Environmental and economical impacts of the changes in farming practices in Ban Bon Na, Northern Thailand

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GROUP 4

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Abstract

This study focuses on the economical and environmental implications of the changes in the farming practices in Ban Bon Na.

The village like many other Upland hill tribe communities in Northern Thailand has experienced the shift from subsistence and swidden cultivation to cash-cropping and intensification of land use. These changes have induced consequences for the environment as well as for the household economy.

Soil quality including soil fertility and soil erosion has decreased in the last decades. Water quality assessment indicated that contamination from agriculture has taken place. No clear impacts on forest are evident; rather the opposite is the case, as the establishment of the national Park has played an important role behind the changes in farming practices.

The shift to cash-cropping has impacted on household economy since it implies high production costs. However, the expenditures are not balanced by the income which has forced the farmers to take up loans. Due to the difficulty in repaying loans the farmers seem to be trapped in a vicious circle of indebtedness.

***Key words*:** Northern Thailand, Farming Practices, Cash-crops, Household economy, environmental implications

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ABBREVIATIONS

NTFP	Non-Tmber Frest Poducts
JOMPA	Join Management Project
NGOs	Non-Gvernmental Oganization
NPS	National Park Superintendent
OM	Organic Matter
ppm	Part per Million
PRA	Participatory Rural Appraisal
RFD	Royal Forest Department
TAO	Tambon Aministrative Organization
TDS	Total Dissolved Solids

1 Introduction

1.1 Context

During the 20th century, rural communities in Thailand experienced big changes in their life. Different events at economical, social and policy levels were behind those changes (Lele & Stone, 1989 and Turner & Brush 1987 cited by Rasul & Thapa, 2003). Forest and agriculture were subjected to different governmental plans and projects resulting in deep impacts on rural livelihoods and on the immediate environment (Samata, 2003).

The Thai policy of protected forest zones that created national parks reduced dramatically the areas available for shifting cultivation. This reduction resulted in shorter fallow periods and increased cropping frequency (Ganjanapan cited by Puginier, 2002; Lambin et al, 2001; Prasit, 2002; Rasul & Thapa, 2003).

The governmental programs of infrastructure development, crop diversification and introduction of cash crops led to many adjustments within the subsistence systems and hence significant land-use intensification occurred (Seanjan; Rasul & Thapa, 2003; Samata, 2003).

All those changes have different impacts on the environment. Soil degradation increases due to intensive land-use. Water and soil resources become more contaminated because of agro-chemical use (Seanjan; Rasul & Thapa, 2003).

At the economical level, the introduction of market-oriented crops into the existing subsistence system changed the patterns of household's economy and the livelihood strategies (Rasul & Thapa, 2003; Samata, 2003).

Positioned in Northern Thailand at 18.3° of latitude, 98.5° of longitude and 910 metres above sea level, Ban Bon Na is the southernmost village of the Upper Mae Pae Watershed. The village consists of 31 households and approximately 160 permanent residents.

The aim of this study is to understand whether the community of Ban Bon Na and the surrounding environment have been influenced by some of the above-mentioned processes.

1.2 Research question and sub-questions

MAIN RESEARCH QUESTION

How did changes in farming practices affect economy and environment in Ban Bon Na?

SUB-QUESTIONS

1. What are the actual farming practices and how did they change in the past decades?
2. What are the consequences and the implications of the changes in terms of forest use and conversion?
3. What are the consequences and the implications of the changes in terms of soil quality?
4. What are the consequences and the implications of the changes in terms of water quality?
5. What are the consequences and the implications of the changes in terms of household economy?

1.3 Definition of terms and indicators

Livelihood

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living (Chambers and Conway, 1992).

Farming practices

Farming practices involve a complex inter-related matrix of soil, plants, animals, implements, labour and capital viewed in a holistic manner (….)[1]. The focus during this study will be on the choice of crops and inputs (such as fertilisers, pesticides, capital, technology etc.).

Forest conversion

Forest conversion is defined by the changes from forest land use to other land use types or the long term reduction of tree canopy cover below the 10% threshold (FAO, 2001). In this case, with forest conversion is meant the changes from forest land use to agriculture.

Soil quality

For sustainable agriculture soil quality can be defined as the capacity of soil to sustain biological production, maintain environmental quality and promote plant and animal health (MAF, 2006)

[1] References

Household economy

Household economy is used to mean the sum of the ways in which the household gets its income, its saving and asset holdings, and its consumption for food and non-food items (Save The Children, 2000).

Sustainability

Sustainable development is defined as development that meets the present needs without compromising the ability of future generations to meet their needs (Brundtland, 1997).

Coping strategies

Coping strategies refer to the specific efforts, both behavioral and psychological, that people employ to master, tolerate, reduce, or minimize stressful events (MacArthur, ?)

2 Methodology

The present study has a holistic research approach based on different analytical tools, triangulation and interdisciplinarity. The backgrounds of the five team members are: agronomy, biology, forestry, and development studies. All these disciplines were used to cover and discover the complex interrelation between socio-economic aspects, land uses and environmental implications.

Our primary data was collected through informal transect walks, key-informant interviews, focus group discussions, questionnaire survey, social mapping, wealth ranking, seasonal calendars and experimental data on water and soil quality[2]. Table 1 shows the objectives and the methods used to answer the different sub-question.

[2] For more elaborate descriptions on the methods for soil and water analysis (Appendix 4 and 5)

Table 1: Summary of objectives and choice of method for each sub-question

Sub-questions	Objectives	Methods applied
1. What are the actual farming practices and what changes occurred over the past decades?	To assess the current situation in farming practices and to understand their driving forces behind the changes during the past decades	- Questionnaire - Key-informant interviews - Focus group discussions - PRA Time line - PRA social mapping - PRA activity calendars
2. What are the consequences and implications of the changes in terms of forest use?	To assess the relations between farming practices, forest use and forest conservation issues	- Key-informant interviews - Focus group discussion - Questionnaire - Aerial photo analysis - Direct observation
3. What are the consequences and implications of the changes in terms of soil quality?	To assess the current status of soil quality, and to see whether there is an impact of the farming practices changes of on soil quality	- Experimental soil sampling - Focus group discussion - Key-informant interviews - Questionnaire - Direct observation
4. What are the consequences and implications of the changes in terms of water quality?	To obtain information about the dissipation of agricultural fertilizers and pesticides, and their effects on water quality in the stream near the village	- Experimental water and sediment sampling - Key-informant interview
5. What are the consequences and implications of the changes in terms of household economy?	To understand whether there is an impact of the changes of farming practices on household economy and to assess the economical sustainability of agricultural production	- Loose-structured interviews - Semi-structured interviews - Questionnaires - PRA activity calendar - PRA wealth ranking - Focus group discussion

3 Results

3.1 General information of the village[3]

According to key-informant interviews, Ban Bon Na was founded around hundred years ago. In 1914, 10 people lived in the village. Christianity was introduced at the beginning of the 1950´s. Regarding crop production, traditionally farming was practised as rotational shifting cultivation, ended in 1978 with the establishment of the nature reserve in 1977[4]. Infrastructural changes were made in 1984 when the dam was built and in 1991 with the construction of the first road, while in 1996 the road expanded and electricity reached the village. The agricultural production started to become more market-oriented with the introduction of cash-crops at the beginning of the 90s; cabbage was one of the first cash-crops.

[3] Responsible author: Elena Gioseffi; the other members are contributing authors

[4] The reliability of the information was controversial, therefore is doubted

The role of Christianity

Christianity has a strong influence on social aspects in Ban Bon Na. There are rules regarding religious as well as behavioral aspects (e.g. it is not allowed to consume any kind of alcohol in the village) and forest use (e.g. it is compulsory to ask permission to the community before taking wood from the forest to build a house). Religion also plays a role in educational upbringing. According to the school teacher, the students get a lot of support from a Christian foundation. The support is given to the students all the way through their education up to a university degree. The grants include tuition fees, uniforms, shoes, textbook etc.

Students studying in the cities don't go back to live in the village except for ceremonies and visits. Graduated students often encourage younger students to continue their education. According to the school teacher most of the young pupils want to go and study in the city, and according to the questionnaire results 71% of the parents would like their children to pursue an education in the city.

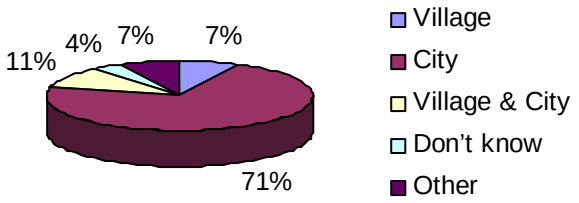


Figure 1: Parents' expectations for future of living of their children

Christianity is also related directly to migration since many young people go to the city and other provinces as missionaries. The questionnaire results showed that out of the 167 people living in the village only 139 (83.2%) live permanently.

3.2 Livelihood strategies[5]

According to the questionnaires and the loose-structured interview, the main activity of the village households is agricultural production, i.e. crops and livestock. 100% of the households have some kind of agricultural production: in 5 households agriculture is self-consumption oriented, but in most households (83%) the selling of cash crops constitutes the main source of income. Off-farm sources of income are wage labour[6], production of handicrafts and in a few cases collection and selling of NTFP and business activity[7]. Other sources of income are remittances from seasonal or permanent migrants

[5] Responsible author: Elena Gioseffi; the other members are contributing authors

[6] In the construction sector, in agriculture as hired labour or in the city, and in a very few cases as high skills required job

[7] For business activity is meant a usually commercial or mercantile activity engaged in as a means of livelihood (Merriam-Webster dictionary, http://www.m-w.com/)

that are members of village families working in the city and in one case a pension from the government (Fig. 2).

Despite not being a so-called income source, most of the households rely on loans as an important source of money that substitutes other sources of income.

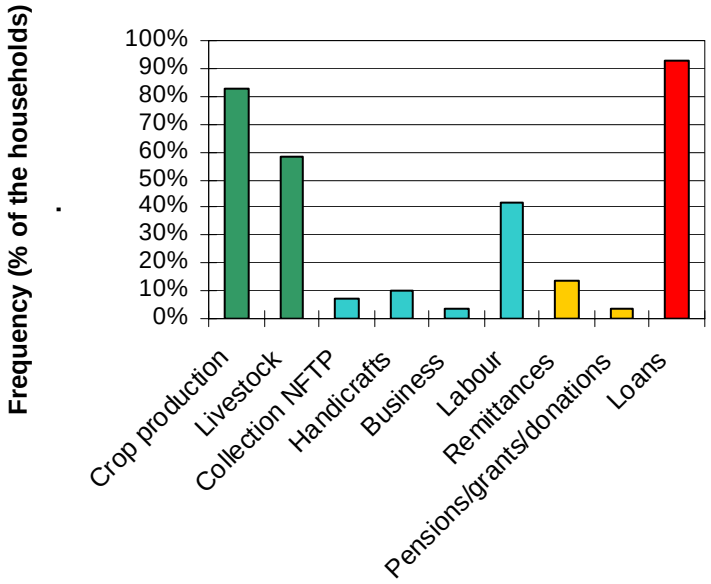


Figure 2: Sources of income in Ban Bon Na

Rice and vegetables, collection of NTFP[8] for self-consumption and production of the traditional Karen clothes are some of the activities that do not directly generate income but have socio-economic values.

Children's perceptions

The previous view is coherent with the description given by the children during the PRA social mapping, where it was requested to draw their parents' daily activities.

The activities that were drawn are connected mainly with agricultural production (work in the field, feeding livestock) and forest products collection (firewood, bamboo shoots and other vegetables) (Fig. 3).

[8] NTFP: Non-Timber Forest Products

Figure 3: Children PRA social map

From the 2 PRA activity calendars, the distribution of the non-farm activities during the year was sketched. The result shows that all these activities are allocated during the dry season, when no crop production is practiced, whilst during the rainy season these activities are suspended (Fig. 4).

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hiring both men and women in the village in building houses	BOTH	BOTH										
Collection of wood for house building	BOTH	BOTH	BOTH									
Labour selling (picking Longan)	BOTH	BOTH	WOMEN									
House building and maintenance		MEN	MEN									
Dam Preparation/reparation				MEN								
Reunion for villagers who work outside the village			WOMEN									
Home returning				MEN								
Fence building				MEN								

Legend: MEN WOMEN BOTH

Figure 4: Activity calendar

The main livelihood strategy in the village is crop production (rice for self-consumption and cash crops for sale). 44% of people engaged in cash crop production also combined it with wage labour.

The average annual total income per household is 24.516 Baht, but the value is very variable: 23% of the households have an income <10.000 baht/year, 50% between 10.000 and 50.000 and 27% >50.000.

However, according to the wealth ranking given by the headman assistant, the wealth of the village is very homogenous: he ranked 3 households as “poor” and only one as “rich”, whilst all the rest was considered “middle”. In fact, he considered some people with relatively high income as middle-rich because of the amount of their loans.

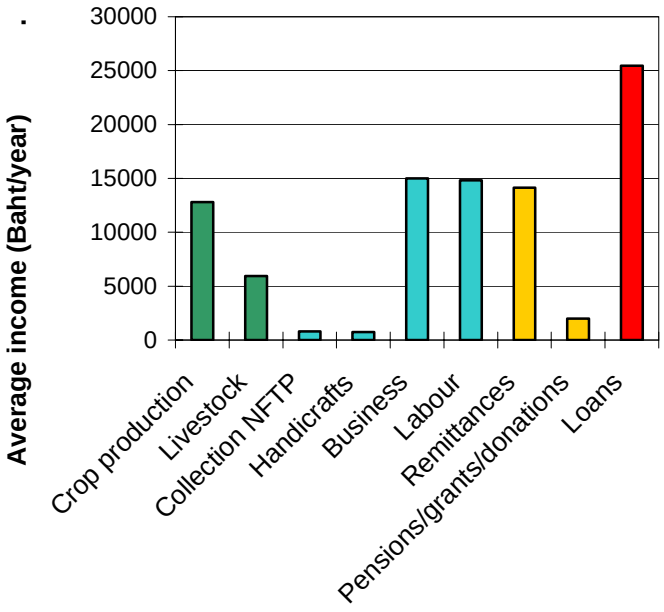


Figure 6: Economical importance of the sources of income

Regarding the perceived importance, during the questionnaire each interviewee was asked to rank the three most important sources of income in the household, including loans. The result was 25 responses to the question. Given 3 points to the most important source, the maximum possible value is 25x3 = 75 points that has been defined as 100%. The graph shows the relative importance perceived for each source of income and for loans

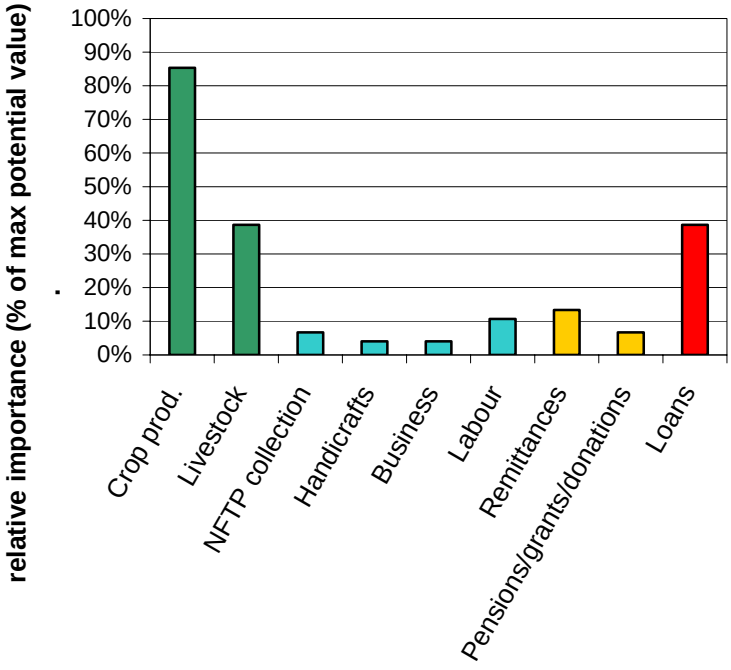


Figure 6: Perceived importance of the sources of income

PRA income ranking

The result from the PRA income ranking seems to be different: crop production is at the first position both in terms of perceived importance than in terms of money; loans have a high score in both aspects and labour is one of the most economically important sources, while all the others are not mentioned in the first 4 positions for any criteria (table 2).

Table 2: ranking exercise results

Ranking	Perceived importance	Generation of money
1	Crop production	Crop production
2	Livestock	Loans
3	Loans	Labour
4	Labour	Livestock

(1 = most important)

3.3 Farming systems[9]

3.3.1 Land and land uses

In Ban Bon Na, the 29 households questioned have a total cropping area of 200 rai and a total number of fields of 91. In average, each household cultivate 3 fields of 2.1 rai. The highest area per house was 30 rai divided in 6 fields.

Three households declared having fields with a Sor-Kor 1[10] status and all the others have fields without ownership status.

Table 3: Distribution of land in Ban Bon Na

Number of households	29
Total Area (Rai)	200.3
Total number of fields	91
Average area per household (Rai)	6.9
Average number of fields per household	3.1
Average area per field (Rai)	2.2

[9] Responsible author: Khalid Haddi; the other members are contributing authors

[10] SOK-KOR1: Land holding form introduced in 1954.It entitles the holder to occupy and farm the land. The land can not be sold; it may only be transferred to direct heirs.

Rice is the most important crop cultivated with a total area of 83.25 rai followed by Red onion (51.5 rai), lettuce and cabbage (12.75 rai), tomato (10.5 rai) and Japanese pea (10 rai). Fallows occupied 14.2 rais. Other crops including wheat, maize, bananas, coffee, mango and flowers have together an area of 18.1 rai.

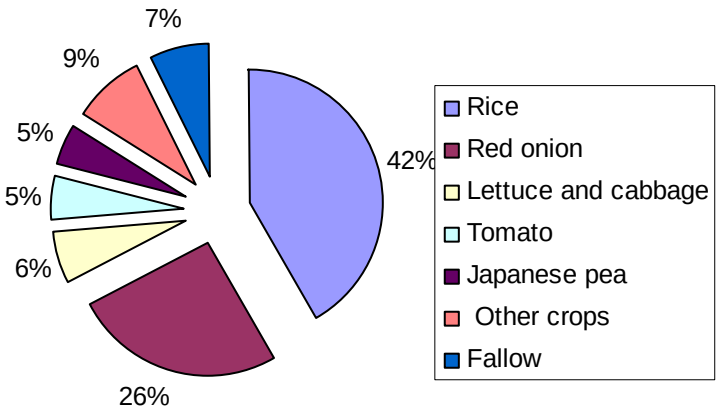


Figure 7: Percentage of different crops in terms of area occupied in Ban Bon Na

3.3.2 Crops and livestock

Cropping Calendar

From the two PRA activity calendars with men and women, the different activities related to crops and land resulted in the following: for men, the season starts with land preparation in April followed with the cultivation of rice (highland and paddy rice) and red onion, and it finishes with the cultivation of other crops like cabbage, lettuce and Japanese pea. The red onion is grown sometimes in the dry season when the availability of water and money allows it.

