?

Question: How does cassava farming conflict with local resource use by other stakeholders?		
Data Needed	**Methods**	**Details**
History and status of protected forest	SSI: Forest Authority	What is the history of the protected area? What was the reasoning behind protecting it? What do you think is its greatest value? Who is responsible for managing it? How is this done? What are the restrictions regarding the forest use? Do you think these are respected?
	SSI: Farmer Group Interview	How would you classify the forest area? How long have you been growing cassava there? Do others do the same?
Sustainability Concerns	SSI: Forest Authority	What is the area used for? Who uses it? What are your concerns about deforestation due to cassava? How would you describe the changes? Have you noticed other changes in the forest? (trails, roads) What are the causes? What are the impacts? What is your main concern about this area for the future?
Resource use by other stakeholders	Data from Livestock Group	Are there any conflicts with the cassava growers? Are they using the same land at all? Are they using cassava for fodder/residue?
	SSI: Forest authority	Which parties are using the forest? What are the consequences (regarding biodiversity, and else) ? What types of conflicts have you seen? How important are they? Who is involved? Does it affect others' livelihoods in the area?
	SSI: community leader/informant	How is the forest area perceived by community members? By cassava farmers? Have you seen any problems come up from different people wanting to use the same land?
	SSI - extensionist	What impact is it having on the protected area? What impact is it having on other resource users?
	Data from Tourism Group	What other parties use the forest resources? What are their objectives and needs? Have they ever been in conflict with cassava farmers?

Appendix II: Schedule of Research Activities

	Task	Notes
Day 1	**Field**: Transect walk, GPS Explore the area Identify informants **Home**: Review sampling of informants; plan the interview schedule and soil sampling sites; go over the questions with the interpreter and soil testing	The whole group together the whole day.
Day 2	**Field**: Make appointments with key informants Take soil samples, GPS readings Observation **Home**: Soil testing. GPS data handling Transfer interview data	The group is divided into 4. Two groups take soil samples and two make appointments with key informants
Day 3	**Field**: Interview informants. Take soil samples. GPS. **Home**: Identify subjects for semi-structured interviews. Soil testing. GPS data handling. Transfer interview data.	Group is divided into groups of 3. Each interviewing 4 informants.
Day 4	**Field**: Interview informants Make appointments subjects for semi-structured interviews. Take soil samples, GPS **Home**: Soil testing	Group is subdivided into groups of 3, each interviewing 4 informants.
Day 5	**Field**: Semi-structured interviews **Home**: Conceptualize the map in preparation for field	Sub-divided groups
Day 6	**Field**: Map-making and Group interview GPS **Home**: Make plan over what's missing Fermented cassava beer party!	The whole group together
Day 7	**Field**: Execute what's missing GPS **Home**: (to be determined)	The group is subdivided according to tasks
Day 8	**Field:** Saying goodbye to the village people. And leaving Jacob with them. (buffer day) **Home:** Sharing data.	

Appendix III

QUESTIONNAIRE: "CASSAVA FARMING"

Thank you for taking the time to talk to us. It is very helpful for us.

We are group of both Cambodian and International students conducting this survey as part of a university course. The aim of this project is to understand cassava farming's impact on the cassava-farmers' lives and on the land. The results of the study will be presented before we depart and we will also send a paper copy of the report to _____. (Somebody maybe the community official).

There are no right or wrong answers and your response will be treated confidentially (and anonymous?). The survey will take about (a half-hour).

