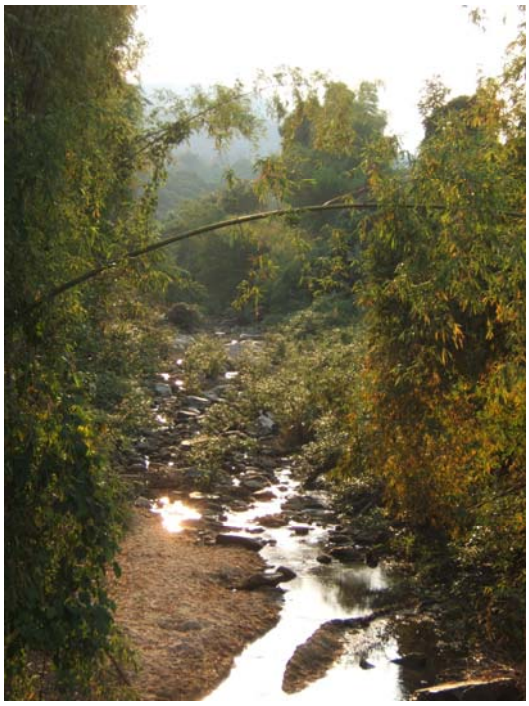
Water Resource Management in Ban Mai Mae Tia Lum Northern Thailand



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Abstract

This study investigates water resource management in the Karen hill tribe village of Mae Tia Lum, Northern Thailand, its role in livelihoods of the villagers, as well as the impact livelihood strategies have on quality and availability of the water resource. An interdisciplinary approach has been adopted, and a number of natural scientific and social scientific methods were employed. The research was conducted in three directions, such as water quality, water quantity, and water management. The results of the study showed how these three dimensions of the water resource affects and are affected by the livelihood strategies of the village. The main findings are that agricultural practices decrease water quality and water availability, which, in turn, cause insecurity of livelihoods. Micro-biotic water pollution, caused by manure and human waste, may be a reason behind incidences of diarrhoea and kidney stone, and thereby may affect villagers' ability to sustain their livelihoods. Insufficient supply of water for irrigation in the dry season is mainly caused by change from subsistence paddy rice production to commercial longan fruit production. Water scarcity and lack of land for further longan expansion have ceased the process of land use intensification a few years ago. Water management appears to be inefficient and unequal. Instances of loss of yield due to water scarcity have been reported.

To summarize the conclusions, there is a moderate level of pollution, dramatic change in access to, and considerable mismanagement of the water resources in Mae Tia Lum.

Recommendations for optimization of the resource utilization have been put forward.

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Index

1. Introduction

1.1. Background Information.

This paper investigates water resource management in the village of Ban Mai Mae Tia Lum (Mae Tia Lum) in Northern Thailand. The village is located in Chom Thong district in Chiang Mai province and situated in the lowlands of Mae Tia Subwatershed, which is a tributary to Mae Klang watershed.

Rich natural resources of the region have created grounds for social and political contest within the communities and between communities and the state. In Northern Thailand, one of the most limiting factors for agricultural production is water (Mingtipol et al 2004). Supply of water for agricultural consumption is not always sufficient to satisfy the demand and literature review on the hydrology of Northern Thailand discusses supply, demand and distribution of water resources. Several factors are mentioned as possible reasons for lack of water such as deforestation, agricultural intensification, changes in rainfall, the mechanisms of distribution and consumption (Walker 2003) and management of the resource (Ravnborg 2004).
In our research we take these indicators as a point of departure.

1.2. Description of the study area

Mae Tia Lum is situated on the hills along the Mae Tia and Mae Tae rivers. The village consists of two parts: upper and lower village with a total of 110 households. The village's agricultural area is spread around the village with its paddy fields mostly downstream in the eastern end and the longan orchards mostly upstream in the western end. The entire village and most of its fields are in agricultural zone, with some fields in the conservation zone where forest was slashed and burned and replanted with longan. In the south-west the fields border the Ob Luang National Park. Since the village and its fields are located outside the National Park, it has no significant influence on the villagers' livelihoods. The village's agricultural fields are provided with four irrigation canals and a reservoir. The reservoir is on Mae Tae River and it is a source of water in the 4th irrigation canal. The other three canals come from Mae Tia River.