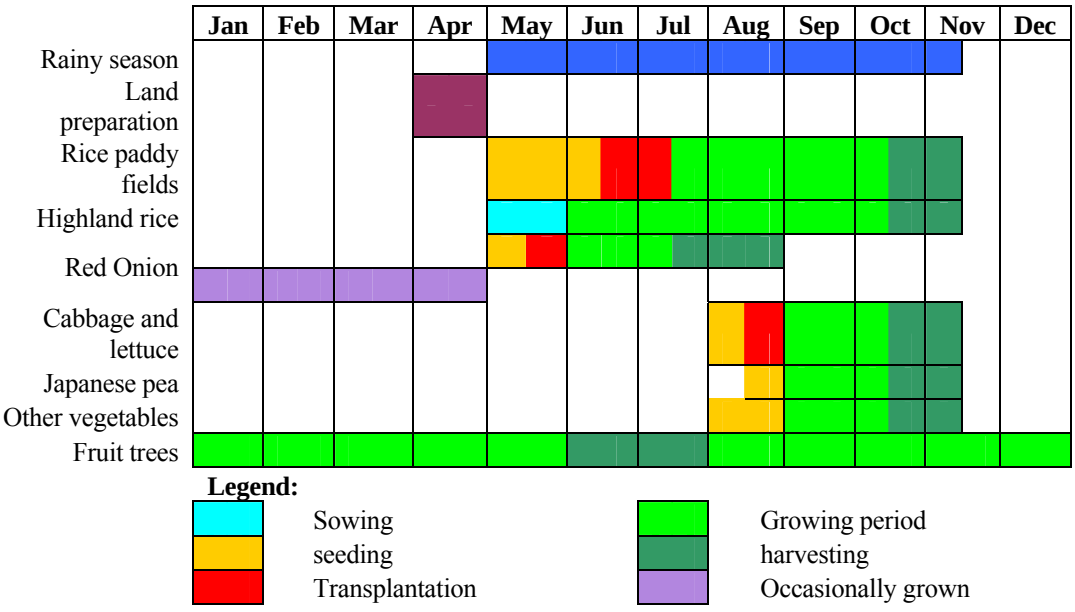


Figure 8: Cropping calendar (men)

For women, the crops are cultivated during the same period and in the same order given by men except for cabbage and lettuce that appear to be grown during a more extended period.

Land preparation is practised in April and includes a slush and burn operation. The fertilizers are applied from May to July and weeding is done during August and September just before harvesting the rice.

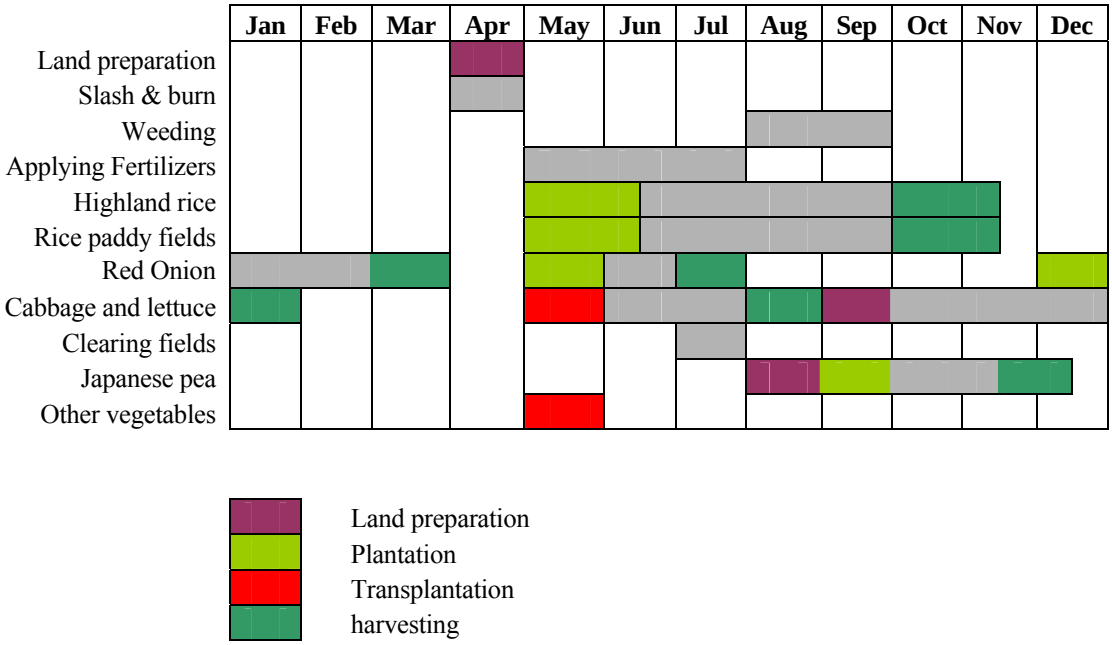


Figure 9: Cropping calendar (women)

Cropping systems

From the questionnaires, it is found that the main cropping system (16 households from the 29 surveyed) was dominated by a combination between rice, red onion and one of the other cash crops like lettuce, cabbage, Japanese pea or tomato. Five households were growing only rice, three were growing rice and onion and five were growing rice with other cash crops.

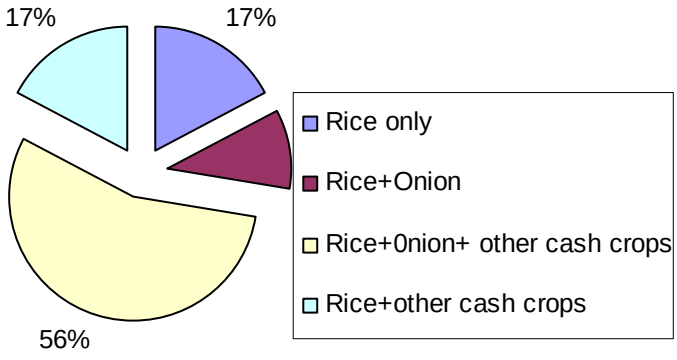


Figure 10: Percentage of different crop combinations practiced in Ban Bon Na

Except for rice all crops are marketed. The cultivated crop for the longest period of time is rice. The product which has the highest price per kg is Japanese pea.

Table 4: Uses, duration, yields and prices of different crops

Crop	SC/M	Duration of cropping	Yield/rai	Price/kg
Rice	SC	4-6 months	600-720 kgs	*
Red onion	M	2-4 months	1500-2000 kgs	5.05
Lettuce and cabbage	M	3-4 months	1500-2000 kgs	6-10
Tomato	M	3-4 months	358 kgs	3
Japanese pea	M	4 months	136.4 kgs	15-18
Other crops[11]	SC&M	*	*	*

(SC = Self-consumption and M = Market)

Livestock

The most important types of livestock in the village are cattle, pigs and chickens. Cattle are used as working power, source of manure, as well as a form of saving to sell when needed. Pigs and chickens are mainly for self consumption; however, occasionally they are sold.

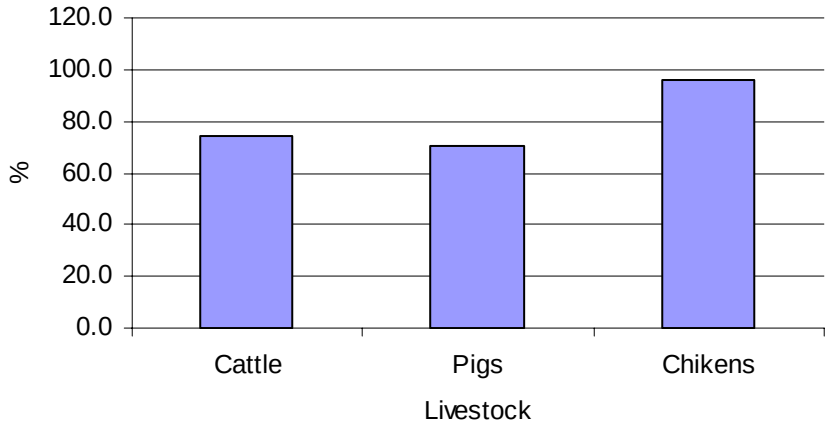


Figure 11: Percentage of households owning different livestock

3.3.3 Inputs

All households use chemical fertilizers for at least one of their crops. The highest amount is used for cabbage, lettuce, and Japanese peas and the lowest for rice (Table 5).

[11] Wheat, bananas, coffee, mangoes

Table 5: Total and average quantities of fertilizers applied

Crop	Area	Kgs	Average Kgs/rai
Rice	83.25	1900	22.8
Red onion	51.5	3650	70.9
Cabbage, Lettuce and Japanese pea	22.75	2650	116.5

The formulas and quantities of fertilizers used depend on the type of crops. For rice, Urea (46-0-0) is the most used (around 20 Kg/rai) followed by 13-21-0 (13.6 Kg/rai). For the red onion, the main used formulas are 15-15-13 (70 Kg/rai) and 8-24-24 (50 Kg/rai), while for the lettuce, cabbage and Japanese pea 16-20-0 (117 Kg/rai) and 15-15-15 (83 Kg/rai) formulas are used. Around 20 households use in their fields a kind of hormone (EM) to accelerate the growth of the crops (around 25 liters/household/year for all crops).

Regarding crop protection, farmers apply insecticides, fungicides and herbicides for both rice and cash crops (Figure 12).

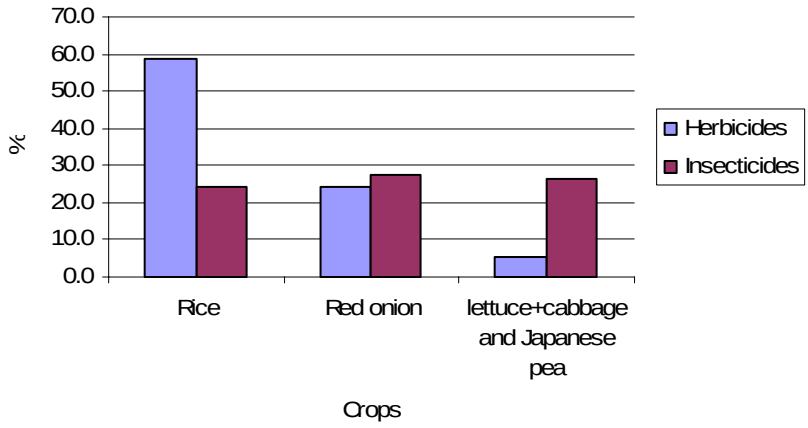


Figure 12: % of households using insecticides and herbicides in different crops

In contrary of cabbage, lettuce and Japanese pea, rice is sprayed with herbicides more than insecticides and fungicides, whilst red onion seems to be equally sprayed with all of them.

In relation to equipments, almost all the households use sprays, while pipeline and sprinklers used for irrigation are owned by less than half of them.

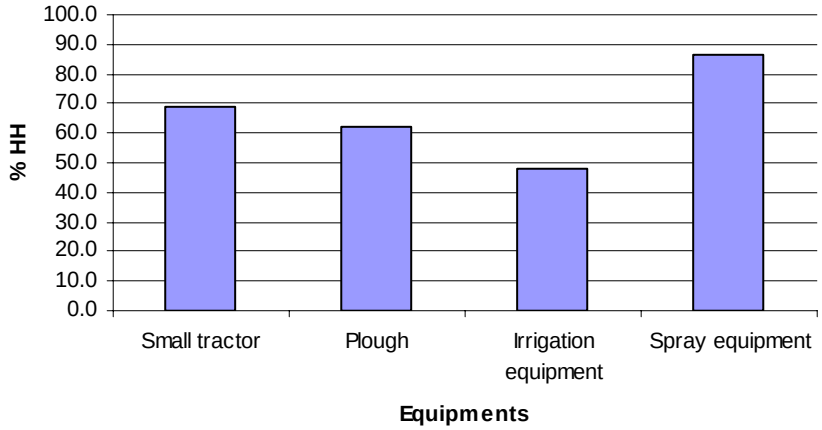


Figure 13: % of households owning different equipment

As part of the inputs, extra labour is used by 25 households. Generally the labour is in form of "exchanged labour[12]" within the co-villagers.

[12] The exchange labour is a process where villagers work in each other fields as a way to avoid labour hiring costs.

3.4 Forest uses and conservation[13]

The villagers perceive the forest as important as agriculture and both are complementary to each other, as stated during the focus group discussion.

3.4.1 Forest use

The households use the forest mainly to extract and collect different products such as firewood, timber and construction material, medicinal plants and food[14], for self-consumption. Grazing areas in forest are used during the rainy season. The frequency of forest products uses in percentage (%) of households is shown in the figure (14).

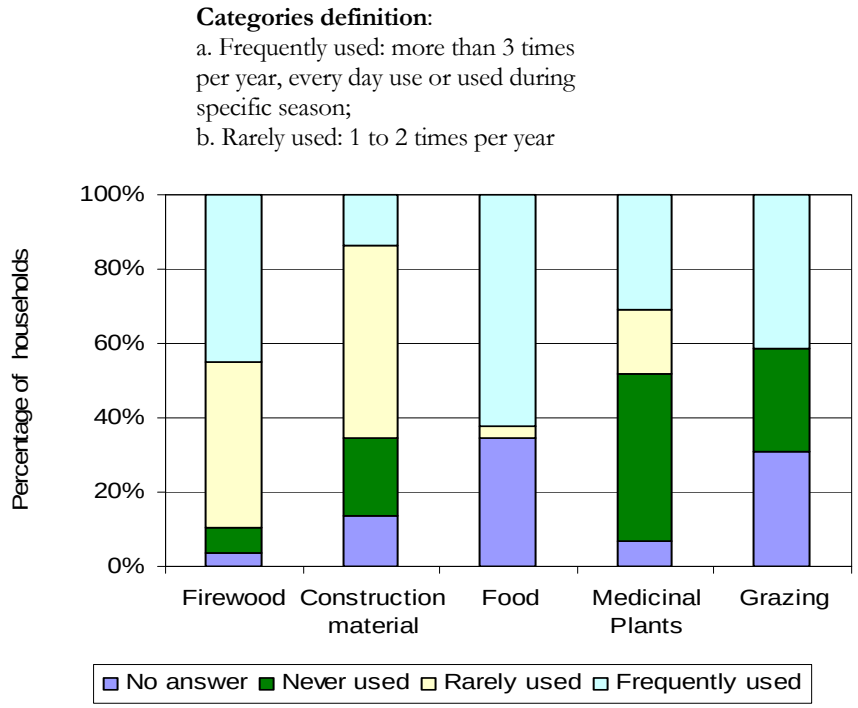


Figure 14: Forest use per percentage of households

The most frequently used forest products and services are: food, firewood, grazing during the rainy season, medicinal plants and the least frequent used product is construction material (including timber), as they are collected according to the needs for house building and maintenance. However, firewood was said to be used both rarely and frequently.

3.4.2 Forest resource changes over the past decades in the village

The perceived driving forces were identified and ranked according to their contribution for forest degradation and other resource changes in the village.

[13] Responsible author: Rosta Mate; the other members are contributing authors

[14] Bamboo shoots, wild vegetables, and small animals

The percentage of perceived factors contribution was calculated using the same method as figure (Figure 1 and 2).

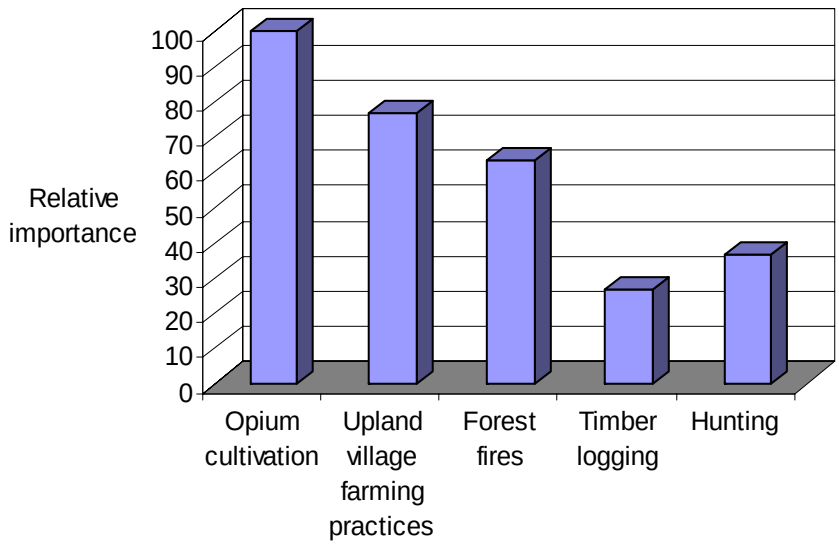


Figure 15: Drivers for forest degradation (farmer's view)

Opium cultivation, upland farming practices and forest fires were considered the major driving forces for forest degradation according to focus group discussion and former Reverend. The National Park Superintendent (NPS) underlined forest fires as the major problem in the all watershed area. The slash and burn practices, population growth and road expansion were the outstanding causes of forest degradation.

On the other hand, burned areas and felled trees noticed through direct observation are evidences of another potential factor of degradation which is related with illegal activities.

3.4.3 Forest conservation versus forest use and impacts on livelihoods

The establishment of National Park and forest reserves had a negative impact on the livelihoods of the villagers through the reduction of land availability for shifting cultivation, as argued during the focus group discussion and interviews. This reduction decreased the length of the fallow period and increased the frequency of available land cultivation.

The NPS explained that the establishment of the National Park had the following objectives: biodiversity conservation, forest conservation and preservation for tourist attractions, research and education purposes. He added that the demarcation of National Park is done in a participatory way, involving the villagers, however it can result in some farmers loosing their fields.

The major constraint faced by the Royal Forest Department concerning the forest management is the lack of financial resources to implement the programmes. As alternative, decentralized planning

trough creation of Tambon Administrative Organization (TAO) was established to work in a gross root level. This resulted in the creation of forest conservation groups in each village which are working with TAO representatives at a local level for the implementation of activities related to forest management and conservation. Despite the fact that the law restricts the extension of land in the watershed areas, according to TAO secretary it is still difficult to control with limited budget and population expansion.

3.5 Soil quality

In order to know to what extent the current farming systems adopted by the Bon Na villagers have influenced the soil quality issues related to soil fertility and soil erosion were investigated.

3.5.1 Soil fertility[15]

3.5.1.1 Perceptions of the changes in soil quality over the past decades

When choosing farming practices, Bon Na villagers are concerned with issues related to improvement of the soil fertility in their fields, as emerged during the focus group discussion.

Today everybody has a general notion of issues related to soil fertility, since they started to use chemical fertilizers 20 years. As the villagers had to use fertilizers, they created a fertilizer and pesticides fund in 1982 where each villager can be a member can borrow fertilizers.

For their cash crops they have been using mainly NPK and Urea, the latter sometimes used also for rice.

It was discussed that in the past decades the production was very low, around 1/5 compared to the present days. However, soil quality in the past was better than today.

In the point of view of the farmers, the establishment of the National Park with the reduction of the fallow period is the main reason why the villagers started to use chemical fertilizers.

In terms of soil fertility improvement techniques, according to questionnaire results, the use of animal manure is the most practiced, followed by the use of inorganic fertilizer and the fallow period, while in order to control soil erosion most of the villagers use terraces in the paddy fields and vetiver grass in slope (Figure 16 and 17).