Response #: _____ Date: _____ Interviewers' names: _____

GENERAL INFORMATION

Name: _____ Sex: Male ☐ Female ☐

Age: _____ years

1. How many years have you lived in Banteay Chmar ? _____ years
2. How did you come to be on this piece of land?

☐ Inherit ☐ bought ☐ given ☐ other _____

3. How many people live in your household?

☐ wife/husband ☐ children #_____ ☐ Parents #_____ ☐ other relatives # _____

☐ others (specify) #_____

FARM INFORMATION

4. Which crops do you farm now, how much, and are they for consumption, sale, or fodder?

☐ Cassava _____ ha (?)	☐ consumption	☐ sale	☐ fodder
☐ Rice _____ ha (?)	☐ consumption	☐ sale	☐ fodder
☐ Fruit trees _____	☐ consumption	☐ sale	☐ fodder
☐ Home garden _____	☐ consumption	☐ sale	☐ fodder
☐ Ground nut _____	☐ consumption	☐ sale	☐ fodder
☐ _____	☐ consumption	☐ sale	☐ fodder
☐ _____	☐ consumption	☐ sale	☐ fodder

☐ _____ ☐ consumption ☐ sale ☐ fodder

5. Do you own or have access to a tractor/other equipment?
☐ own ☐ access ☐ other _____

6. Which animals do you have now, how many, are they for consumption, sale, or both?

☐ (none)

☐ Cattle _____ ☐ consumption ☐ sale ☐ both

☐ Pigs _____ ☐ consumption ☐ sale ☐ both

☐ Poultry _____ ☐ consumption ☐ sale ☐ both

☐ Goats _____ ☐ consumption ☐ sale ☐ both

☐ _____ ☐ consumption ☐ sale ☐ both

7. [IF ANIMALS = YES] Do you use cassava (leaves, wood, root) for fodder ? ☐ yes ☐ no

CASSAVA FARMING PRACTICES

8. For how long has your household farmed cassava? _____

9. Who are responsible for the cassava farming in your household? _____

10. Do you use any inputs in your cassava plots?

☐ None ☐ Don't know ☐ Manure ☐ Fertilizer ☐ Mulch ☐ _____

11. Do you use other farming practices to increase yield? Yes ☐ No ☐ Don't know ☐

12. If yes, what _____

13. [IF FARMED FOR SEVERAL YEARS] Have you experienced any changes in your cassava yield?
No ☐ Increase ☐ Decrease ☐ Not Sure ☐

14. Do you ever use the cassava fields for anything else?

☐ No ☐ rotation with _____ ☐ fallow ☐ grazing ☐ intercropping with _____ ☐ other _____

15. When you need to harvest cassava, do you have enough labor? Yes ☐ No ☐ Don't know ☐

16. What is the biggest challenge for you in producing cassava? (rank if possible):

☐ decreasing yield ☐ weed problem ☐ labor shortage ☐ lack of storage
☐ tenure problem ☐ selling at unfavorable time ☐ border conflict ☐ other

LIVELIHOOD

17. Do you receive any income from working off the farm? Yes ☐ No ☐ Don't know ☐

18. If yes, what _____ how much: _____

19. How much money did you make from the last cassava harvest?

20. Is cassava your main cash crop? Yes ☐ No ☐ Don't know ☐

21. If yes, describe _____

22. Do you feel more financially secure now that you are cultivating cassava?
Yes ☐ No ☐ Don't know ☐

23. Do you ever run out of food?
Yes ☐ (which months) _____ No ☐ Don't know ☐

24. What do you do if this happens? _____

_____

25. Do you usually have enough money to buy food if you need to? Yes ☐ No ☐ Don't know ☐

26. Do you have access to any kind of credit?
☐ private ☐ state subsidy ☐ NGO ☐ other _____

27. What is your biggest concern regarding your livelihood? What are you worried about most?

_____

_____

That was our last question, is there anything you would like to ask us about before we leave?

Appendix IV

SEMI-STRUCTURED INTERVIEW: CASSAVA FARMER

Thank you for taking the time to talk to us again. The goal of this interview is to help us understand cassava farming in more detail. You can speak as openly and honestly as you wish; your responses will be kept private.

The survey will take about (a half-hour).

Response #: _____ Date: _____ Interviewers' names: _____

Name: _____ Sex: Male ☐ Female ☐

Age: _____ years

1. Do you farm cassava together with any other farmers?
2. From whom did you learn to cultivate cassava?
3. Do you use any inputs in your cassava plots?
4. Type?