The villagers belong to the Karen hill-tribe, which is the largest among the hill tribes of Thailand. Their main occupation is farming with production of upland paddy rice for subsistence and of longan fruit for sale as well as labour in the fields.

The Karen traditionally practiced animism; however, certain groups have adopted the state's main religion – Buddhism, as it is the case in Mae Tia Lum. Nevertheless, strong influence of the traditional belief can be observed in the customs of the villagers.

1.3. Problem Statement and Objectives

The research interest has been stimulated by the increasing tensions over the access to water resources between communities. There are claims that so-called outsiders use too much water for their fruit orchards in the village while the upstream villages are blamed for deforestation, which causes fall of water flow. Local villagers seem to experience pressure in terms of insufficient supply or poor quality of water. The exact cause of the tension remains unclear and constitutes the overall research question:

How do water resources affect and are affected by livelihood strategies in Mae Tia Lum?

In order to answer the main question we set the following objectives:

1) to study ***how water quality affects livelihood strategies***

Understanding of the villagers' livelihood strategies can explain how, where and what they use water resources for and their perception as to the level of quality and supply.

Knowledge of the quality of water especially drinking water and how it affects or is affected by agricultural and household consumption can lead to understanding of the causes behind pollution and insufficient supply of clean water.

Research methods: water quality analysis, group interview and baseline survey.

2) to study ***how livelihood strategies affect water quantity***

Knowledge of the cultivated crops and applied production systems can help to draw a pattern of water consumption for irrigation and assess sustainability of the consumption. Examination of the

irrigation practices will help us to assess water demand and supply for agricultural consumption. Research methods: transect walk, GPS mapping, group interview, baseline survey, in-depth interview and water flow measurement.

3) to study ***how livelihood strategies affect and are affected by the water management***

Understanding of formal and informal institutions of land and water management in the village can shed light on the issue of water resource distribution.

Investigation of the relations between the villagers and other communities, or outsiders, sharing the same water resources, can give a perspective on the factors determining demand for, supply and quality of water.

Research methods: group interview, transect walk, in-depth interviews and baseline survey.

2. Methodology

This chapter introduces the research methods applied in the field. Application of every method is described and it is given justification. The conclusive section discusses general problems generating inconsistency of our data.

2.1. Transect walk

The first thing we did arriving in the village was a transect walk, where we walked through the study site. Our intentions were to get an overview of the village's water supply and fields and be able to identify, discuss, and register the problems and opportunities of the village (Chambers 1997:117) in relation to land use and water resource management.

We intended to carry out the transect walk with the headman of the village, and it should take form as an informal interview at the same time. But since the headman did not have time to show us the entire village, the local T.A.O. officer took over in the same afternoon and showed us the rest of the village. The headman and later the T.A.O. officer drew a map of the village which aim was to get an overview of the land use and the irrigation canals in the village (for the map, see appendix 1).

2.2 Village meetings

During our stay in the village we arranged two village meetings for different purposes.

The first village meeting was called for by the headman over the speakers on the first day of the field work. The purpose of the meeting was to introduce ourselves to the villagers, and after that to let them draw a map of the households and fields in the village in order for us to get an overview of the village.

Twelve persons, among them eleven men and one woman, participated in the meeting. Only one person was from the lower village, while the rest came from the upper village (where the headman comes from as well). Approximately half of the participants were actually involved in the drawing and discussion of the map, while the others were sitting away from it in smaller groups conversing with each other. Keeping everybody's attention at drawing the map posed a challenge. Every respondent was asked to mark his/her household and fields on the map, and as soon as they had done that they withdrew to smaller groups. In order to gain control over the disformed meeting a

few members of the research group moved to “subgroups” and carried out informal conversations with them, while others continued to work on the map. This solution allowed every respondent to communicate with the research team.

The second village meeting took place the day before the end of the field work. It was called for in order to inform the villagers on what we had done in the village during the nine days stay. At the same time villagers were given an opportunity to ask the research team any questions. Villagers expressed great interest both in the research matters and in the lives of the student researchers.
Twelve villagers turned up to this meeting.