[15] Responsible author: Suzie Aly; the other members are contributing authors

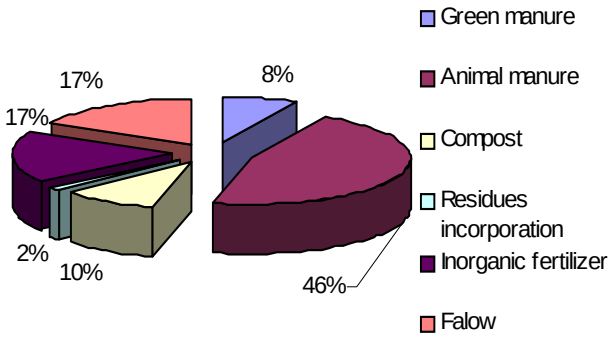


Figure 16: Techniques to improve soil fertility

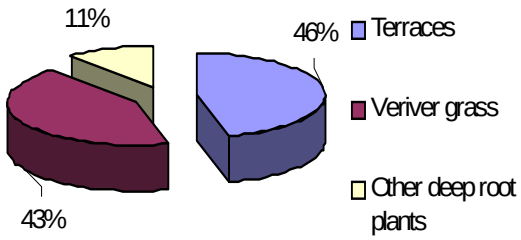


Figure 17: Techniques for soil erosion control

3.5.1.2 Current status of soil fertility in the fields

Tables 6 presents the analytical results and the classification of the soil samples collected in some fields in Bon Na village.

The pH level in the 5 soil samples range between strongly acid to medium acid being in average medium acid, while the percentage of organic matter range from 1.78 to 14.41 % which means that the levels of organic matter in the samples are relatively high to very high. Available phosphorus varies from very low to low with exception in site 1 (red onion field with chemical fertilizer) which presents a moderate concentration around 22.07 ppm. An opposite situation is found for the % of total Nitrogen since this range varies from 0.089 % to 0.720, which means from moderate to very high, being in average very high.

Table 6: pH, SOM and soil nutrients from different land use type

Site	Site 1	Site 2	Site 3	Site 4	Site 5	Average
	Onion + Inorg.	Onion + Inorg. + Org.	Rice + Inorg. + Org.	Reforst. 10.	Reforst. 20	
pH	5.8	5.7	5.1	5.6	5.2	5.48
Classification	Medium acid	Medium acid	Strongly acid	Medium acid	Strongly acid	Medium acid
OM (%)	4.57	3.02	3.05	1.78	14.41	5.37
Classification	Very high	High	High	Moderate	Very high	Very high
P (ppm)	22.07	17.32	6.14	8.89	7.87	12.46
Classification	Moderate	Low	Very low	Very low	Very low	Low
Total N (%)	0.229	0.151	0.152	0.089	0.720	0.268
Classification	Very high	Very high	Very high	Moderate	Very high	Very high

In terms of exchangeable cations, most of the samples present the content of potassium very high being in average around 336.6 ppm. The content of calcium and magnesium exchangeable are in general moderate, ranging from 424 to 2,244 ppm for the case of calcium and 85 to 326 for the case of magnesium respectively. An exception is seen in the 10 and 20 year reforested area (sites 4 and 5), where the content of calcium is low (Table 7).

Table 7: Content of K, Ca and Mg in ppm from different land use

Site		Exchangeable cations					
		K	**Classif.**	**Ca**	**Classif.**	**Mg**	**Classif.**
site 1	Onion + Inorg.	436	Very high	2,244	High	326	Moderate
site 2	Onion + Inorg. + Org.	527	Very high	1,056	Moderate	178	Moderate
site 3	Rice + Inorg. + Org.	176	Moderate	1,556	Moderate	85	Moderate
site 4	Reforst. 10.years ago	421	Very high	424	Low	139	Moderate
site 5	Reforst. 20.years ago	123	Moderate	700	Low	93	Moderate
Average		336.6	Very high	1,196	Moderate	164.2	Moderate

3.5.2 Soil erosion[16]

3.5.2.1 USLE equation method

The soil erosion calculated with USLE formula resulted in different levels of erosion for the four sites (table 8). The most severe erosion occur on the site S2 whilst it is very slight to slight in sites S3 (paddy fields) and S4 (reforested area 10 years ago). Site S5 was not included because of data missing.

Table 8: Levels of soil erosion in the different land use type

Site		Erosion		Erosion level
		(ton/ha)	**ton/rai**	
site 1	Onion + Chemicals fertilizes	101.81	16.3	Moderate
site 2	Onion + Chemicals & Organic fertilizes	409.90	65.6	Severe
site 3	Paddy field rice	5.96	1.0	Very slight to slight
site 4	Reforestation 10 years ago	0.98	0.2	Very slight

3.5.2.2 Conservation method

Since this method is different with the USLE equation, the soil sample collected will be called field 1, 2 and 3, instead of "sites". For the soil samples collected to estimate the soil erosion impact on

[16] Responsible author: Khalid Haddi; the other members are contributing authors

nutrient levels in the fields subjected to conservation systems the results and further classification in terms of soil fertility can be seen in Appendix 6.

Analysis of variance at 0.05 shows no differences between the fields for pH, available phosphorus, Ca, K and Mg. However, for N and organic matter the paddy rice field showed higher amounts with respective average values of 0.172 % and 3.44% while the lowest values were from field 2 with 0.123% and 2.47% respectively.

Within the fields, only field 1 (without soil conservation methods) has a decreasing gradient of almost all the nutrients (except K) from the upper part to down part of the slope. In fields 2 and 3 (paddy rice field), almost all the nutrients (except K) do not show any particular gradient. K levels increase from the top to the bottom of the slope for all the fields.

For the texture, the differences between fields are only on the silt, the values being 22.67%, 17.76% and 15.95% for field 3, 2 and 1 respectively.

3.6 Water quality[17]

3.6.1 Water quality indicators

Table 9 shows some of the general water quality indicators.

pH is within the normal range of 6.5 – 8.4. DO (Dissolved Oxygen) is very low at all three locations compared to the reference sample and to water quality standards in Thailand (Appendix 7).

Table 9: Water quality indicators

Site		pH	DO mg/l	TDS mg/l	Salinity ‰	Conductivity µs/cm	Turbidity ppm	NO3 mg/l	PO4 mg/l
Site 0	Reference sample	7.5	6.0	623	0.6	1265	5.8	0.053	0.016
Site 1	Before the village	8.1	1.6	642	0.6	1285	8.9	0.109	0.072
Site 2	Middle village	7,5	1.0	852	0.8	1704	4.5	0.103	0.089
Site 3	After village	7.4	1.5	899	0.9	1799	2.3	0.197	0.106

Nitrate and phosphate concentrations are higher compared to the reference value (Figure14). However, the nutrient concentrations are below critical threshold values (Haygarth and Javis, 2002)[18].

[17] Responsible author: Susanne Korsch; the other members are contributing authors

[18] Standards also given by Dr. Orathai (pers. comm.). The threshold values used are 0.5 mg/l for nitrate and 0.15 mg/l for phosphate

Nitrate is highest at site 3, whereas phosphate is highest at site 2 and 3, which is in correspondence with higher TDS (total dissolved solids), salinity and conductivity values. Nitrate and phosphate in drinking water is approximately 5 to 20 times less compared to the reference value and far below the critical values[19] recommended for drinking water.

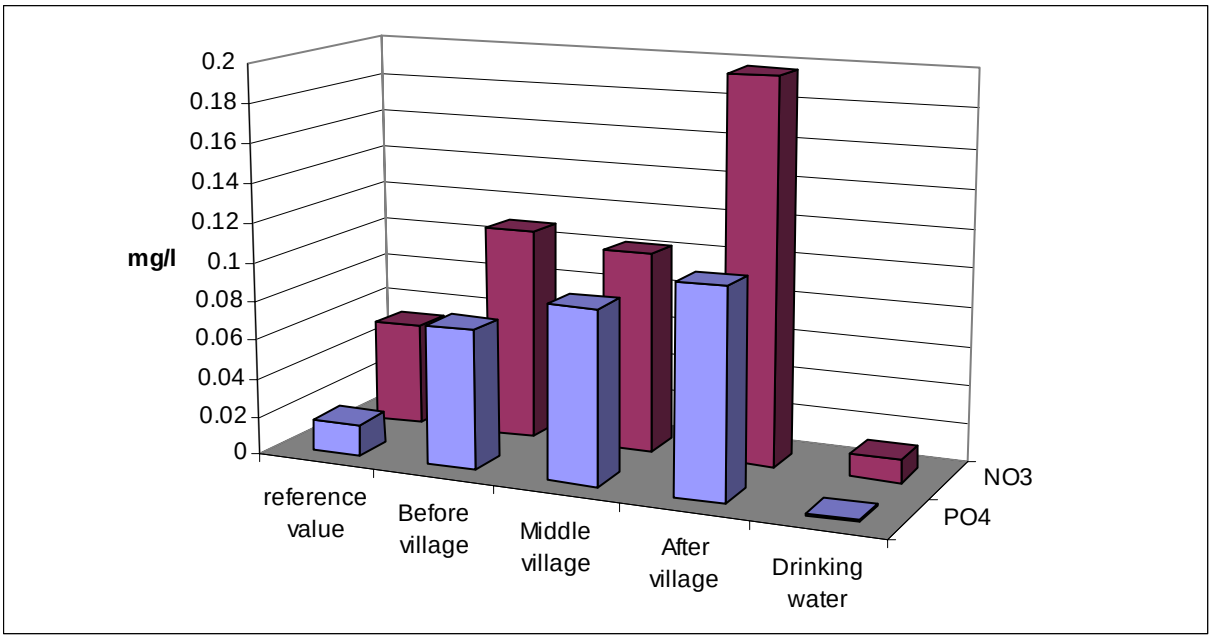


Figure 18: Nitrate and phosphate concentrations

Water index

Damselflies, dragonflies and caddisflies were some of the organisms found in the stream. All of these species indicate good water quality, whereas certain snails and cockles found indicate poor water quality[20]. Table 10 shows the scores that were obtained from the three locations.

Table 10: Qualitative water quality index

Site		Score	Status
site 1	Before village	5	Rather dirty water to average
site 2	Middle village	8	Very clean water
site 3	After village	7,2	Rather clean to clean water

3.6.2 Pesticides

In total 6 different kinds of pesticides were found in the sediment samples. All pesticides found are insecticides. Mevinphos, Chlorpyrifos, and Malathion are organophosphates. Carbofuran, Phosalone,

[19] US EPA

[20] Appendix 9

and Methomyl are carbamates. Figure (19) shows the concentrations of the insecticides at the three locations except for phosalone and methomyl. Methomyl was only found as a trace and phasalone was only found at location 2 and was below the threshold limit value[21]. Mevinphos, Chlorpyrifos, and Carbofuran exceed the threshold limit values which are indicated as a red line in the graphs. Malathion concentrations are below the threshold limit value.

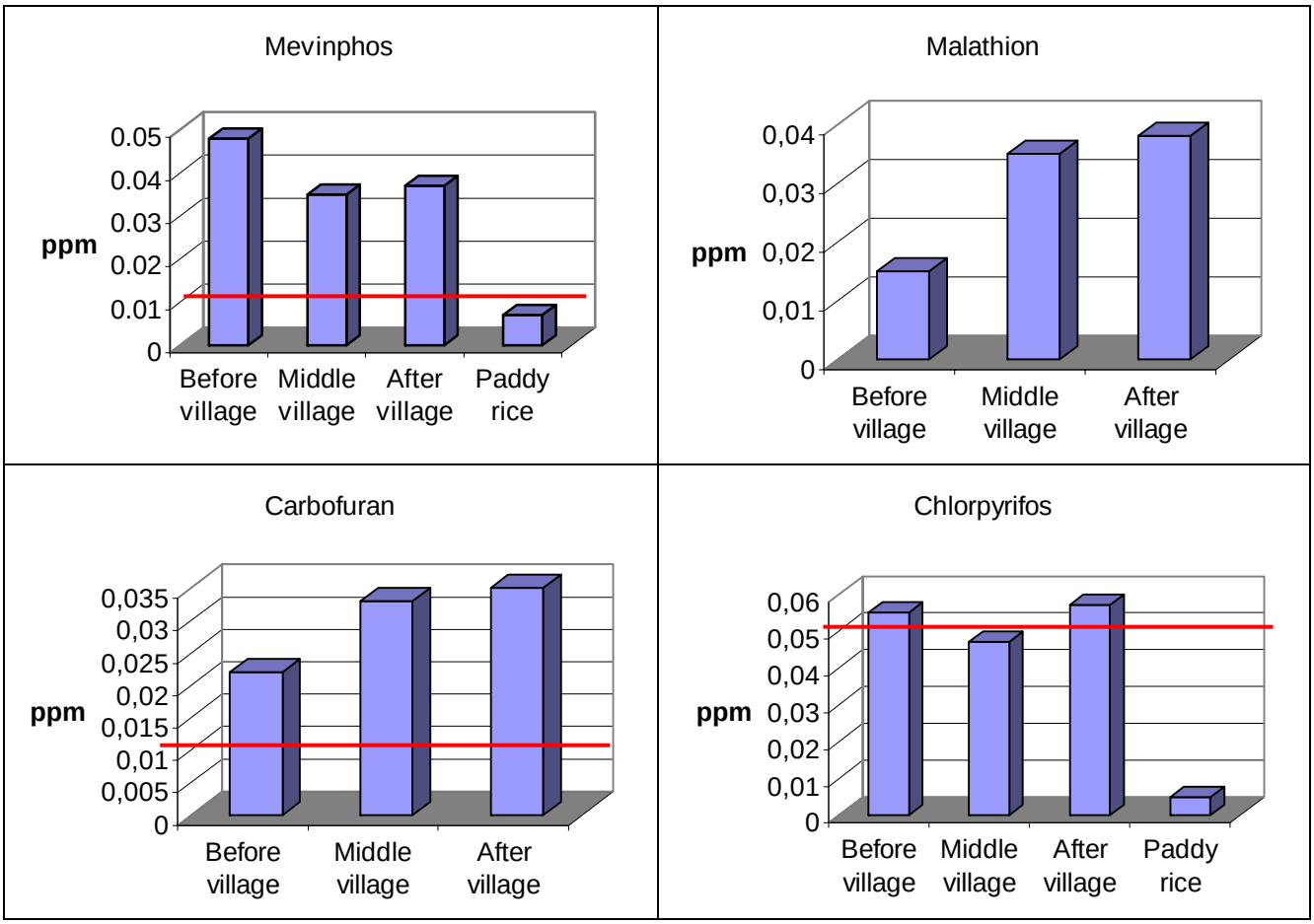


Figure 19: Pesticide concentration in sediments of the Mae Pae stream

3.6.3 Perceptions on water quality

In the opinion of an interviewed farmer water quality in the stream is good. However, it was also stated that water quality has changed during the last decades and that it has become poorer, especially regarding the reduction of aquatic animals. It is believed that water quality has decreased due to population growth and the use of chemicals in the fields. One week after spraying the fields, the farmers don't collect any animals from the stream or the fields because of the poison from the agrochemicals.

[21] To see all values and the complete table consult appendix 9

3.7 Household economy[22]

3.7.1 Expenditures and net income

Based on the questionnaire results, the average of the annual total expenditures is 31.205 baht, and the average net income is 6888 baht.

The agricultural inputs constitute the biggest expenditure in the household economy, followed by food and education (20).

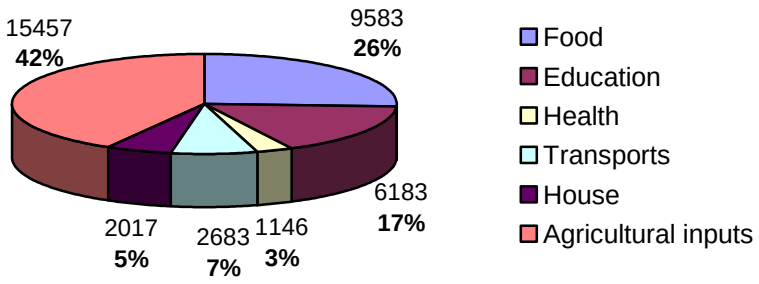


Figure 20: Household expenditures (baht/year)

3.7.2 The credit system and the loan situation

The main credit sources present in Ban Bon Na are the following:

Village fund

Every village receives 1 million baht from the government used as a fund to give loans to the villagers. Each villager cannot borrow more than 20.000 bath, which should be repaid in 2 rates (10.000 baht/year); however, if not possible the villager will pay only the interest, postponing the payment.

This fund is only for agricultural purposes, but can be used for other aims in case of emergency (e.g. serious sickness).

Guarantees are not required, it is self-guaranteed from the villager that asks for the credit.

Agricultural bank

This bank lends money only for agricultural purposes. The loan consists of two parts: the first one is given in cash up to a certain maximum, and the second is given in agricultural inputs.

[22] Responsible author: Elena Gioseffi; the other members are contributing authors

If the borrower can pay back the first year, the interest rate is low (around 6-8%), otherwise it raises up to 12-13% the following years.

The guarantee is given by the Royal Project through a certificate given to the farmer.

Housewife group

This association has a fund aimed at supporting agricultural production. However, the amount of money lent is only of few thousand baht per creditor.

There is no particular guarantee required, it is a self-guaranteed fund.

Fertilizers and pesticides fund

This fund was created by the villagers in 1982. It works as a cooperative saving system, where every member has a share. However, it is even smaller than the Housewife group fund. The interest rate is 24%.

Royal project

Even if not a proper credit institution, the Royal Project facilitates investments in agriculture for the contracted farmers giving inputs that can be paid back after harvest. Moreover, it facilitates the access to credit by giving a guarantee to the Agricultural Bank.

In the opinion of the villager that was interviewed, access to credit in Ban Bon Na is quite easy.

All of the households are having access to credits or project benefits.

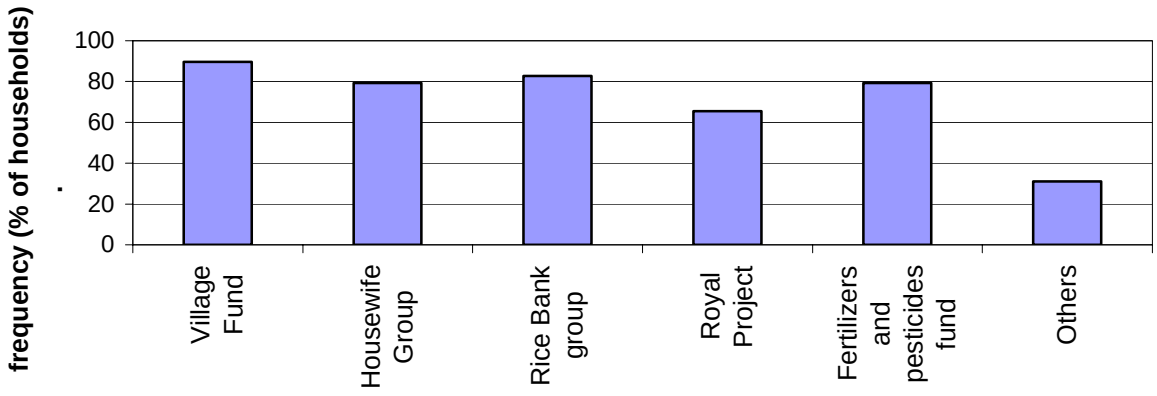


Figure 21: Creditors institutions, organizations and projects in the village

According to the result of the focus group discussion about loans, the villagers borrow the money to invest in agriculture and when they have harvested and sold their products they are supposed to repay the loans. However, often they can only afford to repay the rate of interest, and sometimes they ask

for new loans to repay the old ones. In their opinion, the fact that they have many creditors is not always good because it makes them take more loans to repay others.
If they cannot repay the rate of interest and neither takes more loans, they go to sell labour in the city or they borrow money from relatives.