   ☐ Manure quantity _____ frequency _____

   ☐ Fertilizer quantity _____ frequency _____ type _____

   ☐ Mulch quantity _____ frequency _____

   ☐ _____ quantity _____ frequency _____
5. Do you think about the soil fertility?
6. How else do you manage the fields?
7. How would you describe the forest area you grow cassava in? (community , state, no one, etc.?)
8. [IF FARMED FOR SEVERAL YEARS] Have you experienced any changes in your cassava yield?
9. Do you ever use the cassava fields for anything else? (please describe)
10. Do you feel that your status on this land is threatened in any way?
11. Do you have any plans for buying/getting access to more land?
12. Have you ever had to borrow money before? Why was that?
13. Have you tried cultivating any other cash crop?
14. Do you think that cassava is an (easy) crop to cultivate, compared to other cash crops?
15. Do you think it's worth the effort?
16. Have you increased your acreage of cassava?
17. (also in questionnaire) When you need to harvest cassava, do you have enough labor?
18. (also in questionnaire) What is the biggest challenge for you in producing cassava?

☐ decreasing yield ☐ weed problem ☐ labor shortage ☐ lack of storage
☐ tenure problem ☐ selling at unfavorable time ☐ border conflict ☐ other

19. How much is grown on your own land? In the forest area? Grazing area?
20. How would you classify the forest area? Do others think of it the same way?
21. How you increased the amount of cassava you grow?
22. Have you changed the way you use your land? (e.g. growing cassava now where there once was rice)
23. What is your biggest concern regarding your financial or food security? Has cassava helped your family?
24. What are you worried about most?
25. Could you describe a regular day for you?

That was our last question, is there anything you would like to ask us about before we leave?

Appendix V

SEMI-STRUCTURED GROUP INTERVIEW: CASSAVA FARMERS

Thank you for taking the time to talk to us again. The goal of this interview is to help us understand cassava farming in more detail. You can speak as openly and honestly as you wish; your responses will be kept private.

The survey will take about (a half-hour).

Response #: _____ Date: _____ Interviewers' names: _____

Names of those present:

_____ _____

_____ _____

_____ _____

_____ _____

1. When did cassava farming start in this community?
2. Whose idea was it?
3. Why did you start farming cassava?
4. Has cassava farming been good for the community?
5. Is there anything you wish you could improve about cassava farming?
6. Do you usually get a fair price for your harvest?
7. What do you do if you can't sell your harvest? (for example the border to Thailand is closed, market shifts)
8. Have you ever had to sell your cassava for less than what you expected?
9. Who grows the best cassava here?
10. Why?
11. Are there others who wish you didn't grow cassava?

That was our last question, is there anything you would like to ask us about before we leave? Is there anyone else you think we should talk to?

Appendix VI

SEMI-STRUCTURED INTERVIEW: FOREST AUTHORITY

1. What is the history of the protected area?
2. What was the reasoning behind protecting it?
3. What do you think is its greatest value?
4. What is the area used for? Who uses it?
5. Who is responsible for managing it? How is this done?
6. What are the restrictions regarding the forest use?
7. Do you think these are respected?
8. How would you describe how the farmers are managing cassava fields?
9. What are your concerns about deforestation due to cassava? How would you describe the changes?
10. Which parties are involved? Who else should we talk to?
11. What are the consequences (regarding biodiversity, and else)?
12. What types of conflicts have you seen?
13. How important are they? Who is involved?
14. Does it affect livelihood in the area?
15. Have you noticed other changes in the forest? (trails, roads)
16. What are the causes?
17. What are the impacts?
18. What is your main concern about this area for the future?

That was our last question, is there anything you would like to ask us about before we leave? Is there anyone else you think we should talk to?

Appendix VII

SEMI-STRUCTURED INTERVIEW: CASSAVA TRADER

Thank you for taking the time to talk to us again. The goal of this interview is to help us understand cassava farming in more detail. You can speak as openly and honestly as you wish; your responses will be kept private.

The survey will take about (a half-hour).