2.3 Baseline survey

The questionnaire for the baseline survey was made after the first three days in the field on basis of observations made during the water sampling, transect walk, village meeting and informal conversations.

The objective of the baseline study was to gather overall information of the households in connection to our three objectives of water quality, water quantity, and water management assessment. This information helped to shape the following group interviews and key informant interviews.

Our initial plan was to take 50% sample of the 110 households in the village, but due to time constraints only 20 households were chosen. According to Neuman (2000), large sampling ratios around 30% are required for small population (less than 1000) in order to get an accurate sample (Neuman 2000:217). Our sample consists of 18% of the households, but our purpose is not to show accurate statistics about the village, the intention is rather to determine tendencies in the village, for what our sample ratio is sufficient.

The respondents were chosen by stratified selection (inspiration from Fisker et al. 1995 & Neuman 2000), and are grouped into four categories according to size of land ownership: 1) those who own no land; 2) those who own less than two rai of land; 3) those who own from two to five rai of land; and 4) those who own more than five rai of land. Size of farmland can be an indication of wealth, thereby representing a certain livelihood, and consequently of a certain water use pattern. Therefore

we chose our categorization in order to find correlations between size of land ownership and water use; however, the baseline survey did not show any direct correlation. Villagers with no land were included in the baseline study in order to cover the entire diversity of the livelihoods in the village.

By the stratified selection five households were chosen for in each sample category. The number of households in each group does not reflect the variation of farmland size in the village; there could be more of one category and less of another. However, we draw conclusions on the livelihoods of the village from the baseline study, since the farmland size can be an indication of wealth, and thereby can show differences in livelihoods.

Headman was asked to choose respondents for each category. Even though such selection strategy implies high risk of getting biased responses, it appeared to be the most feasible in the given circumstances of limited time. Nevertheless, some of the selected respondents never became available; therefore four households were randomly selected by the team.

The actual conduction of the questionnaires took all days in the village. The farmers were in the fields or at work during the day, and therefore it was possible to reach them only in the morning or in the evening. At the same time it was agreed, that a student from each country represented in the team (Thailand and Denmark) should be present when conducting the questionnaires in order to make sure that we all got the same information. Anyhow, the baseline study served its purpose of structuring group interviews and the key informant interviews only partially since collection of questionnaires went on until the end of our stay in the village. The key informant and group interviews were based on the questionnaire interview data collected by the date.
For Questionnaire see appendix 2.

2.4 Group Interview

Three group interviews were carried out in the village: one with members of different Water User Committees (WUC), one with farmers of the village and one with women. Since group interview participants often “have an overlapping spread of knowledge which covers a wider field than that of any single person” (Chamber 1997:148) we chose this kind of interview in order to get as wide a field of information and experience as possible. The main objectives were to cross check already

obtained data, get in-depth knowledge on specific issues, and open doors to issues that were not explained deeply in the questionnaire.

WUC

The interview with members of different Water User Committees was conducted on the sixth day of our stay in the village, and the main purpose of the interview was to get information on the water management system, regulations, and structure of the water committee. Five water committees' representatives, selected since they were the persons responsible for the irrigation and water management in Mae Tia Lum, participated in the interview.

Farmers

The farmer group interview was conducted on the seventh day of the field work. We had been told that there had been major changes in land use in Mae Tia Lum. Therefore the main objective of the interview was to understand these changes in land use in the village and in correlation to this find out how supply of water had changed in the same perspective of time. To enable and encourage all of the persons to share their experiences and information with us, we used PRA instruments in this interview by making a historical timeline (Mikkelsen 1995).

Headman had, over the speakers in the village, invited farmers to join the group interview, where after five farmers (four men and one woman) turned up. During the interview one person was dominating the process of timeline drawing, but he involved the other farmers in the discussion in order to crosscheck his own knowledge.
For timeline see appendix 3.

Women

The women group interview was conducted on the same evening as the farmers' interview. A few persons had, in the questionnaires, indicated that they have had health problems caused by bad water quality. So the main purpose of this interview was to obtain knowledge on changes in the history of quality of drinking water and try to link it to agriculture in the area. To get as much information as possible, we also made a historical timeline in this group interview.