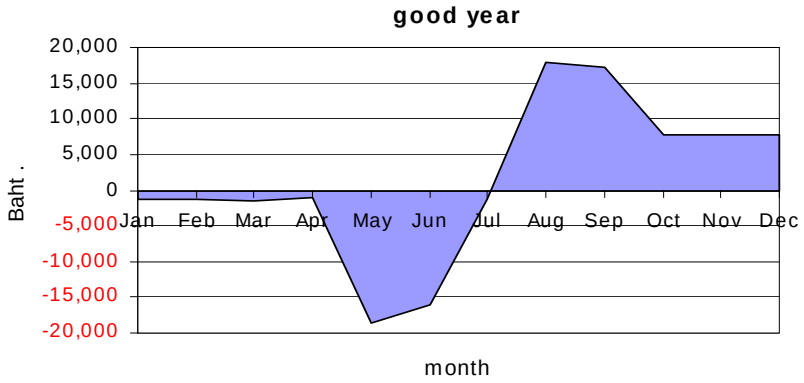
3.7.3 Annual cash flow: two case studies

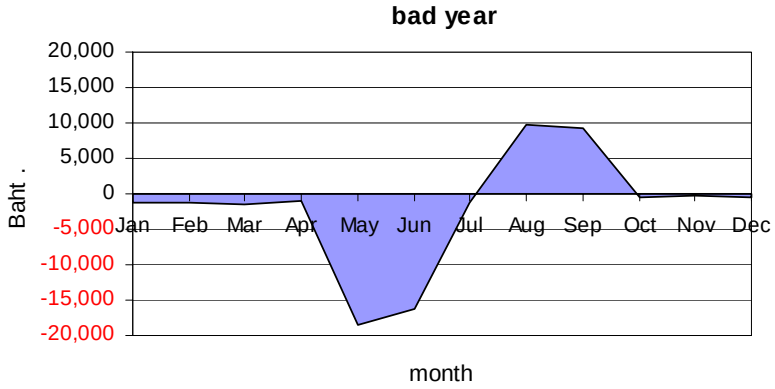
Two case studies were identified in order to compare economies and cash flows between households with different livelihood strategies (Appendix 10).

Case study n.1 - Cash flow of a household where cash crops are the most important source of income

Mr. Pongpraison bases his income generation on selling red onion, integrating it with some off-farm agricultural seasonal labour as a coping strategy. The onion production is highly variable from year to year, as well is the market price. The seedling costs 30 baht/kg. The maximum yield he can have is around 3000 kg/rai, and the minimum is 1800 kg/rai. The transportation price from the village to the market is 1 baht/kg. The maximum price he can sell the onions for is 10 baht/kg, while the minimum is 2.5 baht/kg, and the price is usually closer to the lower one.

Therefore, with these two factors combined some years are good and some years are bad, in terms of income generation. The terms "good" and "bad" years are used according to the definition of Mr. Pongpraison: in a good year the income from cash crop sale is around 45.000 baht, while in a bad year it is around 4.000 baht. During the last 10 years, the first 5 were good years, but during the last 5 years they have been getting worse and worse.

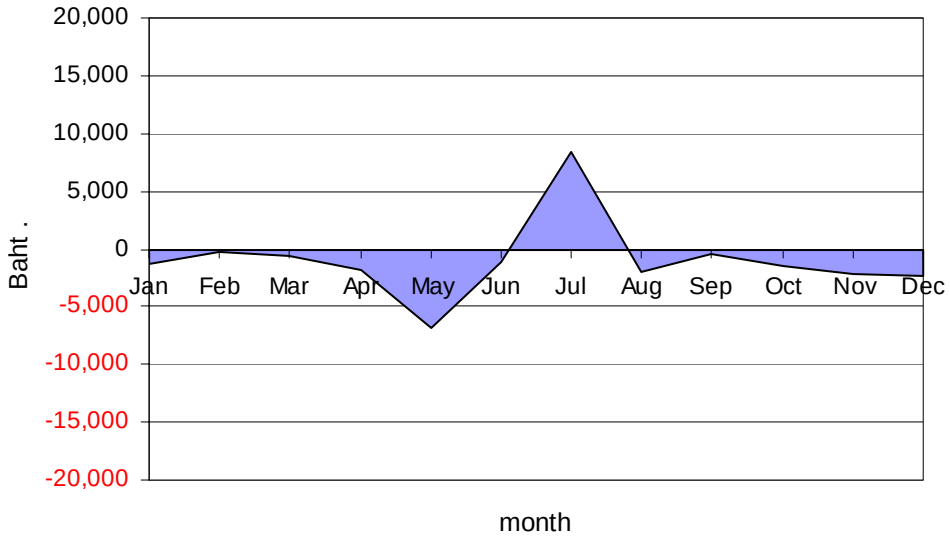




Mr. Pongpraison receives some loans from several organizations and institutions present in the village. He has 60.000 baht of debt: with the bad income of the last years he could not repay the loan and in order to pay back he chose to be a soldier the next year, when he will receive a salary of 4000 baht/month.

Case study n.2 – cash flow of a household where a fixed salary Is the most important source of income

Mrs. Sripermprum lives alone in her house in Ban Bon Na. She has 1 son working in the city, 2 sons working in other districts and 1 studying in the city. The first son is helping partly supporting the expenditures for the student, but in general they don't send money back to her. She got 2000 baht last year from one of her sons for agricultural inputs.



Mrs. Sripermprum is a chef at Bon Na village school. She earns 70 baht/day and works 20 days/month for 9 months/year. She also has some crop production (rice for self- consumption and Longan for selling), where she uses sharing labour to work her fields.

Even if they have different livelihood strategies, the cash flows in the two case studies have aspects in common and the two villagers face similar problems related with loans.

4 Discussion of results

4.1 Environmental implications

4.1.1 Forest use and conversion[23]

The use of forest has changed compared to the past, not in terms of products extracted but in terms of frequency of use, as they still use the forest as a source of construction material[24], firewood, food, water, grazing and recreational. The changes in the use of forest products could be either related to policy restrictions (e.g. timber) or for the scarce availability of NTFPs as too much time is spent in their collection. The seasonality of the availability of NTFPs also plays a role in the frequency of use (Rathanapanya, 1987 and Nguyen 1994 quoted by Johnson 2007).

As the collected and extracted products are only for self consumption, the use of the forest seems to have no significant impact on the degradation of the forest in the village, as evidence of cleared areas for agriculture purposes were observed. However, considering the actual conflicts existing between the forest conservation interests and subsistence farming, in long-run the sustainability of forest use could be undermined, if no balance of local people needs and conservation are found. It can also be worsened by the fact that the most of the Thai national parks were often established without considering the needs of people living inside the protected areas (Puginier 2002).

There have been changes in farming practices adopted by the villagers over the past decades and no clear link has been found for the implication of the changes in forest conversion or degradation. In contrary, it seems that the changes in forest targets by putting much more emphasis in conservation, had lead to impact in the farming practices, i.e. trough the National Park boundaries demarcation which resulted in the reduction of land holding per farmer.

These changes in the forest policy contributed the reduction of fallow period practiced by farmers in the past, as the participatory demarcation does not ensure that the boundaries suggested by the farmers will be accepted by the RFD. Conflicts emerge due to the lack of willingness of RFD in recognizing the villagers' delineations and they keep confiscating the land from the farmers (Puginier 2002).

The changes occurred in government policies and regulations have not only impact on the farming practices changes, but also restricted the local people access over the natural resources. This raised conflicts between authorities and villagers and among different villages.

[23] Responsible author: Rosta Mate; the other members are contributing authors

[24] Timber and other construction material

The resources are owned by the government and local people have no clear defined rights over them. In case of Ban Bon Na none of the households have land property titles. Self-regulation based on "de facto property" is used to manage the forest resources. So far the villagers have coped with the locally defined rules. De facto arrangements can enable to reduce the resource use inefficiency and develop operational rules matched to the particular physical and economical conditions (Schlager and Ostrom, 1992).

To promote local people involvement and participation on natural resource conservation the actual initiative of demarcation is done using participatory approaches. The Community Network was created to take part in the decision making process, with the Join Management Project (JOMPA) and NGOs support. Even though it seems to have positive results, boundaries negotiation is still difficult between local people and RFD officials.

The impacts of agricultural use on the forest in the village was difficult to assess as from the questionnaire the forest is rarely used, except for food, firewood and grazing and no quantitative data was provided by the users. However, land use intensification and encroachment to forest have contributed to deforestation and land degradation in Northern Thailand (Brady 1996 quoted by Rasul and Thapa, 2002). Aerial photos analysis using Arcview GIS, have indicated that in all Mae Phae Watershed about 10% of forest area have been converted to agriculture from 2000 to 2006 (Appendix 11). However, the precision of the source was not high enough to assess the changes of the specific village; in addition, the boundaries of the village were not clear due to lack of information available. During the fieldwork a GPS demarcation could have been done, but even the farmers did not have a clear idea of the village boundaries.

Major advantages and shortcomings of the methods applied

The questionnaire was good to gather quantitative data, but did not work as it was subjective and unclear. Focus groups were used to have in-depth understanding of the people's perception, and it worked but influence of dominant people was noted, so that the information gathered was less representative. Aerial photos analysis worked but the global classification used in the data base could not match with the reality in the village land use. Satellite images analysis did not work as the images available seem to have been taken in different seasons. Transect walk and direct observation worked to assess sensitive issues such as illegal activities and general idea of the forest management status.

4.1.2 Farming systems[25]

In ban Bon Na the cropping system is based on traditional rice cultivation combined to recently introduced crops like onion, lettuce, cabbage and Japanese pea. The area cultivated is generally small and divided to several plots. Rotations and fallows of long periods are no more possible. The production of rice is dedicated mainly to self consumption and other crops are for the market and generating some income for households.

Technologies used in cultivations are basic including fertilizers, pesticides and some machinery. Flood irrigation is practiced for rice in paddy fields while sprinklers are occasionally used for the cash crops some soil conservation techniques are used to control soil erosion in slopes.

The actual cropping system can be seen as the result of different government policies regarding establishment of national parks, protected areas and agriculture extension (Samata, 2003). Those regulations restricted the access of farmers to land and made the shifting cultivation very difficult.

To face this situation of agricultural land scarcity, farmers were obliged to intensify the use of the available fields (Prasit, 2002; Rasul & Thapa, 2003). This was done through the frequent use of the small areas and introduction of new crops requiring more inputs such as fertilizers and pesticides.

This combination between the subsistence system and cash crops became widely spread in north of Thailand and resulted in a negative impact in terms of soil and water quality (Rasul & Thapa, 2003).

4.1.3 Soil quality

4.1.3.1 Soil fertility analysis[26]

The soil results from the different land uses do not show any major differences but do show some trends that may confirm the assumption that the different farming practices adopted by the villagers can have an environmental implication in the soil quality.

In general the fertility of these soils is relatively moderate since most of the parameters analyzed present values ranging from moderate to very high except phosphorus which was found with low levels.

The high values of OM are probably due to the fact that the samples have been taken during the dry season when it was possible to see in the slope fields a lot of grass vegetation and in the paddy fields a lot of animal manure. Those high values will positively influence soil quality and supply of plant nutrients (Mingthipol, ?).

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[25] Responsible author: Khalid Haddi; the other members are contributing authors

[26] Responsible author: Suzie Aly; the other members are contributing authors

The pH level is in average medium acid. In general within this range the level of acidity will rarely affect the growth of most crops directly, but probably can influence the availability of the other nutrients for some crops. An exception was found in the paddy rice field (site3) and in the reforested area 20 years ago (site 5) where the soils are strongly acid. A possible explanation for this fact mainly for the paddy rice fields can probably be due to the kind of chemical fertilizer used by the villagers since they are using mainly Urea in paddy rice fields. Continuous application of N fertilizers normally results in depletion of soil pH (Prasad & Power, 1997). Another reason for this depletion can be the amount of basic cations removed by the last crops, since normally all plants take up exchangeable bases during their growth. When the plants are completely or partly removed from the land the net result is loss of some amount of bases from the soil, and this leads to the development of soil acidity.

The very low to low content of available phosphorus found in most of the samples might be due to the unavailability of phosphorus in organic compounds present in the fields such as the grass residues in the slope fields (site 2) and also the organic material present in the reforested areas (site 4 and 5). The phosphorus becomes available after organic compounds mineralization (Ahn, 1993). In the paddy rice field the very low concentration of available phosphorus might be related to the phosphorus fixation in this soils; it is because the pH level in this soil is strongly acid contributing to rapid phosphorus fixation. The low concentration of phosphorus indicates that crops growing in these soils will have high response to phosphate fertilization. Optimum concentrations of phosphorus in the soil solution for many crops are believed to be between 46-71 ppm, depending partly on soil texture (Heckman, 2006).

Exchangeable cations - Potassium, Calcium and Magnesium - are other parameters that can influence the fertility of the soils. As can be seen from the results, in the slope fields (site 1, 2) and in the reforested area 10 years ago (site 4) available potassium is found to be very high. However in the paddy rice field the available phosphorus is moderate. This moderate content might be due to the nitrogen supply, since from the focus group discussion the villagers pointed that in the paddy rice fields they apply mainly Urea as inorganic fertilizer. Sometimes if nitrogenous fertilizers are applied to a soil with only just enough available potassium, a potassium deficiency can result (Ahn, 1993).

Calcium and magnesium are in average moderate in most of the samples. The moderate content may probably be enough: since when they are added or are available in the soil not so much is necessary to the plants, but they are in order to make the soil less acid and therefore improve the uptake by plants of other nutrients (Ahn, 1993).

Normally Nitrogen testing is not recommended because the levels of available nitrogen are variable due to its mobility in the soil with rainfall and irrigation. As the soil samples in average present a high

concentration of nitrogen, probably no response to nitrogenous fertilizers will occur. Since from the questionnaire and focus group discussion the villagers referred they are using a lot of chemical fertilizer and mainly Urea in their fields it can be one of the reasons of high level of nitrogen in the soil samples. In this level the nutrient is considered adequate and will probably not limit crop growth, and then there is a low probability of economic crop yield response to additions of nutrient (Heckman, 2006).

4.1.3.2 Soil Erosion analysis[27]

The soil erosion calculated with USLE equation gave predicted results. Two sites (site 1 - red onion + chemical and site 2 - red onion + chemical and organic fertilizer) presented erosion levels higher than the tolerance limit of 12.5 ton/ha/year (Mingthipol, ?) and than the two others with very low levels. In this case, the major determinants of erosion are high amount of rainfalls (1248mm), topography with steep (12 and 45%) and long (96 and 165 m respectively) slopes and plant cover.

Cropping systems including crops with wide row-spacing and requiring regular weeding (like onion crops) contribute to dramatically increase the erosion rates while under the forest cover (site 4) the erosion levels are low (Anon 1996 quoted by Mingthipol, ?). The use of erosion control measures like terraces (paddy fields) can reduce effectively soil erosion by reducing the slope length and hence the damage caused by runoff (Manas, 2000).

On the other hand, the results from the three fields with different conservation methods should be interpreted cautiously. In fact, the differences between the fields in terms of N can be due to the high mobility of the nutrients in the soil leading to losses by leaching rather than erosion. And for organic matter, the differences can be due to a supply of animal manure which is widely practiced in the village. For the other elements, even if the USLE equation shows the existence of high levels of erosion in slope sites of the village, no clear effects on those nutrients and no differences between the fields were found especially for K, Ca and Mg.

The differences on the level of silt can be considered as an indicator for soil particles removal due to the erosion, since the highest level of silt was found in the field with vegetative and mechanical measures of soil conservation and the lowest level was in the field without any conservation methods.

Within the fields, the increasing levels of K from the top to the bottom of the slope also indicate the existence of erosion in the three fields, because generally the erosion affects nutrients content by

[27] Responsible author: Khalid Haddi; the other members are contributing authors

removing the nutrients and chemicals associated with fine particles (Manas, 2000). However, this is not the case for all the nutrients in those fields.

4.1.3.3 Discussion[28]

The soil analysis indicates that soil fertility status in the investigated fields is moderate. Though, the high nitrogen level might be explained by inputs from fertilizers. The villagers perceive that soil quality has been decreasing since they have to put higher quantities of fertilizer on their fields.

The soil erosion results, especially for the fields without soil conservation, draw a slightly more negative picture of the impact from agricultural practices on soil quality. This fact was confirmed by the farmers when they stated that the annual restoration of irrigation drains is necessary in order to avoid sediment blocking.

The fact that conservation methods are practised in some fields shows that the farmers are well aware of and concerned about soil losses, degradation and overall soil quality, even tough the efficiency of those methods has not been clearly proved in the present study.

An effect of continuous soil erosion will be deterioration of the top soil quality, resulting in a negative effect on crop production, which leads to production costs increasing due to higher input requirement.

Soil degradation (low soil fertility and higher level of erosion) is therefore the ecological impact resulting from a more intensive use of the land due to the change in farming practices.

Major advantages and shortcomings of the methods applied

However, due to the few amounts of samples and also missing data about the slope, the size of the fields and the previous crops no clear evidence on the impact of the adopted farming practices was found. To give more accuracy to the results and be more reliable, sampling should have been conducted over a much longer period, in more fields and with mores replicas. Despite this shortcoming soil test is the best available guide to the application of fertilizers and other nutrient sources also is an excellent diagnostic tool for problem of soil quality.

4.1.4 Water quality[29]

The Mae Pae stream is no exception when it comes to contamination from agricultural inputs; from the beginning of the 90's the agricultural intensification and use of fertilizers and pesticides has been

[28] Responsible authors: Suzie Aly and Khalid Haddi; the other members are contributing authors

[29] Responsible author: Susanne Korsch; the other members are contributing authors

increasing in Ban Bon Na and probably in similar villages along the stream, resulting in poorer water quality [30].

This picture was confirmed through an interview, where it was stated that decreasing water quality is due to use of agrochemicals, which means that the farmers of Ban Bon Na are very well aware of the potential negative impact that agriculture has on water quality.

In water management it is generally assumed that concentrations above 0.05 mg/l are the result of anthropogenic influences showing that the water in the stream is influenced by human activity, which is also confirmed by the reference sample (Haygarth & Jarvis, 2002). However, the nutrient levels in the water samples are below the critical level[31], which means that the overall nutrient status in the stream does not look critical.

Water contamination from agricultural inputs varies with rainfall, fertilizer application rates, soil type, and overall land use. The samples were taken during the dry seasons, which might not be the most representative time for analysing whether agricultural fertilizers influence nutrient status in the stream. First of all application of fertilizers is mostly performed in the rainy season when farmers are growing rice and red onion. Secondly, most of the runoff from the fields occurs in the rainy season. Water samples from the rainy season would probably show somewhat different results and it could be expected that the nutrient levels would be considerably higher.

Appropriate DO[32] levels for living aquatic organisms are equal to or more than 3 mg/l (WEPA, 2006). All DO levels found are less. Qualitative assessment of water quality by using aquatic indicator animals does not indicate that low DO levels, which contradicts the information found in the samples. The low DO levels might be due to failure in measuring since DO optimal range is approximately 4-6 mg/l in the northern regions of Thailand (WEPA, 2006).

Water quality assessment through the use of aquatic indicator animals has to be interpreted carefully, because much more animals should be counted in order to make a fully validate assessment. It is a very good method to cross-check experimental information.