Response #: _____ Date: _____ Interviewers' names: _____

Name: _____ Sex: Male ☐ Female ☐

Age: _____ years

1. To whom do you sell the cassava to?
2. How long have you been doing this?
3. What form do you get it in?
4. Are you Thai or Cambodian?
5. What's the high season for selling? Are there any fluctuations?
6. Why are there fluctuations in the wholesale price?
7. What do you do when Thailand closes the border?
8. How do you measure quality?
9. Can you describe the manufacturing process for us?

That was our last question, is there anything you would like to ask us about before we leave? Is there anyone else you think we should talk to?

Appendix IX

SEMI-STRUCTURED INTERVIEW: EXTENSIONIST

1. What has made cassava farming attractive for local farmers?
2. From whom did they learn to grow it?
3. What types of farmers are more interested in it?
4. What are typical management practices?
5. What sorts of problems have come up with the cassava market?
6. How do farmers deal with them?
7. What impact is it having on other resource users?
8. What impact is it having on the protected area?

Thank you for your time. Is there anyone else you think we should talk to?

Appendix X

CHECKLIST OF FIELD OBSERVATIONS

(to use when visiting households…)

1. Roof type
   ☐ Thatch roof ☐ Tile roof ☐ Fibro roof
   ☐ Zinc roof ☐ Concrete roof ☐ Other _____
2. Wall type
   ☐ _____ ☐ _____ ☐ _____
   ☐ _____ ☐ _____ ☐ Other _____
3. Household items
   ☐ tv ☐ generator ☐ furniture
4. Subjective health condition
   ☐ good ☐ ok ☐ poor
5. State of household/garden… tidy, messy,
   ☐ tidy ☐ messy ☐ don't know

Appendix 2:
Extract of Cambodian Protected Areas (Draft 2005) Law under Environment Ministry authority (Personal source, received in 2009)

Article 28:

The Minister of Environment shall have the authority to allocate any part of the sustainable development zone to the local communities and indigenous ethnic minorities who reside in or near the protected area to organize a protected area community. The protected area community shall enter into an agreement with the Natural Protection and Conservation Administration and that agreement shall be valid for a period not exceeding fifteen (15) years.

Article 29:

Local communities and indigenous ethnic minorities shall have no rights to clear or work the earth in forestlands of the protected area community as entered into agreement with the Natural Protection and Conservation Administration of the Ministry of Environment in order to transform it into agricultural land or privately owned land, or sell, exchange, rent, mortgage, donate, share, divide or transfer the management zone of the protected area community to any physical or legal entities.

Article 34:

Citizens, monks, students, civil servants, members of the armed forces, and local authorities shall have the obligation to participate in the protection, conservation and rehabilitation in protected areas.

Article 44:

Clearances or earthworks in forestlands for the purposes of constructing and developing all types of public infrastructures crossing the core and conservation zones of protected areas shall be prohibited.

This can be carried out only in the sustainable development and local community zones of protected areas with approval from the Royal Government in consultation with the Ministry of Environment.

Article 45:

Each protected area shall be protected and kept safe from all activities that cause damage or negative impacts on the biodiversity, the quality of water, soil, coasts, wetlands, slopes, ecosystems, infrastructures and other natural resources in the protected area.

Activities causing damage and negative impacts that shall be prohibited include:

1. Moving, removal or destruction of protected area boundary posts or markers
2. Felling, tying, uprooting and destroying trees in all other forms
3. Collecting forest by-products by cutting tree branches and stems
4. Housing settlement, clearance, burning, earthwork and fencing forestlands for building houses or public buildings, expanding farming land, private or collective state ownerships
5. Forest concessions, establishment of timber processing factories
6. Setting forest fires
7. Destroying water quality in all forms, poisoning, using chemical substances, disposing of solid and liquid wastes into water or on land, using electric shock equipment
8. Catching, hunting, collecting wild eggs, offspring and birds of all kinds
9. Storing, buying and displaying for sale all kinds of wild animals and samples
10. Destroying grassland, plants and wildlife sanctuaries
11. Releasing cattle and livestock and walking hunting dogs

12. Establishing bases for processing Klemchan, Mreas Prov, Vor Romeat, and other plants
13. Illegal fishing, collecting or other practices harmful to natural resources, both marine and freshwater
14. Deforesting or damaging mangrove and flooded forests, corals and seaweed
15. Taking pictures of commercial nature, including films, videos, and documentaries without permission
16. Using heavy machinery, explosives, all kinds of motors, loudspeakers and vibrators that harm the natural environment without permission
17. Research and exploration for mines without permission.