Like the farmers interview, the womens' group interview was announced over the speakers in the village by the headman, where after six women turned up. The group discussion was led by one person while other women were involved in the discussion the timeline to various degrees.
For timeline see appendix 4.

2.5 Key informant interview

We have done a number of in-depth interviews with key informants about the village. The purpose of these key informant interviews was to get knowledge on specific issues concerning water and management of water in the village.

The key informant interviews were conducted from our 6th day in the field. At this point of the field work we had gathered enough information to be able to know which sort of in-depth knowledge we needed from the different respondents.

We have had interviews with the water headman from the lower village and the water headman assistant in upper village. The objectives of the interviews was to cross check already obtained knowledge and get more information about the management of the canals and the land use changes in the village. The water headman from the lower village also made a historical map of the changes in land use around canal 4 which he controlled.

The water headman assistant was not very informative and he could or would not answer several of the questions. The main problem of this interview was also that the T.A.O. officer was present at the interview, and the respondent discussed the answers with him. This could be a reason why he was not very informative.

We also did an interview with the T.A.O. office. We had different information on T.A.O.s' role in the water management and therefore the objective of the interview was to get information on the role of T.A.O. in management of water resources in the village. The interview was carried out with the other research groups and there was limited time, so the respondent gave rather formal answers.

An in depth interview with Tanid Japar who is responsible for the water distribution section in the Royal Irrigation Department (R.I.D.) in Chiang Mai was carried out. This was done in order to supplement the T.A.O. and WUC group interview and get a point of view of the irrigation management from a higher level in the governmental system.

Our interview with the outsiders was carried out in the last 2 days of our research. From the introduction sheet given to us before we went to Thailand there was an indication that there was dissatisfaction with the management of the water concerning outsiders' use of water. During our field work we did not find any clear evidence on this matter, but we still wanted to cross check it. Therefore we did in depth interview with 3 outsiders in order to get information about their access to water from the irrigation canals and to compare this data with the data obtained from the villagers to see if there was any inconsistence. In general the respondents gave limited information and were not interested in discussions on water use, and we could therefore not use the information to conclude on conflicts between villagers and outsiders.

Due to limited time we only conducted one in depth interview with a farmer, and this was the last day. The in-depth interview with the farmer in the village was in order to get information about conflicts concerning water in the village. On basis of the interview with the outsiders and information gathered through the questionnaires and group interviews we wanted to look more into conflicts concerning access to water. This is a very sensitive issue, and it was difficult to get any information about this issue from the farmer.

2.6 Observations

Participant observations were an inseparable part of the field work, e.g. walking in the village or in the fields as well as driving a vehicle around the area with the purpose of getting visually acquainted with the area and its characteristics.
For instance data on the infrastructure of the irrigation system and on the cultivated crops was, among other methods, gathered by observation. Observation of the villagers in their homes and gardens performing their daily duties, observation of their facilities and lifestyle contributed to the general understanding of the research area. Participant observation was combined with different

methods. It supplemented the data from respondents by the researchers' interpretation of the context and interaction of the respondents with each other and with the interviewers.

2.7 Informal conversational interview

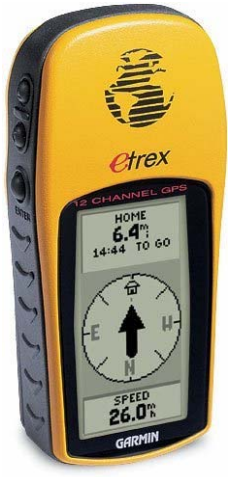
Informal conversations have played a big role in our field study, by getting to know the village and getting an insight into the lives of the villagers. The first three days in the village, we spent most time observing and conducting informal conversational interviews with the villagers, especially during the New Year celebration.

The strength of the conversational interview is its informal setting and openness to many issues that may emerge. Its limitations are that (1) many irrelevant issues maybe brought up by a respondent, and that (2) the data collected may not be comparable with the data from another interview (Carsley & Kumar 1988:11-12).

In informal conversational interviews there are no predetermined questions (Mikkelsen 1995;102), and we asked the questions that emerged in the situation of the conversation. We had a natural interest in the water resources and livelihoods of the village and the information gathered helped us in the construction of the questionnaire since we had an idea of issues that concern the villagers and an understanding of their livelihoods.