Only insecticides were found in the sediment samples, even though the farmers use more herbicides. Either the herbicides used degrade rapidly in the environment or no analysis of herbicide residue was performed in the lab. The insecticides found where organophosphates (OPs) and carbamates. OPs figure in many official use-for-concern priority lists because of their toxicity, especially to the aquatic

[30] Information from to different interviews with farmers

[31] see Appendix 7

[32] Dissolved Oxygen

environment (US EPA, 2006). Carbofuran and chlorpyrifos which are exceeding the threshold limits are classified as respectively highly hazardous and moderately hazardous (Roland and Pingali 1993).

Specific pesticides are used for different crops, vegetable, and fruit trees at different times in the year. To obtain better comparative information on pesticide use, samples should be taken just before application, immediately after, and some weeks after application.

One of the characteristics of sustainable agricultural development is the concern for water resources. In the present study, it was found that agrochemicals and fertilizers are influencing water quality in the Mae Pae stream. However, it is hard to say to what extent this influence is harmful or unsustainable considering the timing of the year and the scarce amount of samples that were taken. Though it should be stated that, if fertilizer use and agrochemical use continues to increase in Ban Bon Na and other villages, it might reduce water resources and quality, and thus be unsustainable in a long term perspective. Not least for the water availability and quality in the lowlands, where water is an essential part of rice production and hence of economic value too.

Major advantages and shortcomings of the methods applied

Conducting experimental sampling on water and sediment was good in order to obtain a snapshot picture on the current status of water quality in the Mae Pae stream. Samples, however, were too few to make any statistical analysis and therefore the values should be interpreted carefully. The interview about the perception on water quality was necessary to triangulate the experimental findings on water quality with the point of view from the farmers.

4.2 Household economy[33]

With the change in agricultural practices and livelihood strategies, also the household economy in Ban Bon Na experienced a substantial change. The shift from subsistence agriculture to a more market oriented one due to the establishment of cash crops implied a series of consequences.

Since cash crops require high inputs per area in terms of chemical fertilizers, pesticides and machinery (Tungittiplakon and Dearden, 2002) the farmers need to have some cash which is generated from crop sales. This aspect is not present except in minimum part when the agricultural production is for self-consumption.

There are two main factors that determine the income from cash crops, and the farmers have little influence on them:

[33] Responsible author: Elena Gioseffi; the other members are contributing authors

1. Productivity. Farmers face high risk of crop failure mainly due to events beyond their control, and there is no guarantee that farmers harvest what they expect to get (Singzon & Shivakoti, 2005). This issue is also related with soil fertility soil and erosion discussed in chapter 4.

2. Product farmer price. Even if the production is good, the income is very much dependent on the price that the farmers get per unit of product.

The figure 18 illustrates the price variations from year to year for red onion which is the main cash crop cultivated in Ban Bon Na. Note that the price is very unstable and the farm value (the income from red onion) has had a trend in decreasing.

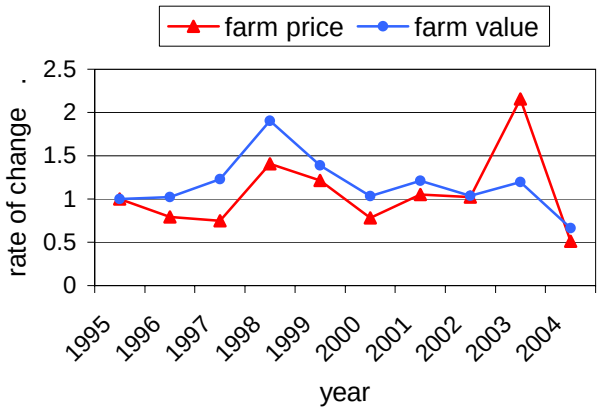

Figure 22: Trend of red onion farm price and farm value in Thailand[34]

The two above-mentioned factors make the production of cash crops very risky.

Despite the fact that crop production does not seem economically the most important income source, it has a very high value in terms of perceived importance (Fig.5 and 6), and apart from subsistence-cropping, the sales of cash crop is the main livelihood strategy in Ban Bon Na, often combined with wage labour.

Due to high variability in cash-crop prices and productivity versus high production costs, the profit from cash-crops is very low and sometimes even negative.

Loans play a fundamental role in this situation, illustrated by the very high importance that the households attribute to them. Furthermore, the loans given by the creditors are predominantly for agricultural purposes (the fact that many creditors give part of the loan in the form of agricultural inputs is a proof).

[34] Source: Agricultural Census Northern Region, 2003.

Ban Bon Na is not an exception: because of the market-driven, profit-oriented nature of cash crop production, farming in many places in Thailand has become highly intensive and requires many external inputs, and in absence of own-cash savings, farmers are dependent upon loans from the middlemen, moneylenders, cooperatives and banks (Singzon & Shivakoti, 2005).

Moreover, the fact that in Ban Bon Na there are many credit institutions and the fact that all households have access to them, shows the importance of the phenomenon; recently banks, cooperatives and other government agencies have been more accessible to the farmers (Singzon & Shivakoti, 2005).

The constant dependence on the credit system is evidenced by the annual cash flows of the case studies (Chapter 3.7.3): firstly, the income from cash crop sales comes temporally after the main expenditures that are for agricultural inputs (Fig. 20) during the months before crop production (compare cash flows with figs 8 and 9); secondly, the income generated is not big enough to pay back the cost incurred the same year plus accumulating cash in order to buy the inputs of the following year, even in a good year (case study n.1).

The following discussion will be based on the case study of Mr. Pongraison (case study n.1), since the main livelihood strategy (besides subsistence cropping) is cash crop production with agricultural wage labour, being aware that the situation for other households could be different.

Calculations of six different possible scenarios resumed in table 11 have been done to simulate the household cash flow over a period of 10 years (fig. 23). The variables determining the scenarios are the probability of "good" and "bad" years and the addition of a coping strategy. The latter is based on flexibility of hours of labour sold. One of the fixed conditions is the expenditure for agriculture (30.000 baht/year, as in the case study). It is also assumed that the farmer starts with a saving of 10.000 baht.

Table 11: Description of the scenarios

Scenario n.	Probability of "good" and "bad" years	Strategy
1	**Historical**[35]: first 5 years good, second 5 years bad	No adaptability
2	**Historical**: first 5 years good, second 5 years bad	Flexible
3	**50%**: 1 good year followed by 1 bad year	No adaptability
4	**50%**: 1 good year followed by 1 bad year	Flexible
5	**66%-33%**: 2 good years followed by 1 bad year	No adaptability
6	**66%-33%**: 2 good years followed by 1 bad year	Flexible

[35] Description given by Mr. Pongraison

It should be noted that since the topics "income" and "debt" are very sensitive, some information is missing and several assumptions have been done. A detailed description of the assumptions and calculations for the scenarios is attached in Appendix 12.

The main idea of the flexible strategy is that the farmer can increase the amount of hours of labour per day when the previous year his accumulated debt resulted in a negative budget in the household economy. However, he can increase the amount of daily hours of work only up to 13 hours per day, for a total of 60 days per year (20 days per month x 3 months, see activity calendar at (fig.4) with a salary of 100 baht per day[36].

The result of this simulation is similar in all of the cases: at some point the debt becomes too big to be repaid and it generates a vicious circle that provokes the crash of the household economy. The only thing that changes is the period that passes before the irreversible point: the shortest is before the second year, occurring when the scenario is 50% of probability without adaptability, whilst the longest is around 10 years either with 50% probability + adaptation from the farmer or with 66% probability of good year + adaptation (scenarios 4 and 6).

This shows that both "luck" and adaptability play an important role, but in case also other strategies of adaptation are not found, a livelihood strategy based only on cash crop production and low-paid salary does not seem sustainable.

In addition, this type of adaptability is not completely effective mainly due to 2 factors: i) the limit in the daily amount of additional hours (the total amount assumed to be not more than 13), and ii) the delay of the "reaction": the farmer increases the amount of hours worked only the year after he has a negative budget.

[36] Standard salary for agricultural labour, given by Mr. Pongraison and crossed with national data from National Statistical Office

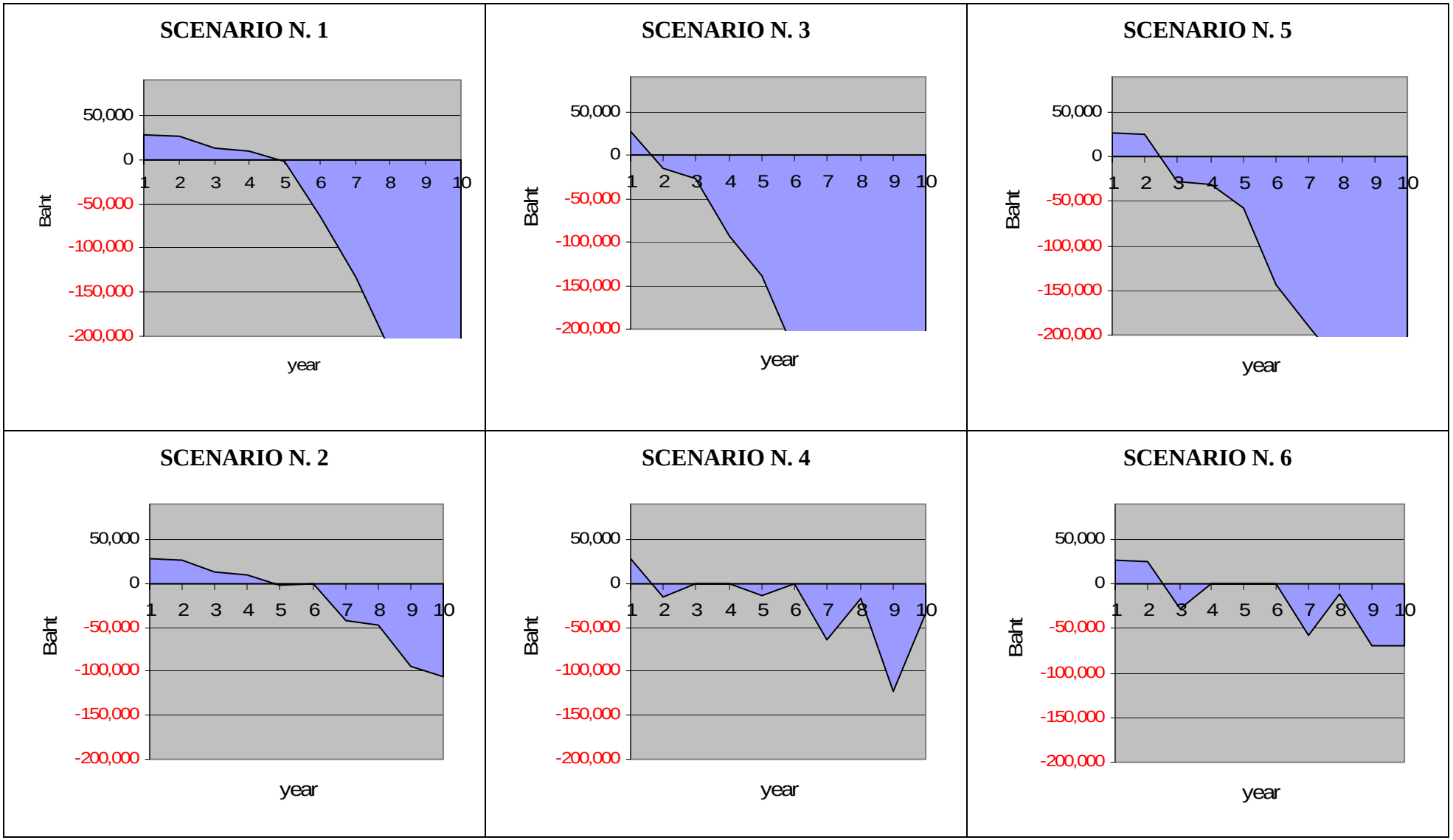

Figure 23: Simulation of 10 year cash flow for 6 different possible scenarios

Certainly, even if to some extent we can say that a specific livelihood strategy is not economically sustainable; the same can not be argued for the household economy in general. The real situation is much more complex than the presented case since adaptation to new conditions is a characteristic of human being. This is also the case of Mr. Pongpraison: in order to compensate the deficit of income, the next year he will stop his agricultural production and will be a soldier with a fixed salary. In this way, on one hand he will eliminate the expenditures for agricultural inputs, and on the other hand he will be sure that at the end of the year his income will be at least 48.000 baht. Other coping strategies include the reduction of household expenditures, receiving remittances as well as others, and of course the mix of different strategies.

Adaptation and diversification therefore are among the most important factors in the choice of strategies ensuring a sustainable household economy.

Major advantages and shortcomings of the methods applied

While the choice of the questionnaire was good to investigate the frequency of specific livelihood strategies and to get an overview regarding the loan situation, this tool resulted quite ineffective in the calculation of all households' income and many errors could be there. This is probably related also to the sensitivity of the issue, and questionnaire as structured interview do not facilitate the respondent confidence. On the other hand, detailed information but low level of generalization was given by the case studies through the semi structured interview, becoming therefore low representatives. The focus group discussion about the problem of the debt was very appropriate since the respondents could share opinions and stimulate their discussion

5 Conclusion/Perspectives

Ban Bon Na like many other Upland hill tribe villages in Northern Thailand has experienced the changes from subsistence and shifting cultivation to cash-cropping and intensification of land use.

Since the establishment of the Natural Reserve in the beginning of the 90s, that implied as immediate result the drastic reduction of the land available for swidden cultivation, farmers started to rely partly on cash-cropping, and simultaneously they began to put more fertilizers and other agrochemicals on their field thanks also to the promotion campaign of the government.

The intensification of land use induced some consequences for the environment. From soil and water samples, soil fertility was reckoned as being moderate, while water quality values indicated the presence of contamination from agricultural activity. Significant soil erosion was also found, confirmed both by farmers and experimental data. The consequences of increasing use of fertilizers and pesticides have therefore negatively influence on soil and water quality, perceived as decreasing also by the farmers.

The changes in the farming practices seem to have a no negative impact on the forest; most probably the situation is the opposite because of the many national regulations. However, the perceived conflict between the government and the locals is an element to take into consideration when speaking about forest conservation and local needs, and therefore no definite answer can be given in the study.

The shift from mere subsistence cropping to cash-cropping has led to a shift in livelihood strategies and impacted also on the household economy. On one hand, cash-crops introduced liquidity and increased considerably the production costs. On the other hand, scarce monetary resources forced the farmers to take loans in order to buy the agricultural inputs. Moreover, they have experienced difficulty repaying the loans due to the high variability of yields and market prices. This dilemma has put many farmers in a vicious circle of indebtedness. From the present study the actual economical situation of Ban Bon Na farmers seems to be hardly sustainable. However, as humans are adaptable, the future might not look as bad as commented in this study. Many of the young people are migrating to the city to get a high education and to increase their opportunities, and hopefully they will find good jobs that will allow them to help members of their families staying in the village.

6 Acknowledgements

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8 Appendices

Appendix 1: Synopsis

Influence of non-farm income sources on farming strategies and environmental impact in Ban Bon Na, Northern Thailand

ILUNRM 2007

Group 4:

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Background

During the 20th century rural communities in South East Asia started to experience big changes in their life due to the process of interpenetration of rural and urban. The importance of non-farm activities has grown and, 'although national statistics may indicate that South East Asia is still dominated by rural based agriculturalists, village level studies […] have revealed a remarkable diversification of rural livelihoods into non-farming activities' (Rigg 1998). Non-farm income plays a substantial role in the total household income of highland farmers in Thailand. One particular study shows that non-farm income is 5 times higher than farm income in terms of net return over cash cost (Katangul P. 2002).

Two important processes that contributed to the change are commercialization and deagrarianization (Rigg 2001). The overall economy, and agricultural production as part of it, started to become more market oriented. Construction of infrastructures, especially roads played an important role for creating a regular contact with urban areas, markets and sources of employment. At the same time, four parallel processes: occupational adjustment, livelihood reorientation, social re-identification and spatial relocation led to a shift in rural economies from farm to non-farm activities (Bryceson 1997 cited by Rigg 2001). As a consequence, the landscape and the farming systems have gradually changed. Non-farm work is having important effects on agricultural methods and production, where the clearest impact is linked to the effects that non-farm work has on labour availability in the household and in the village (Rigg 1998).

Positioned in Northern Thailand at 18.3° of latitude, 98.5° of longitude and 910 metres above sea level, Ban Bon Na is the southernmost village of the Upper Mae Pae Watershed. It is the first village to be reached when approaching the area from the main road which is located relatively close to the village. The village consists of 29 households and approximately 160 permanent residents.

Ban Bon Na has probably been affected by the processes described above. Non-farm activities and income did probably have an influence on the decision-making processes, also regarding the choice of farming systems. Did these changes influence land use, and did they provoke any environmental impact?

Objective and Research Questions

Main research questions

How do non-farm income sources influence farming strategies in Ban Bon Na and what are the environmental implications?

Sub-questions

1. What are the actual farming strategies? Why and how did they change over the past decades?

2. How do non-farm income sources contribute to total household income and how does it influence the farming strategies?

3. What implications did the changes in farming strategies have for the environment in terms of…

   a. Soil degradation (fertility and erosion)
   b. Forest conversion (deforestation and implantation)
   c. Water use (quality and irrigation techniques)

Definition of terms

i. Non-farm income sources

Non-farm is defined by Rigg in (2001) as all non-agricultural work, whether undertaken on-farm, in the local vicinity, or extra-locally. In the present study, non-farm income sources mean activities as in the definition above plus all other income sources which are not directly connected to any specific job such as remittances, loans and pensions.

A first categorization of non-farm income sources can be inspired by Rigg (1998) where he describes different types of activities in relation with level of skills and capital required. In addition, a category where other sources of income apart of work activities are taken into account (e.g. remittances) should be included.

Four possible categories are:

1. Mainly activity that doesn't require skills (or little skills required) nor capital (or little capital required)
2. Mainly activity that requires skills but no capital (or little capital required)
3. Mainly activity that requires skills and considerable capital
4. Mainly money coming from out of the household

ii. Farming strategies

Farming systems involve a complex inter-related matrix of soil, plants, animals, implements, labour and capital viewed in a holistic manner[37]. The focus during this study will be on the choice of crops and inputs (such as fertilisers, pesticides and herbicides, capital, technology etc.). Based on these two aspects, three possible categories of farming systems could be identified:

1. High inputs, market oriented
2. Low inputs, market oriented
3. Low inputs, subsistence oriented

iii. Environmental implications

Environmental implications considered in this study will be those defined by the indicators chosen in sub-question 3.

Relevance of the sub-questions

1. What are the actual farming strategies? Why and how did they change over the past decades?

The aim is to identify different farming strategies adopted in Ban Bon Na with regard to intensity, choices of crops, technology and other inputs used. Identifying the actual farming strategies gives the opportunity to classify different households into groups based on different farming strategies Identifying strategies adopted today also gives the opportunity to make comparisons to former practices.

[37] www.nri.org

Investigating on farming strategies applied in the past helps to identify when and why changes in farming occurred. Our aim is to see whether non-farm income sources can be linked to the changes that might have occurred in farming practices.

2. **How do non-farm income sources contribute to total household income and how does it influence the farming strategies?**

The aim is to identify all different non-farm income sources and to understand the role they play in the household decision-making, especially regarding farming strategies.

Investigating the different non-farm income sources will lead to a better understanding of their importance for the different households in terms of income generation, time allocation and perceptions about different values (social, cultural).

3.a. What implications did the changes in farming strategies had have for the environment in terms of soil status?