Article 49:

Punishments for natural resource offenses include imprisonment, fines by court, transaction fines, confiscation of evidence, damage cost recovery, warnings, and suspension or termination of activities.

Article 52:

The fines imposed by the court decision or judgment and revenues from selling confiscated evidence shall go into the state budget. The Royal Government may decide to pay rewards to citizens and officials who have participated in suppression of natural resource offenses committed in protected areas.

Definition of Protected Landscape according to the law:

An area in land and/or water territories, in which human interactions with nature create uniqueness in natural beauty or ecology or culture, and generally abundant in biological resources.

Objective of Protected Landscape management:

1. Maintain the complementary interactions of natural and cultural factors, through protection of inland natural landscape or coastal or island natural landscape, or a mixture of both, and maintain the traditional patterns of land use, patterns of construction, and performance through social and cultural activities.
2. Support traditional lifestyle and economic activities that are compatible with nature and maintain connections between social and cultural activities of relevant communities.
3. Maintain the variation of landscape and habitats, as well as relevant species and ecosystem.
4. Eliminate and prevent the use of land and activities that are inappropriate in terms of size or form, or both.
5. Provide opportunity for public enjoyment, through recreation and tourist activities, that are compatible, in terms of size and form, with the main qualities of the area.
6. Encourage research and educational activities that contribute in the long term to supporting the well-being of people in the area and mobile public support for environmental protection of the area.
7. Benefit and contribute to supporting the well-being of local community through provision of natural products and services.

Appendix 3: Soil nutrient analysis

Nitrate and Ammonium:
Extract soil in 1 M KCl solution, 1:5 (i.e. 5 grams of soil in 25 ml solution) for 30 minutes (shake), filter and measure extract. Use 1:10 for high clay soils (>25% clay)

K
Extract soil in 0.5 M ammonium acetate ($C_2H_7NO_2$) solution, 1:10 (i.e. 2.5 grams of soil in 25 ml solution) for 30 minutes (shake), filter and measure extract.

P
Extract soil in 0.5 M SodiumHydrogenCarbonate (Sodium-biCarbonate – $NaHCO_3$) solution regulated to pH 8, 1:20 (i.e. 0.5 grams of soil in 10 ml solution) for 30 minutes (shake), filter and measure extract.

Al
Extract soil in 1 M KCl solution, 1:5 (i.e. 5 grams of soil in 25 ml solution) for 30 minutes (shake), filter and measure extract. Use 1:10 for high clay soils (>25% clay)

pH and Electrical Conductivity
Extract soil in water, 1:2.5 (i.e. 5 grams of soil in 12.5 ml solution) for 30 minutes (shake). Measure pH and conductivity in the suspension.
Correct values if necessary:
$pH_{CaCl2} \approx pH_{H2O} - 0.5$
$EC_{sat.} \approx 3.6 \_ EC_{1:2.5}$