Land degradation leads to a temporary or permanent reduction in the productive capacity of land. Soil fertility decrease and soil erosion are two of the many indicators of soil degradation and can be brought about by inappropriate land use practices.

The aim of this section is to assess to which extent the farming strategies adopted by the Ban Bon Na villagers leads to soil degradation in terms of soil fertility and soil erosion. This will be investigated from a scientific point of view and from the villagers' point of view.

3.b. What implications did the changes in farming strategies have in terms of forest conversion?

This sub-question is important because it will help to answer, whether the changes on the choice of farming strategies have influenced the forest uses. Indicators considered for change in forest uses will be : i) deforestation: conversion of forest either by clearing forest areas (e.g. cash crop agriculture expansion) or reforestation /reestablishment of new forest areas and ii) change on the uses of forest products and services (such as: timber, non-timber forest products, water supply, etc.).

The defined indicators will contribute to make a correlation between the changes in forest uses and non-farm income sources. However, we are aware that the forest conversion could have

occurred for other reasons than non-farm income such as: infra-structure development, population density, labour and land availability, etc., which will be investigated during the field work.

3.c. What implications did the changes in farming strategies have in terms of water use?

The aim is to identify the current situation of water use and water quality and to assess whether changes in farming strategies have affected water use and water quality. Finally, the aim is to find out whether there is any correlation between changes in water use and non-farm income sources. This will be investigated from a scientific point of view and from the villagers' point of view.

Analytical framework for the research study in Ban Bon Na

Sub-question	Data needed	Source(s) of information	Method (s)	Sampling strategy
1. What are the actual farming strategies and how did they change over the past decades? Why?	List of crops, livestock, and horticulture	Households	Questionnaire, Direct observation Seasonal calendar	Total working population
	List of farming activities	Households Key informants	Questionnaire Semi-structures interviews Seasonal calendar	
	Disposition of fields	Focus groups Primary data collection	Community map GPS mapping	Purposive sampling
	Inputs of resources: capital, labour, time, chemicals (fertilisers, pesticides, herbicides), green manure, animal manure, seeds, irrigation-systems, tractors	Households Key informants	Questionnaire Semi-structured interviews Direct observation	Total working population Purposive sampling
	Data on historical events and agricultural changes	Key informants	Semi-structured interviews	Purposive sampling
	Outputs and uses: yields, income, market, self-consumption etc.	Households Key-informants	Questionnaire Semi- structured interviews	Total working population Purposive sampling
	Social and demographic household data: size of household, age, employments, tenure etc.	Households	Questionnaire	Total working population
2. How do non-farm income sources contribute to total household income and how does it influence the decision on the choice of farming strategies?	Demographic and social data of the households	Households	Questionnaire	Total working population
	Non-farm activities and other sources of income			
	Inputs for each activity (physical, human, time…)	Key informants Focus groups	Semi-structured interviews PRA techniques Time line Social mapping	Purposive sampling
	Temporal distribution of each activity			
	Temporal distribution of each activity			
	Income generated by each activity			
	The use of this income (auto consumption, investments …)			
3.a. What implications have	*Soil fertility*			

the changes in farming strategies had for the environment in terms of soil degradation (fertility and erosion)?	Soil acidity – pH Cation exchange capacity (CEC) Soil organic matter (SOM) Salinity/conductivity (CE) Plant nutrients (N,P,K and total bases)	Primary data collection	Soil and water sampling Laboratory analysis Test kit analysis	Stratified purposive sampling
	Perception of soil fertility decrease	Key-informants	Semi-structured interviews	Purposive sampling
	Soil erosion Annual rainfall data (last 5-10 years) Soil particule size & Soil structure code Permeability class Length of slope and slope gradient Cropping and conservation factors	Primary data collection Secondary data Literature review	Infiltration rate analysis USLE formula Direct observation	Stratified purposive sampling
	Perception of soil erosion	Key-informants	Semi-structured interview	Purposive sampling
3.b. What implications have the changes in farming strategies had for the environment in terms of forest conversion (deforestation and implantation)?	Changes in forest cover area	Secondary data from RFD (Royal Forest Department) Focus groups	Aerial photos and satellite images analysis Transect walk Historical trend line Community mapping Direct observation	Purposive sampling
	Data from sub-question n. 1 and 2	Households Key informants	Questionnaire and Interviews	Total working population
	Land held by household and for which uses	Households Head of the Village	Questionnaire and Interviews	Total working population
	Degree of villager's dependence on forest services (people's perceptions)	Households	Interviews Focus group	Purposive sampling
3.c. What implications did the changes in farming strategies have for the environment in terms of water use (quality and irrigation techniques)?	pH Conductivity/Salinity Mineral N and dissolved organic P Sediment sampling for fertiliser residues	Primary data collection Households Key-informants	Water sampling, semi-structured interviews, questionnaires	Total working population Purposive sampling

Methodology

The present study will have a holistic research approach based on different analytical tools, triangulation and interdisciplinarity. With triangulation, different methods applied will help to find answers to the same question, contributing to increase the reliability level of the data. In addition, interdisciplinarity will help to describe and analyze human processes, which are characterized by complexity and multi-causality.

Main Methods used

The **questionnaire** is a highly-structured interview appropriate to collect information that can be quantified. Some of the advantages of this method are cost and time saving (and therefore the possibility to cover a higher number of respondents) and the relative simplicity of data analysis. Some of the disadvantages are the rigidity of the questions, the impossibility to get supplementary information, the absent interaction between respondents and researcher. For these reasons this method will be used to collect general data regarding all the households present in the village, but for more specific information semi-structured interviews will be carried on.

Semi-structured interviews permit to collect qualitative data that fit in a pre-determined structure. This method is appropriate to extract in-depth information that can be quantified somehow, but the face-to face interview are enormously time consuming (Gillham, 2000). Some of the advantages of this method is the possibility of investigate questions that are more related with "how" and "why" and to use prompts and probes during the interview. This method will be used to get a better understanding of the choices in farming system strategies and to investigate the farmers' perception of environmental aspects.

Participatory Rural Appraisal (PRA) covers a range of participatory tools and techniques that are intended to enable local communities to conduct their own analysis and to plan and take action (Chambers 1992 cited by Cavestro 2003). At the same time the basic concept of PRA is to learn from and with rural people (Cavestro 2003).

PRA techniques used in the present study are: informal transect walk, time line, seasonal calendar, and social/community mapping, wealth ranking.

An **informal transect walk** will be conducted to get a general idea of the context in Ban Bon Na in terms of topography, soils, land use, forest, community assets, different zones/conditions and as well as to introduce the team to some of the farmers in the village. The information gathered during the walk will also serve as an instrument to generate new and better ideas for questions to be asked in the questionnaire.

The **time line** will be conducted consulting elderly people in the village in order to gain insight into events and changes that have occurred in the past. Special focus will be put on the local history of the agricultural and environmental changes.

Seasonal or annual calendar will be drown during the community meeting in order to get an overview about the changes in livelihood over the year; seasonality of agricultural and non-agricultural workload, incomes, expenditures, water, credits, holidays etc. Special focus will be put on the seasonality of farm and non-farm activities and incomes.

Social/community mapping will be conducted to learn about the structures in the village and the differences among the households in terms of religion, wealth, size, farming etc.

Wealth ranking will be conducted with a group of key-informants to identify the richer and poorer households in the village by dividing them into groups. The point of this technique is to see whether there is any correlation between wealth and the amount of non-farm income sources. Considering that this might be a sensitive area, the possibility of skipping this exercise will be discussed.

Direct observation will be one of the sources of data extraction during our walks with the villagers. Direct observation will help to discover the field reality from an outsider point of view. The landscape, the different local practices and the body language will be observed and analysed. Triangulation with the data from other methods will be necessary for an in-depth understanding of village patterns and for a better future planning and investigations.

Soil and water sampling: The goal of soil and water sampling and testing is to characterize the nutrients status as accurately as possible.

For the specific case of Ban Bon Na, **soil samples** will be collected in different fields influenced by different farming strategies; e.g. intensive or extensive farming. Slopes and

terraces will also be considered. Once a field is selected a standard sampling method will be used to collect soils systematically at fixed intervals. A number of samples higher than 10 and replicas higher than three are required to compute statically acceptable results.

Bio-physical snap-shot **water sampling** of possible contaminated streams will be collected to see, whether agricultural changes had an impact on water quality. For the water use, several streams under different agricultural strategies will be investigated; e.g. streams running next to highly intensified fields, streams next to extensively cultivated field and/or streams close to the forest area. However, this task will only be possible, if there is any water in the streams and as we conduct our study at the end of the dry season, this might not be the case.

Several methods for measuring soil-erosion exist; e.g. USLE equation, infiltration-rate and gutter collectors. If it is possible to obtain all required data for using the USLE equation, this method will be applied. Otherwise infiltration-rate and gutter-collectors will serve as the measure for soil-erosion. However, the "gutter" method will only work if it rains during the field work.

Aerial photos or satellite analysis: this method consists of a definition and comparison of criteria according to the degree of variation of object's heterogeneity such as: color, shape, object compactness, and object smoothness. It will help to aggregate different objects on the image according to their similarity, helping to identify different land use patterns.

Sampling strategies

Working population: the working population in this study is the entire households in the village. The unit of analysis will be the individual households within the village.

Purposive sampling: will be used to select key informants (e.g. specific farmers; local government offices, RFD, University teachers, etc.) for in-depth interviews.

Stratified purposive sampling: will be used to select different fields and streams according to their environmental status for the soil and water use evaluation.

Utilization of different disciplines

The five members of the group have Different backgrounds. Agronomy, biology, forestry and development studies (with a focus now in sustainable development in agriculture – horticultural crops management) are the disciplines present in the group. All these disciplines will allow having a better understanding of all covered subjects.

The two agronomists and the biologist will be in charge of issues related to farming systems, soil degradation and water use.

The question related to the impact on the forest will be investigated by the forester and the socio-economic aspect will be responsibility of the member with the background in development studies that will also collaborate in the more agronomic parts because of her specialization.

All group members will contribute to carry out different tasks in order to exchange knowledge and to triangulate the different points of view.

Time schedule

Activity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Arrival at Ban Bon Na, introduction to village representative									
Direct observation									
Transectional walk									
Focus group discussion									
Un-structured interviews									
Key informant interviews									
Pilot questionnaire									
Questionnaire									
Soil sampling									
Water sampling									
Infiltration rate and gutter collector									
Complementary data collection									
Historical time line									
Data transcription, processing, analysis									
Diary writing									

LITERATURE

Books and articles

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Cavestro, L., 2003 - PR.A. – **Participatory Rural Appraisal, Concepts Methodologies and Techniques.** Department of territory and agro-forestry systems, University of Padova.

Gillham, B., 2000 - **The research interview**. pp. 1-52 and 91-94. Continuum. London.

Jones, C and Jacobsen, J., 2005 – **Soil Sampling and Laboratory Selection**, Nutrient Management Module no. 1, Montana States University, Extension Service.

Katankgul, P., 2002 – **An Economic Assessment of Highland, Upland and Lowland Farming**, Department of Agriculture and Resource Economic, Kasetsart University, Thailand.

Rigg, J., 1998 - **Rural-urban interactions, agriculture and wealth: a Southeast Asian perspective.** Progress in Human Geography 22,4 pp. 497-522.

Rigg, J., 2001 - **Embracing the Global in Thailand: Activism and Pragmatism in an Era of Deagrarianization.** World Development Vol. 29, No. 6, pp. 945-960.

Websites

Natural Resources Institute (NRI), University of Greenwich at Medway, United Kingdom
www.nri.org

Appendix 2: Activity sheets

Activity sheet_Khalid Haddi

Date	Activities
06/03 Tuesday	- Arrival & welcome meeting with Royal project representative - Loose interview with the headman assistant about the village history
07/03 Wednesday	- Loose interview with Primary school teacher about School history, educational system and Village history - Questionnaire adjustment
08/03 Thursday	- Semi interview with the former reverend about Village history - Questionnaire adjustment - Transect walk and direct observation with the headman assistant
09/03 Friday	- Pilot testing of the questionnaire and final adjustments. - Questionnaires survey
10/03 Saturday	- Soil sampling for soil quality
11/03 Sunday	- Visit to the village church and loose information of Christianity - Seasonal calendar, Social mapping and income sources ranking with men group - Processing data
12/03 Monday	- Questionnaires survey & Processing data
13/03 Tuesday	- Semi-structured interview with 1 key informant on farming systems, non-farm sources of income and soil quality changes - Questionnaire survey - Processing data
14/03 Wednesday	- Semi-structured interviews with 3 key informants about Loans and credit system and Cash flow in Ban Bon Na. - Slope measurements.
15/03 Thursday	- Processing data & farewell meeting with villagers

Activity sheet_Suzie Aly

Date	Activities
06/03 Tuesday	- Arrival and welcome meeting with the Royal Project representative - Loose interview with the headman assistant about the village history
07/03 Wednesday	- Loose interview with the village consultant about the farming systems
08/03 Thursday	- Direct observation of the Ban Bon Na fields - Loose interview with a farmer about farming systems - Direct observation of the forest to see the status of the forest - Transect walk with the headman assistant for fields locations
09/03 Friday	- Focused transect walk of the field for soil and water sampling - Focus group discussion of soil fertility changes
10/03 Saturday	- Soil sampling for soil quality
11/03 Sunday	- Visit to the village church and loose information of Christianity - Seasonal calendar with women group on temporal distribution of their activities
12/03 Monday	- Semi-structured interviews with 2 key informant on farming systems, non-farm sources of income and soil quality changes
13/03 Tuesday	- Semi-structured interview with 1 key informant on farming systems, non-farm sources of income and soil quality changes - Questionnaire survey
14/03 Wednesday	- Focus group discussion on loans and migration - Transcription of the key informant interviews
15/03 Thursday	- Transcription of the key informant interviews - Farewell meeting with the community

Activity sheet_ Rosta Mate

Date	Activities
06/03 Tuesday	- Arrival and welcome meeting with the Royal Project Representative in the Base Camp - Presentation to the Headmen Assistant and recognition of the village - Loose structured interview with the Headman Assistant
07/03 Wednesday	- Loose structured interview with the Primary School Teacher in the Village
08/03 Thursday	- Direct observation in the village forest and National Park area - Transect walk in the village with the Headman Assistant
09/03 Friday	- Semi-structured interview with the TAO Secretary,; - Semi-structured interview with National Park Superintendent - Semi-structured interview with Agriculture Extension Officer
10/03 Saturday	- Water and sediment sampling in different location in the village - Data Processing
11/03 Sunday	- Meeting with the village in the Church - PRA social mapping with group of Children
12/03 Monday	- Questionnaires survey - PRA focus group with the village Forest Conservation Group
13/03 Tuesday	- Loose-structured interview (in-depth) and PRA: Wealth Ranking with the Headmen Assistant - Questionnaires survey - Semi-structured interviews with the Former Reverend (about Christianity history in Ban Bon Na) - Data Processing
14/03 Wednesday	- Loose-structured interview with the Elder men in the village - Semi-structured interview Key informant (Mr. Solophon) about farming practices and water quality - PRA focus group about Loans and Migration process - In-depth interview with the Primary School Teacher
15/03 Thursday	- Farewell meeting with the villagers

Activity sheet_Elena Gioseffi

Date	Activities
06/03 Tuesday	- Afternoon: Arrival and accommodation after lunch, meeting with representant of the Royal Project; - Evening: meeting with the assistant headman
07/03 Wednesday	- Morning: Interview with Chnreonpupm, village consultant - Afternoon: group debriefing, questionnaire adjustments - Evening: group discussion and planning, data computation
08/03 Thursday	- Morning: field observation, interview with farmer - Afternoon: interviews with farmers, meeting with assistant headman, transect walk - Evening: group discussion and planning
09/03 Friday	- Morning: transect walk focused on field and stream identification for samples - Afternoon: Focus group discussion with farmers about soil fertility
10/03 Saturday	- Morning: collection of soil samples - Afternoon: finishing collection of soil samples, relax - Evening: group discussion and planning, data computation
11/03 Sunday	- Morning: meeting with the community at the church - Afternoon: mid-term evaluation, PRA exercise (social mapping with children) - Evening: group discussion and planning
12/03 Monday	- Morning: Questionnaire data typing - Afternoon: Questionnaire data typing, relax - Evening: Questionnaire data typing
13/03 Tuesday	- Morning: Group discussion and planning, questionnaire data typing - Afternoon: preparation guidelines in depth semi structured interviews for 2 key informants, questionnaire interviews
14/03 Wednesday	- Morning: Typing data - Afternoon: In depth interviews about cash flow and loans with 2 people selected from the questionnaires - Evening: In depth interview about cash flow and remittances with person selected from the questionnaires
15/03 Thursday	- Morning: Typing and analyzing data - Afternoon: farewell meeting with the villagers

Activity sheet_Susanne Kortsch

Date	Activities
06/03 Tuesday	- Arrival and welcome meeting with the Royal Project Representative in the Base Camp - Presentation to the Headmen Assistant and recognition of the village - Loose structured interview with the Headman Assistant
07/03 Wednesday	- Loose structured interview with the Primary School Teacher in the Village
08/03 Thursday	- Direct observation of the fields and the forest - Loosely-structured interview with farmer - Transect walk in the village with the Headman Assistant
09/03 Friday	- Selection of fields and water sampling sites - Preparations for water sampling
10/03 Saturday	- Water and sediment sampling - Data Processing
11/03 Sunday	- Meeting with the villagers in the Church - Social mapping with group of men - Seasonal calendar mapping with men - Income ranking
12/03 Monday	- Questionnaire survey - PRA focus group with the village ´Forest Conservation Group`
13/03 Tuesday	- Key-informant interview and wealth ranking with the headmen assistant - Transect walk of the village with headman assistant - Semi-structured interviews with the Former Reverend - Data Processing
14/03 Wednesday	- Loose-structured interview with the old men - Semi-structured interview key informant about farming practices and water quality - PRA focus group about loans and migration - In-depth interview with the Primary School Teacher
15/03 Thursday	- Farewell meeting with the villagers in the church

Appendix 3: Questionnaire form

QUESTIONNAIRE

Date: _____

Name of interviewer: _____

Household n. ____

Introduce the researchers, explain the objective of the study, tell the approximate time the questionnaire will take.

Name of interviewee: _____

A) GENERAL DATA:

1) How many members are there in the household? ____

2) How many live permanently? ____

3) Components:

N.	F	M	Months spent out of household	Position	NAME	AGE	EDUCATION	Income (Specify unit)
1								
2								
3								
4								
5								
6								
7								
9								

4) Religion: ____

5) Are you member/part of any organization/association/group? O YES O NO
If yes, which one(s)?

Village fund O YES O NO	Royal project participant O YES O NO
Housewife group O YES O NO	Forest conservation group O YES O NO
Rice bank group O YES O NO	Fertilizer and pesticides fund O YES O NO

Other(s) (specify): _____

B) INCOME:

1. Household income activities:

	DRY SEASON		**RAIN SEASON**	
FARMING	PERSON(S) N.	Amount (Baht)	PERSON(S) N.	Amount (Baht)
Crop production				
Livestock				
Other (specify):				
NON FARM	PERSON(S) N.	Amount (Baht)	PERSON(S) N.	Amount (Baht)
Collection NFTP for self consumption		_____		_____
Selling NFTP				
Selling handicrafts (weaving..)				
Other business activity (specify)				
Selling labour (also agricultural work out of the household)				
Service sector				
Other (specify):				

2. Sources external to the household:

SOURCES OF INCOME	YES (specify who, how much, rates, source…)	NO
Remittances		
Donations		
Loans		
Pensions/grants etc.		
Other (specify):		

3. Importance of the sources of income:

a) What are the most important activities or sources that you have? Ranking the 5 most important; 1 is the most important.