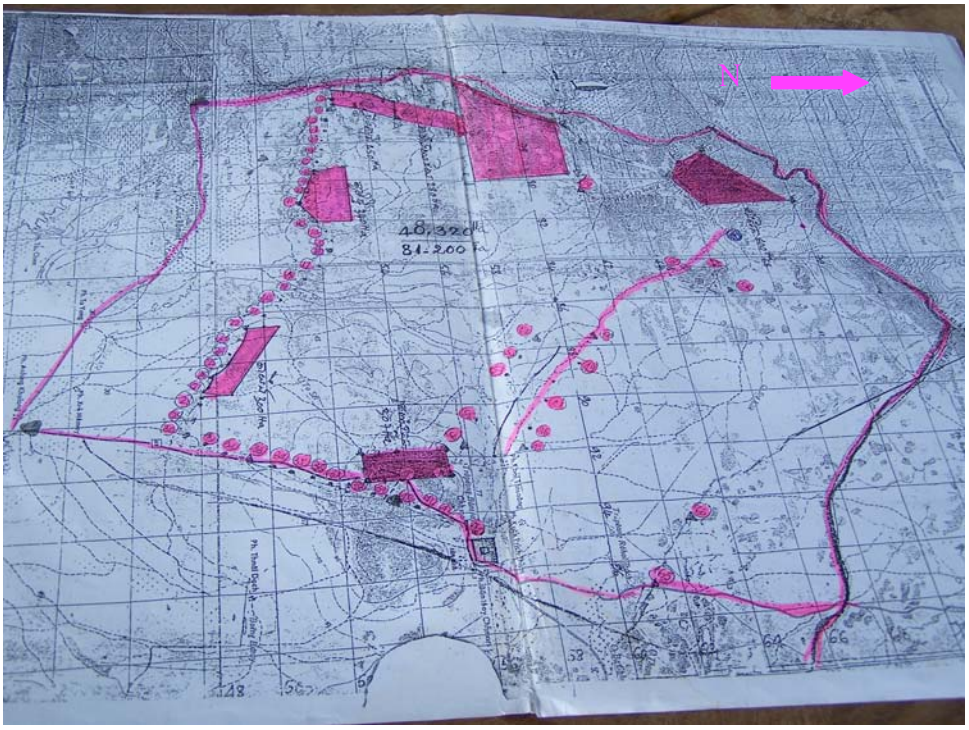
Texture analysis:
Disperse soil in 5% NaCl solution (i.e. 50g NaCl in 1 liter water), 1:3 (i.e. 10 g soil in 30 ml) for 30 minutes (shake). Allow suspension to sediment in a clear cylindrical flask or beaker. Measure the thickness of recognisable particle size layers (sand, silt, clay) and express in % of total height. NaCl can be replaced with any other salt, i.e. KCl.

MEHLICH I EXTRACTING SOLUTION

1. Dilute 162 ml, hydrochloric acid and 28 ml. sulfuric acid to 40 liters with deionized water and mix well.

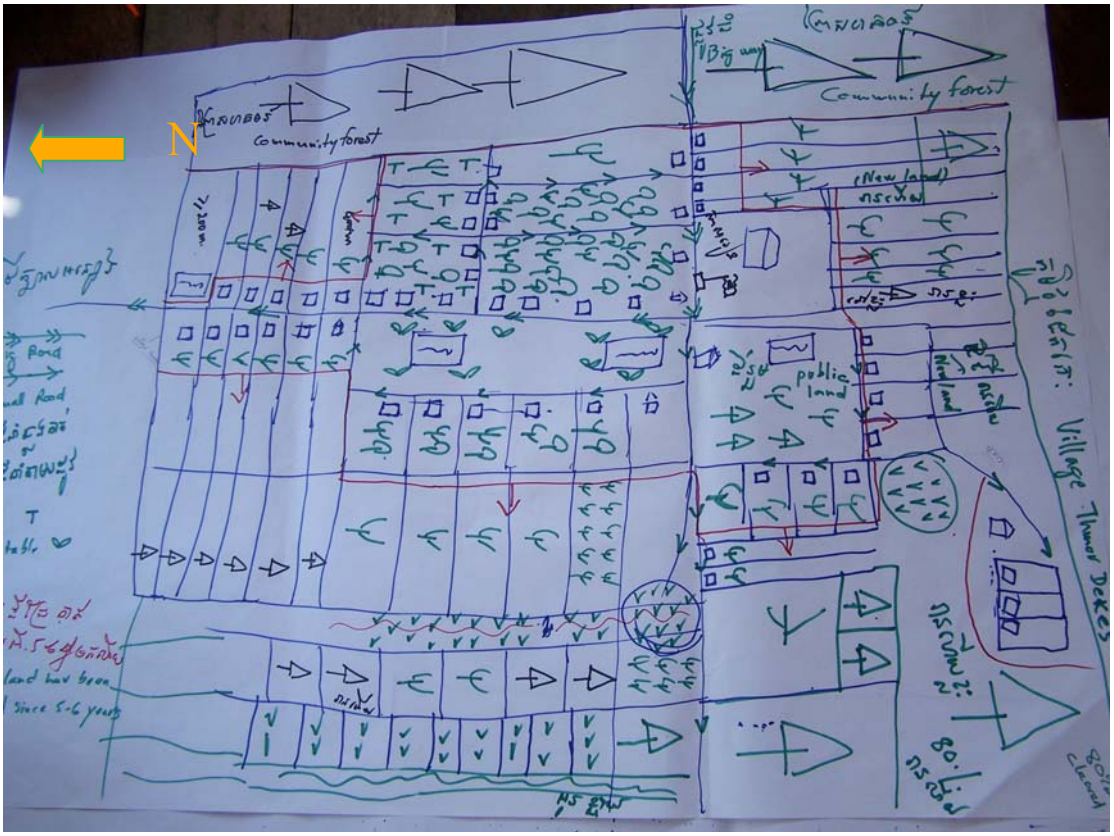
Extracting solutions (KCl, ammoniumacetate etc.) can most probably be prepared by your local counterparts. If not, you can bring the salts from Denmark and prepare the solutions locally on the basis of distilled water.