O Crop production	O Service sector
O Livestock	O Remittances
O Collection NFTP for self consumption	O Donations
O Selling handicrafts	O Loans
O Other business activity (specify)	O Pensions/grants etc
O Selling labour (also agricultural work out of the household)	O Other (specify) _____

b) What are the most profitable activities or sources that you have? Ranking the 5 most important; 1 is the most important.

O Crop production	O Service sector
O Livestock	O Remittances
O Collection NFTP for self consumption	O Donations
O Selling handicrafts	O Loans
O Other business activity (specify)	O Pensions/grants etc.
O Selling labour (also agricultural work out of the household)	O Other (specify) _____

c) What are the activities where you spend the longest time? Ranking the 5 most important; 1 is the most important.

O Crop production O Livestock O Collection NFTP for self consumption O Selling handicrafts	O Other business activity (specify) O Selling labour (also agricultural work out of the household) O Service sector O Other (specify) _____

4. What are the main monthly expenditures you have?

	Y	N	Amount (approximate) in Baht
Food			
Education			
Health			

	Y	N	Amount (approximate) in Baht
Transports			
House (electricity, water…)			
Agricultural inputs			

5. Do you own the following facilities? (more than one choice is allowed; if visible, don't ask)

O Bicycle O Motorcycle O Fridge	O Electric rice pot O Gas stove O Other relevant (specify)_____

6. Characteristics of the house (**don't ask**, briefly description: size, construction material, roof, electricity…)

_____

_____

_____

C) FARMING SYSTEMS:

a) CROPS

1. Number of fields: _____
2. Tenure of fields: _____
3. Do you have fields outside the village? If yes, specify location, number, area.

4. Crops information and outputs:

Field N.	Crops produced:	IC/MC (Intercrop/ monocrop)	Area (Rai)	Period of production (months)	Yield (per season and area)	Quantity SC/M (Self consumption/Market)		Transportation		Price of the final product per unit (specify units)	
						SC	M (specify also place)	Cost	Method	Royal Project	Middleman

5. Inputs:

INPUT	Type/formula	Which crops	Price/unit (write if not producing)	Quantity (specify units)	Period of application (months)	Other relevant information
Seeds						
Chemical fertilizers						
Organic fertilizer						
Pesticides: insecticides and herbicides						

	Type	Which crops/ activity	Price/unit	Quantity (specify units)	Period of application (months)	Other relevant information
Tractor/ small tractor						
Plough						
Irrigation equipment (pumps, pipelines, sprinklers…)						
Spray equipment						
Labour (people working)						
Other (specify):						

6. Productivity and fertility perceptions:

   a. Are you satisfied with the productivity of your land?

   O Completely satisfied O Partially satisfied O Not satisfied

   b. If not completely satisfied , for which crops? _____

   c. What are the main problems that you have to face for the crop production?

PROBLEMS PERCEIVED	**YES (specify reason, if perceived)**	**NO**
Low productivity:		
Too high costs of production :		
Too many pests/diseases:		
Water shortage:		
Other (specify):		

7) What are the practices of soil fertility management you are using in your fields, if any?

TECHNIQUE	**YES (amount and frequency, specify units)**	**NO**
Organic fertilizer • green manure		
• animal manure		
• compost		
• residues incorporation		
Inorganic fertilizer:		
Fallow:		
Other (specify):		

6) What are the practices/techniques of soil erosion control you are using in your fields, if any?

TECHNIQUE	**Y**	**N**	**Additional information**
Terraces			
Vetiver grass			
Other deep root plants			
Other (specify)			

b) LIVESTOCK

Type of livestock owned:	Use(s)	Amount (specify unit)		Price/unit		Period of production (months)
		SC	M	buy	sell	
Chickens						
Buffalos						
Cattle						
Pigs						
Goats						
Sheep						
Other (specify):						

D) FORESTRY

1. What do you use the forest for?

USES OF THE FOREST	Y	N	Frequency (specify units)	SC/M (Self consumption/Market)
Wood for fuel				
Construction material				
Food				
Medicinal plants				
Grazing				
Other (specify):				

2. Did you clear forest for agriculture uses within the past ten years? If yes, how big area?

_____

3. Did you replant trees within the last ten years? If yes, which kind of trees and how big area? _____

E) EXPECTATIONS

1. In which activity/activities would you like to invest more money?

_____

_____

_____

2. Does anybody in the family would like to move to the city? If yes, why?

_____

_____

_____

3. Would you like your children in the future to be working in

O The farm O The city

O Both in the farm and in the city O Don't know

O Other (specify)_____

THANK YOU! ☺

F) ADDITIONAL NOTES *(Only for group members)*:

_____

_____

_____

_____

_____

_____

_____

_____

_____

Appendix 4: Water sampling methods

Water and sediment sampling methods:

Water and sediment sampling was conducted on three locations along the Mae Pae stream. First site (GPS: 4445047, 2024514) was before entering Ban Bon Na. Second site (GPS: 4466710, 2023847) was approximately in the middle of the village and close to a small stream running through the paddy rice fields, where an additional sediment probe was taken. Third site (GPS: 4475780, 2023299) was right after the village. The reason for selecting the three sites was to compare the agrochemical impact from the village to locations before and after the village. The sediment probe from the small stream was taken to see, if there is any direct impact from agrochemicals. A reference sample for comparison was taken from the protected forest, where no anthrogenic influence is expected[38]. An additional water sample was taken from a drinking water tank in the village, to see whether nutrients slip into their drinking water.

The water samples for investigating N and P were collected using plastic bottles. Sediments samples were taken from the bottom of the stream. Only clay sediment was collected using plastic bags from an approximately 1 square meter area. After collecting the probes, they where send to the lab in Chang Mai.

During sampling general parameters such as pH, dissolved oxygen (DO), temperature, and conductivity were measured on site with a combined pH, DO, temperature, and conductivity meter.

In addition qualitative information on water quality was gathered by identifying aquatic organisms living in the stream. Classification of animals was performed using a guide to freshwater invertebrates of ponds and streams in Thailand **(**Kanjanavanit, Oy 1999).

One key-informant interview on perception about water quality was carried out to enable triangulation with the results from the experimental data.

[38] The sample was kindly borrowed from group 6

Appendix 5: Sampling methods for soil fertility and erosion

In order to assess the impact of the adopted farming systems in the soil quality, soil samples were collected in twelve sites.

To assess the soil quality in the present study the sampling were divided in two groups: five soil samples for soil fertility analysis and soil erosion calculated with USLE equation and three for soil erosion estimation.

The sample was taken only in the top soil (about 0-20 centimetres depth) with random sampling within the area of the field.

A-Soil Fertility

.

The criteria of dividing the sites 1, 2 and 3 in this manner was to see if there was a difference in soils fertility when the villagers are cultivating applying chemical and organic fertilizers in different ways. These criteria were accorded after three days of direct observation and recognition of the fields were the villagers are cultivating and also through informal discussion with the assistant headman. The forest areas (site 4 and 5) were sampled to have an indication of soil fertility in undisturbed soils comparing with agricultural area. The sample from the site 5 should ideally have been taken from primary forest, but it was not possible to find a primary forest surrounding the area.

After the site selection composite soil samples were collected from each land use type, by using a simple random sampling for the small single samples in the same site. Each single sample was taken in a depth level ranging from 0-20 cm and afterwards the coordinates were recorded for each land use type.

The sample collected were air dried, ground and sifted by the group in the base camp, then taken to a laboratory analysis. The analysis determined were pH, organic matter content, available Phosphorus, exchangeable cations (K, Ca and Mg), total Nitrogen and texture

Site description of soil samples (collected at 10/3/07)

Selection

- **Site 1**→ Red onion field with chemical fertilizer (**Onion + Inorg.**)
- **Site 2**→ Red onion field with chemical and organic fertilize (**Onoin + Inorg. + Org.**)

- **Site 3**→Paddy rice field with chemical and organic fertilizer (**Rice + Inorg. + Org.**)
- **Site 4**→Reforested area 10 years ago (**Reforst. 10**)
- **Site 5**→ Reforested area 20 years ago (**Reforst. 20**)

B- Soil erosion

1- USLE

USLE EQUATION (WISCHMEIER AND SMITH,1978)FOR SOIL EROSION CALCULATION

$$A=R*K*LS*P*C$$

R factor

The rainfall factor can be calculated from the annual rainfall by using the following equation:
R = 8.276 * P – 215.058
The unit for R is Mt/ha and P is the annual rainfall measured in cm.
To calculate the R-factor we have used annual rainfall data from Chiang Mai from 2003-2006 (Agricultural statistics of Thailand for crop year 2002-2003). We have taken the average for the 3 years: (1500+1393,4 +1208,9 +889,6) / 4 = 1248mm
P in cm = 1248 / 10 = 124,8 cm
R = 8.276 * 124,8cm – 215.058 = 506,8 Mt/ha

K factor

The soil factor is calculated for each individual plot as follows:
$K = 2.1 * M^{1.14} * 10^{-6} (12 – OM) + 0.0325 (SSC – 2) + 0.025 (PPC – 3)$
M is the particle size, OM is the organic matter content in %, SSC is the soil structure code, PPC is the permeability class .
M is found by doing soil texture analysis in the laboratory; here we find the content of silt, clay & very fine sand:
$M = (100 - \%clay_{<0,002\ mm}) * (\%silt_{0,05\text{-}0,002\ mm} + \%\ v.f.\ sand_{0,1\text{-}0,05\ mm})$ (Jensen 2003). From each of the plots the specific K-value is calculated (see the calculation table).
Content of %SOM has been determined in the laboratory. The measured infiltration rates are necessary to determine the PPC and the soil texture can give us a rough estimate of the SSC.
PPC is both determined in the laboratory and in the field. See the PPC classes below

Table: Profile permeability classes

PPC class	Infiltration rate	
	General	**Basic (cm/hr)**
1	Rapid	>12
2	Moderate rapid	6-12
3	Moderate	2-6
4	Moderate	0.5-2
5	Slow	0.1-0.5
6	Very slow	<0.1

Table: The Soil Structure Codes (SSC) .

SSC	soil structure
1	Very fine granular
2	Fine granular
3	Medium or coarse granular
4	Blocky, platy or massive

LS factor
By using the length of the slope and the slope (in %) we can determine the LS.
Calculation of LS:
$LS = (L/22.13)^k (0.0065 S^2 + 0.045 S + 0.065)$, k = 0.5 for slopes above 5%. In all of our observations the slope was much larger than 5%. The LS-values can be found in the appendix about soil erosion

C & P factors

Table: P and C factors for different crops/vegetation (Ministry of agriculture 2002)

Crop/vegetation	P factor	C factor
Paddy rice	0.1	0.280
Vegetables	1	0.250
Hilly evergreen forest	1	0.001
Agroforestry (coffee)	-	0.004
Mixed cropping	1	0.225
Cabbage	1	0.6
Fallow (1-2 years)	1	0.25
Coffee orchard	1	0.3
Maize	1	0.502
Groundnut	1	0.406

Crops grown in hilly areas use a P-factor of 1 (ARS-USDA 1975), which means we assume they use no soil conservation methods, except for paddy rice fields which are terraced.

8.1.1.1 Erosion classes

Table Classification of the erosion levels for Thailand (Ministry of agriculture 2002):

Erosion level	Loss (t/rai)
Very slight	0.01
Slight	1.01 – 5
Moderate	5.01 – 20
Severe	20.01 – 100
Very severe	100.01 – 966.65

B-2 -Conservation methods

The second method was a comparison of nutrients and physical properties of three fields in different slopes subject to different method of soil conservation. Three samples were taken from each field from the top, the middle and down slope

- Field1: No conservation methods were practiced.
- Filed 2:Terraces were adopted and plantation lines were perpendicular to slope sense
- Filed 3: Terraces and vetiver grass in their contour.

References:

"Control of water pollution from cropland", ARS-USDA and ORD-EPA, 1975.

Nipon Thangtham & Apinon Korporn, 1997, "Erosion control parameters for slope areas in the USLE-equation – Case study of Mae Sa Watershed, Chiang Mai Province", Journal of Agriculture, 32: p. 41-51.

"Soil erosion in Thailand", Department of land development, Ministry of Agriculture and Cooperatives, 2002, 39 pages.

Wischmeier and Smith, 1978 in http://www.fao.org/docrep/T1765E/t1765e0e.htm

Appendix 6: Soil Analyses Results

Laboratory of Department of Soil Resources and Environment
Faculty of Agricultural Production, Maejo University, Chiang Mai
18/03/07

Site (field)	pH	% OM	%N	Available P (ppm)	Extractable forms (ppm) K	Ca	Mg	% sand	% silt	% clay	Texture
Site 1	5.8	4.57	0.229	22.07	436	2.244	326	60.96	13.28	25.76	Sandy clay loam
Site 2	5.7	3.02	0.151	17.32	527	1.056	178	54.96	21.28	23.76	Sandy clay loam
Site 3	5.1	3.05	0.152	6.14	176	1.556	85	56.96	9.28	33.76	Sandy clay loam
Site 4	5.6	1.78	0.089	8.89	421	424	139	78.96	9.28	11.76	Sandy loam
Site 5	5.2	14.41	0.720	7.87	123	700	93	82.96	11.28	5.76	Loamy sand
Field 1 P1	5.7	2.94	0.147	10.34	342	728	187	68.96	13.28	17.76	Sandy loam
Field 1 P2	5.7	3.43	0.172	5.36	374	616	164	58.96	17.28	23.76	Sandy clay loam
Field 1 P3	5.6	2.79	0.140	5.63	405	248	84	68.96	17.28	13.76	Sandy loam
Field 2 P1	5.4	2.74	0.137	12.39	325	652	130	58.96	15.28	25.76	Sandy clay loam
Field 2 P2	5.3	1.93	0.097	6.80	395	656	284	50.24	18	31.76	Sandy clay loam
Field 2 P3	5.5	2.74	0.137	7.46	421	320	117	58.24	20	21.76	Sandy clay loam
Field 3 P1	5.7	3.55	0.177	7.87	314	1.204	196	54.24	26	19.76	Sandy loam
Field 3 P2	5.1	3.19	0.159	10.77	211	556	95	64.24	22	13.76	Sandy loam
Field 3 P3	5.9	3.59	o.180	26.76	539	948	392	42.24	20	37.76	Clay loam

Legend: Site 1→ Red onion field with chemical fertilizer

- **Site 2**→ Red onion field with chemical and organic fertilizer
- **Site 3**→Paddy field with chemical and organic fertilizer
- **Site 4**→Reforested area 10 years ago
- **Site 5**→ Reforested area 20 years ago
- **Field 1:** No conservation system in the plot
- **Field 2:** Conservation system by mechanical measures
- **Field 3:** Conservation system by mechanical measures + vegetation measure
    - P1 – Up slope
    - P2 – Middle slope
    - P3 – Down slope

Table: Values of Calculated F (ANOVA1) for different soil elements F (0.05; 2; 6) = 5.14

	N	P	K	Ca	Mg
Calculated F	5,645	1,325	0,051	0,012	0,46
	sand	**silt**	**clay**	**pH**	**OM**
Calculated F	2,077	5,364	0,723	0,875	5,69

Appendix 7: Guideline for pesticides and general water quality parameters

Ass. professor Orothai, Chiang Mai University

Guideline for pesticides and general water quality parameters		
Parameter	**Value**	**Source**
Mevinphos (PEL-TWA ppm)	0.011	Dr. Orathai (pers. comm.)
Chlorpyrifos (PEL-TWA ppm)	0.050	Dr. Orathai (pers. comm.)
Malathion (PEL-TWA ppm)	0.740	Dr. Orathai (pers. comm.)
Cabofuran (PEL-TWA ppm)	0.011	Dr. Orathai (pers. comm.)
Phosalone (PEL-TWA ppm)	0.050	Dr. Orathai (pers. comm.)
Methomyl (PEL-TWA ppm)	0.375	Dr. Orathai (pers. comm.)
Salinity (‰)	0.500	FAO
DO (mg/l)	2.000	WEPA
N03 (mg/l)	0.250	Dr. Orathai (pers. comm.)
PO4 (mg/l)	0.150	´Umweltsbundesamt` 1997[39]

[39] Hargarth P.M, and Jarvis S.C, 2002

Appendix 8: Water quality index

Animal	Score	Site 1	Site 2	Site 3
Stonefly numphs	10			
Flattened mayfly nymphs	10			
Prong-gilled mayfly nymphs	10			
Spiny crawling mayfly nymphs	10			
Caddisfly larvae with sand/gravel cases	10		**10, 10**	**10, 10**
Caseless caddisfly larvae	10		**10**	
Long-mouthed saucer bugs	10			
Dobsonfly larvae	9			
River prawns	8			
Caddisfly larvae with cases made from leaf	7			
Dragonfly nymphs	6	**6**	**6, 6**	**6, 6**
Damselfly nymphs	6	**6, 6, 6**	**6**	**6**
Freshwater limpets	6			
Swan mussels	6			
Pagoda mussels	6			
Lesser water boatman	5			
Greater water boatman	5			
Other water bugs	5			
Adult beetles	5			
Beetle larvae	5			
Flatworms	5			
Other fly larvae	5			
Common net-spinner larvae	5			
Swimming mayfly nymphs	5			**5**
Square-gilled mayfly nymphs	4			
Freshwater shrimps	4			
Alderfly larvae	4			
Other snails	3	**3**		
Pea cockles	3	**3**		
Water hoglouse	3			
River crabs	3			
Leeches	3			
Rat-tailed maggots	3			
Non-biting maggots	2			
Segmented worm	1			
Total score		**30**	**48**	**43**
Number of animal		**6**	**6**	**6**
Water quality index		**5**	**8**	**7.2**

- Scoring system:
  7.6 - 10 very clean water
  5.1 - 7.5 rather clean to clean water
  2.6 – 5.0 rather dirty to average
  1.0 – 2.5 dirty water to rather dirty
  0 – 1.0 very dirty water to no life

Appendix 9: Pesticides residue samples

The values in red are the concentrations that exceed the threshold limit value.

Residue samples	**Organoposphate**	**ppm**	**Carpamate**	**ppm**	**Guideline note PEL-TWA** Permissible Exposure Limits/*Time-Weighted Average **(ppm)**	**Guideline note TVL-TWA** Threshold Limit Value/*Time-Weighted Average **(ppm)**
1. Before village	*Mevinphos*	0.048			0.011	0.011
	Chlorpyrifos	0.055			0.05	0.05
	Malathion	0.015			1	0.74
			Cabfuran	0,022	0.011	0.011
			Methomyl	trace	0.375	0.375
2. Middle village	*Mevinphos*	0,035			0.011	0.011
	Chlorpyrifos	0.047			0.05	0.05
	Malathion	0.035			1	0.74
			Phosalone	0,015	0.05	0.05
			Methomyl	Trace	0.375	0.375
			Cabofuran	0,033	0.011	0.011
3. After village	*Mevinphos*	0.037			0.011	0.011
	Chlorpyrifos	0.057			0.05	0.05
	Malathion	0,038			1	0.74
			Phosalone	trace	0.05	0.05
			Methomyl	Trace	0.375	0.375
			Cabufuran	0,035	0.011	0.011
4. Paddy rice field	*Mevinphos*	0,007			0.011	0.011
	Chlorpyifos	0,005			0.05	0.05
			Cabofuran	trace	0.011	0.011

*based on an 8-hour time weighted average (TWA) exposure.

Appendix 10: Cash flows

Case study n. 1: Mr Pongpraison

Cash out	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Food	-500	-500	-500	-500	-3000	-500	-500	-500	-500	-500	-500	-500	**-8500**
Health	0	0	0	0	0	0	0	0	-500	-500	0	0	**-1000**
Education	-400	-400	-400	0	0	-400	-400	-400	-400	0	-400	-400	**-3600**
Tranports	-200	-200	-500	-500	-500	-200	-200	-200	-200	-200	-200	-200	**-3300**
House	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-100	**-870**
Agriculture	0	0	0	0	-15000	-15000	0	0	0	0	0	0	**-30000**
Total	**-1170**	**-1170**	**-1470**	**-1070**	**-18570**	**-16170**	**-1170**	**-1170**	**-1670**	**-1270**	**-1170**	**-1200**	**-47270**

Cash in - bad year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Agriculture	0	0	0	0	0	0	0	800	800	800	800	800	**4000**
Livestock	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Labour	0	0	0	0	0	0	0	10000	10000	0	0	0	**20000**
Total	0	0	0	0	0	0	0	10800	10800	800	800	800	**24000**

Net income - bad year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Total	-1170	-1170	-1470	-1070	-18570	-16170	-1170	9630	9130	-470	-370	-400	**-23270**

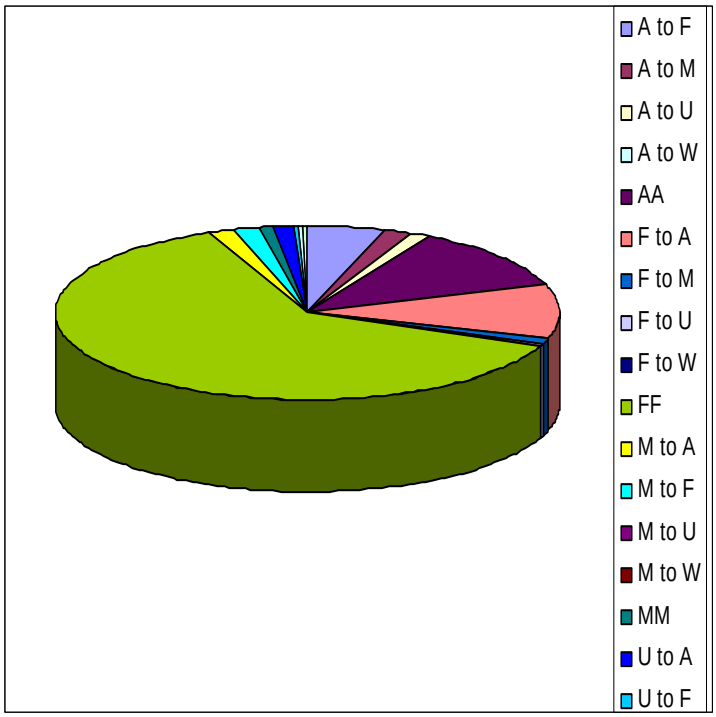
Cash in - good year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Agriculture	0	0	0	0	0	0	0	9000	9000	9000	9000	9000	**45000**
Livestock	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Labour	0	0	0	0	0	0	0	10000	10000	0	0	0	**20000**
Total	0	0	0	0	0	0	0	19000	19000	9000	9000	9000	**65000**

Net income - good year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Total	-1170	-1170	-1470	-1070	-18570	-16170	-1170	17830	17330	7730	7830	7800	**17730**

Appendix 11: Results of Land use Changes from 2000 to 2006

For the analysis two years aerial photos were used 2000 and 2006 respectively.

CHANGE	RAI	PERCENTS
A to F	3571.79	5.13
A to M	1011.08	1.45
A to U	976.09	1.40
A to W	12.70	0.02
AA	8164.41	11.72
F to A	6976.34	10.01
F to M	779.79	1.12
F to U	170.91	0.25
F to W	13.65	0.02
FF	43560.78	62.53
M to A	1058.25	1.52
M to F	1204.24	1.73
M to U	54.22	0.08
M to W	14.18	0.02
MM	562.29	0.81
U to A	903.97	1.30
U to F	214.56	0.31
U to M	256.46	0.37
UU	158.62	0.23
TOTAL	69664.33	100.00

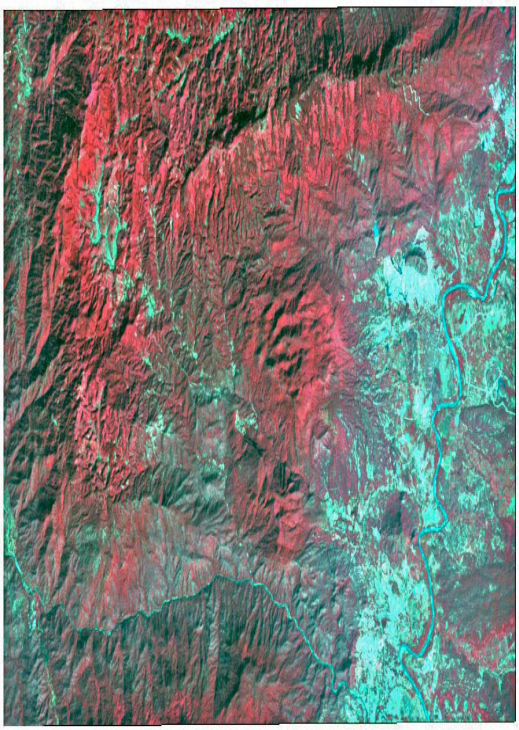


Satellite images analysis

In order to assess vegetation density and greenery area cover spectral measurements was done. Two years satellite images were used Landsat Thematic Mapper (1992, period taken unknown) and Landsat Thematic Mapper February 2006.

The spectral measurements were basically by calculation of reflection in the near-infrared region (NIR) which is associated with inter-cellular space of plants leaves and considerable absorption in the red region (R) of the spectrum of green plants, related to absorption process due to the presence of chlorophyll in plants leaves. Normalized Difference Vegetation Index (NDVI) was used for the analysis in order to measure the greenery cover. The procedure of the analysis:

1. Normalization of images (both years: 1992-2006). e.g. the satellite image 2006, before and after normalization.

 Lansat-TM image of Mae Pae watershed Feb 2006	 NDVI 2006
Before normalization	Normalization

2. Comparison of the normalized images

 NDVI 1992	 NDVI 2006

Calculation of the difference using the formula: NDVI = (NIR-R)/ (NIR+R), (Schiferaw et al., 2005)
 NDVI Difference 1992-2006

The index was out of the normal range and the graph showed discontinuous points (there was peaks), therefore was not possible to calculate the changes. The data were not used in the study.

Appendix 12: Calculations for the simulation of the scenarios based on the case study

The objective is to calculate a 10 year cash flow for a household economy, based on six different possible scenarios changing with the combination of two variables: probability of "good" and "bad" years (as given by Mr.Pongpraison), and the addition of a coping strategy based on flexibility of hours of labour sold (Adaptability 1).

Scenario n.	Probability of "good" and "bad" years	Strategy
1	**Historical**[40]: first 5 years good, second 5 years bad	No adaptability
2	**Historical**: first 5 years good, second 5 years bad	Flexible
3	**50%**: 1 good year followed by 1 bad year	No adaptability
4	**50%**: 1 good year followed by 1 bad year	Flexible
5	**66%-33%**: 2 good years followed by 1 bad year	No adaptability
6	**66%-33%**: 2 good years followed by 1 bad year	Flexible

Note: Since the topics "income" and "debt" are very sensitive, some information is missing and several assumptions have been done.

Assumptions: some of the assumptions are based on information collected and others (deliberate) are decided by the researcher.

- **Annual expenditures for agricultural inputs: 30.000 baht/year** -> based on the case study
- **Other annual expenditures of the household: 17.270 baht/year** -> based on the case study
- **Loan rate of interest: 6%/year ->** based on general information of the credit system in Ban Bon Na given by Mr. Pongraison
- **The loan has to be repaid in 2 years**: -> based on general information of the credit system in Ban Bon Na given by Mr. Pongraison
- **Regarding the addaptation, the farmer increases the amount of work hours only if the previous year his accumulated debt has resulted in a negative budget in the household economy** -> deliberate
- **Total amount of daily work hours possible: 13 hours/day** -> deliberate

[40] Description given by Mr. Pongraison

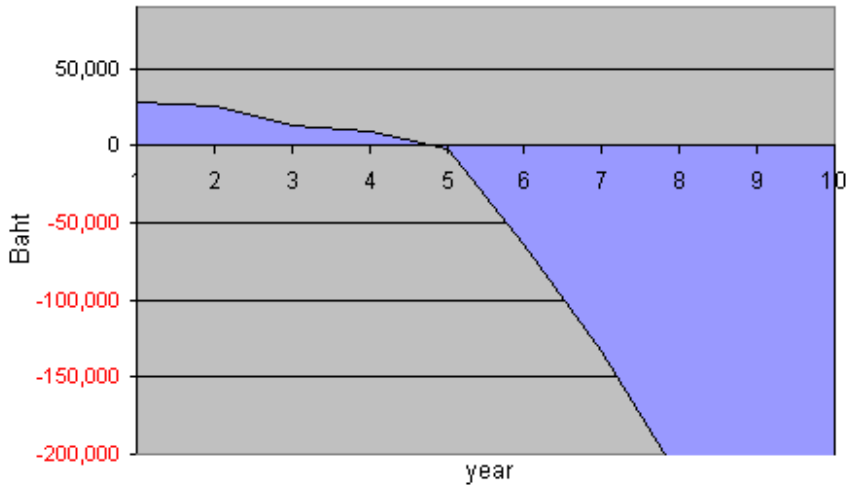
- **Total amount of working days/years: 60 days (20 days/month x 3 months)** -> based on activity calendar
- **Daily salary: 100 baht** -> standard salary for agricultural labour, given by Mr. Pongraison and crossed with national data from National Statistical Office
- **If the farmer has some savings, he will use them first, detracting them to the amount of loan that he will ask to the creditor; if the savings are bigger than the expenditures for agriculture, the loan asked will be 0 and he will also have a positive net budget ->** deliberate
- **At the beginning of the 10 years the farmer starts with a saving of 10.000 baht** -> deliberate
- **The creditor gives a loan only if it's for agricultural inputs and therefore doesn't allow any credit>annual expenditures for agricultural inputs** -> based on general information of the credit system in Ban Bon Na given by Mr. Pongraison
- **The creditor gives a loan only if the previous year the debtor has paid back at least the first part of the loan** -> deliberate

Scenario n.7 and scenario n. 8 with an additional variable regarding the agricultural expenditures (Adaptability 2). In this way scenario 8, with historical probability and adaptation, seem to illustrate the sustainability of the household economy, since the farmer is able to solve the debt situation on time by increasing the hours of worked labour before it becomes too big.

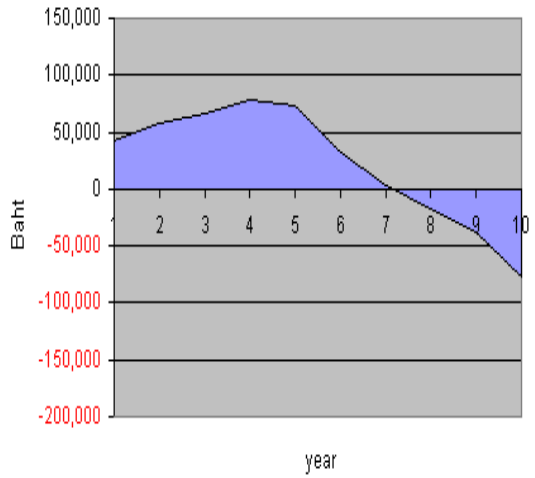
Note: The green cells indicate the fixed values

SCENARIO 1 **HISTORICAL PROBABILITY, NO ADAPTABILITY**

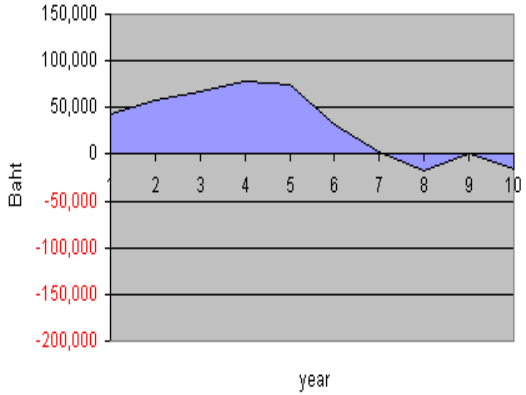
year n	1	2	3	4	5	6	7	8	9	10
Net cash at the beginning of the year	10,000	27,730	25,707	13,328	9,273	-2,415	-63,813	-133,554	-214,957	-301,827
Agricultural expenditures	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Non agricultural expenditures	17,270	17,270	17,270	17,270	17,270	17,270	17,270	17,270	17,270	17,270
Remaining	-37,270	-19,540	-21,563	-33,942	-37,997	-49,685	-111,083	-180,824	-262,227	-349,097
Amount asked for loan	37,270	19,540	21,563	33,942	37,997	49,685	60,000	60,000	60,000	60,000
Interest	2,236	1,172	1,294	2,037	2,280	2,981	3,600	3,600	3,600	3,600
Amount of debt to repay the current year	0	19,753	10,356	11,428	17,989	20,138	26,333	31,800	31,800	31,800
Total amount to repay	0	19,753	30,109	21,785	29,418	38,128	46,471	58,133	63,600	63,600
Value of labour	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Income from cash crops sale	45,000	45,000	45,000	45,000	45,000	4,000	4,000	4,000	4,000	4,000
Net income of the year	65,000	65,000	65,000	65,000	65,000	24,000	24,000	24,000	24,000	24,000
Net cash at the end of the year	**27,730**	**25,707**	**13,328**	**9,273**	**-2,415**	**-63,813**	**-133,554**	**-214,957**	**-301,827**	**-388,697**



SCENARIO



SCENARIO 8



Appendix 13: Time Line from the interviews

Village establishment

1914 10 households in the village

1921 4 people died from smallpox, people moved away from the village

1953 Burmese missionary came to the village

1954 American missionary came to the village

1956 First church was build

1959 Village became Christian

1960 first church was built

1964 The school was built

} from 1960 to 1970: Forest clearing for Opium cultivation

1975 the school was established

1973 The UN programme for Opium culture eradication and introduction of coffee cultivation

1977 Beginning of the Nature reserve

1978 Ending of traditional shifting cultivation system

1984 The Dam was built by the irrigation department

1991 The National Park was established

1991 First road by Royal Project

} First cash crops were introduced to the village

1996 The road was expanded and electricity reaches the village.

2006 Royal project promotes organic fertiliser 8village consultant

Appendix 14: Data collected during the field work

Date	Method	Who	With whom	Topic
6/3	Loose structured interview	All	Headman assistant	- History of the village - Crops produced - Sources of income - Non-farm activities
7/3	Loose-structured interview	Elena, Suzie and Mol	Village consultant	- Farming system and agricultural practices - Impact of National Park establishment - Crops produced and agricultural inputs
7/3	Loose-structured interview	Rosta, Susanne and Khalid	Primary school teacher	- School history - Educational system - Village history
8/3	Direct observation (forest)	Rosta, Tu, Toe, Suzie and Susanne	/	- State of the forest - Evidence of uses and problems
8/3	Semi-structured interview	Khalid	Reverend	- History of village - History of Christianity in the village
8/3	Loose-structured interview	Elena, Suzie and Susanne	Farmer	- Farming system and agricultural practices - Crops produced and agricultural inputs
8/3	Direct observation (Ban Bon Na fields)	Elena, Suzie and Susanne	/	- Field observation
8/3	Semi-structured interviews	Elena	4 farmers	- Agricultural practices in order to identify fields for soil samples
8/3	Transect walk	All	Headman assistant	- Location of fields
9/3	Semi-structured interview	Rosta	TAO Secretary	- TAO role in agriculture/forestry management and current situation and problems - Regulation farming - Partners in agriculture development - Farming system problems
9/3	Semi-	Rosta	Agriculture	- Role of agricultural station

	structured interview		Extension Office	- Problems related to agricultural system - Regulation of agricultural practices - Crops produced in the watershed - Water management - Changes in biodiversity
9/3	Semi-structured interview	Rosta	National Park superintendent	- History of National Park - Impact of National Park establishment - Participatory Forest Management strategies
9/3	Focused transect walk, direct observation	Suzie, Susanne, Elena and Toe	/	- Selection of fields and water sampling sites
9/3	Structured interview	Khalid and Mol	farmer	- Pilot testing of the questionnaire
9/3	PRA focus group	Suzie and Elena	Farmers	- Soil fertility changes
9/3	Questionnaires	Khalid and Mol	Villagers	- General data, income and household economy, forest uses, expectations
10/3	Sampling	Rosta, Susanne and Tu	/	- Water and sediment sampling
10/3	Sampling	Elena, Suzie, Toe,Khalid and Mol	/	- Soil sampling
11/3	Observation	All	Community	- Visit to the church - History of village and Christianity
11/3	PRA social mapping	Rosta and Elena	Children group	- Location of houses, forest, fields - Activities of the adults
11/3	PRA seasonal calendar	Suzie and Mol	Women group	- Temporal distribution of women activities
11/3	PRA seasonal calendar, PRA social mapping, PRA ranking	Khalid and Susanne	Men group	- Temporal distribution of men activities - Location of houses, forest, fields - Importance of sources of income
11/3	Sampling	Mol and Toe	/	- Soil sampling
12/3	Questionnaires	Rosta, Khalid, Mol, Susanne	Villagers	- General data, income and household economy, forest uses, expectations
12/3	PRA focus	Rosta	Forest	- Changes in forest use over the past

	group		conservation group	decades - Different products exploited
12/3	Semi-structured interviews	Suzie and Toe	2 key-informants	- Farming practices - Non-farm sources of income - Soil quality changes
13/3	Loose-structured interview	Rosta and Susanne	Headman assistant	- Household location in the map - Wealth ranking
13/3	Questionnaires	Elena, Khalid, Suzie, Rosta, Toe, Mol	Villagers	- General data, income and household economy, forest uses, expectations
13/3	Semi-structured interviews	Suzie, Khalid and Toe	1 key informant	- Farming practices - Non-farm sources of income - Soil quality changes
13/3	Semi-structured interviews	Susanne and Rosta	1 key informant (former reverend)	- Christianity history in Ban Bon Na
14/3	Semi-structured interviews	Elena and Khalid	3 key informants	- Loans and credit system in Ban Bon Na - Cash flow
14/3	PRA Focus group	Susanne, Rosta and Suzie	Farmers	- Loans - Migration
14/3	Direct observation	Khalid and Toe	/	- Slope measurements
14/3	Semi-structured interview	Susanne and Rosta	1 key informant (elderly man)	- History of the village
14/3	Semi-structured interview	Susanne and Rosta	1 key informant	- Farming practices - Water
14/3	Semi-structured interview	Susanne and Rosta	1 key informant (teacher)	- Migration
15/3	Semi-structured interview	Elena	CARE International representant	- Jompa programme
15/3	Observation	All	Community	- Farewell meeting with community