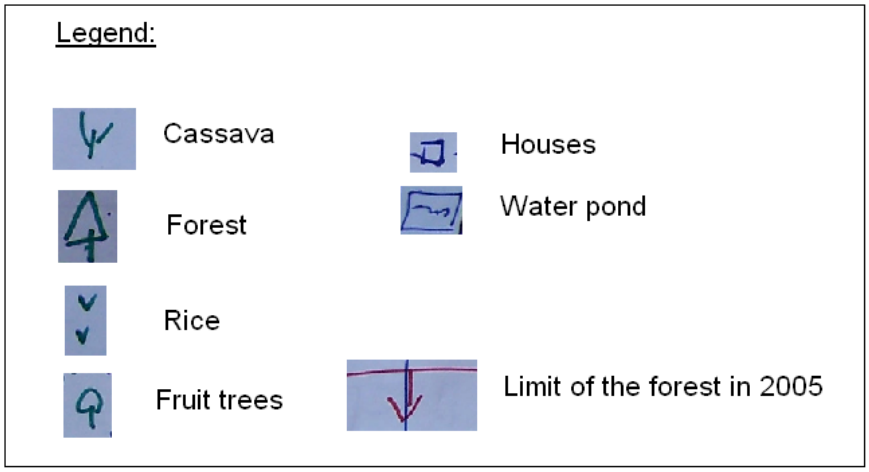
Appendix 4 : Maps



Protected landscape map
The filled in pink areas are delimitating the community forests that have been allocated to villages

Source: Protected landscape administrator





Participatory map of Trapeim Thlok village:
The map shows villagers perception of their village land use.
We can see that they are aware of the community forest because they precised it on their drawing. Water also seems to be a concern for their livelihood as they drew the 4 water pounds they have at their disposal.
At the end of the exercise, we asked them to draw the border of the forest in 2005. According to their thoughts, it seems that they are aware of the great extensification of agricultural land since 2005. We can see that fields that are replacing the forest are exclusively cassava. These confirm our data about the land use change

Appendix 6: Methods Used

Survey	36 questionnaires
Semi-structured interview with farmers	6 interviews
Semi-structured interview with key informant	1 trader 1 big outsider 2 village chief 1 vice-commune chief 1 protected area manager
Land use mapping	4 GPS marking transect walk,
Informal conversation	Landlord others
Soil sampling/testing	pH conductivity phosphorous Carbon Nitrogen Aluminium Calcium