2.8 GPS methodology

A map of the canals and other relevant infrastructures from the irrigation system was drawn in order to get an overview of the complicated irrigation Network in Mae Tia Lum township.



Coordinates and elevation were written down every certain distance while walking along the canals and the recorded waypoints are the ones we considered necessary in order to plot the map. At the same time, complete observation of the canals state was done. We looked for cracks, stones or plants in the canal hindering the water flow, not-working gates and concrete status. Land use on both sides of the canal was also written down.

We used three e-Trex Gps devices from Garmin ltd.

Because of the low accuracy of the equipment we have to be critical with the data we gathered. In the best cases an accuracy of 10 m was achievable but for points under a dense tree cover the accuracy decreased to 15 - 20m. In order to obtain as precise data as possible most of the coordinates were taken with two or three GPS devices at the same time and an average value was calculated.

The irrigation system network map has been overlaid with a digital map of the area showing the most significant terrain unevenness as well as roads and houses. We did it with Arcview.

2.9 Water flow measurements

In order to get an overview of availability of water and its use for agriculture, water flow in Mae Tia and Mae Tae rivers in village inlet and outlet section, canals' inlet points as well as in other relevant sections of the irrigation infrastructure was measured.

Two parameters have to be known to be able to estimate the flow: Water speed and cross section. The equation that relates the three values is:

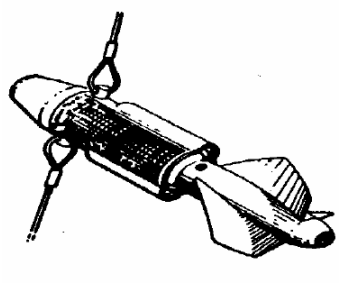
$$Q(\frac{m^3}{s}) = v(\frac{m}{s}) \cdot A(m^2)$$

$$Q = Flow \quad ; \quad v = velocity \quad ; \quad A = area$$

Area of the cross section has been measured using a tape measure. For canals, water height and width are enough to estimate the cross section. To simplify the calculations water velocity in canals can be supposed to be uniform in a given section (Losada 2000).

Since rivers do not have a rectangular section, calculations become less precise. Water velocity is not uniform in a non rectangular section. In order to minimize the error we have repeated the measurement three times for every section or segment but we are aware that there may be some imprecise results.

Since we had limited time on the field and some measurements were taken in distant locations we could not repeat them another day in order to observe changes in the flow.



Water velocity was measured using a General Oceanics Inc. 2030 R series flowmeter with a standard speed rotor attached (see figure). Using a constant, given by the manufacturer, number of rotor revolutions can be converted in water velocity. Most accuracy is obtained for medium and high speed flows whereas for low speed measurements implementation of a low speed rotor is recommended (General Oceanics 2003). Since we did not have this rotor some measurements may be imprecise.

After a few days on the field, the flowmeters were broken, so we had to use another method to measure speed in the last three canals. We placed a floating item in the water stream and measured the time it took to cover a certain distance. This process was repeated three times to increase accuracy. Theoretically the longer the distance and the more uniform section along this stretch, the more accurate the speed estimation. In canal 2 and 3 it was impossible to find long and uniform stretches, for that reason results in these canals may be inaccurate.

2.10 Water quality analysis

The aim of analyzing the water is to support and compare the information we got from the villagers about their perception of drinking water quality, the effects it has on their livelihoods, and also to evaluate how the agricultural and household practices affect the water quality.

On-field and laboratory tests were carried out for three drinking water sources (village well, village tank and rain tank) and in the inlet (Mae Tia and Mae Tae rivers) and outlet point (Mae Tia) of the village. Trying to compare water quality in Mae Tia Lum and in other villages upstream, samples from Mae Tia River were taken in other villages and subsequently analyzed in the laboratory. Since on-field test is a time consuming process and results of poorer quality usually have to be expected than in the lab test, we decided to skip it for the upstream water samples.

In the lab tests we analyzed suspended solids (SS), total solids (TS), total dissolved solids (TDS) and alkalinity in order to evaluate the risk of suffering from kidney stones. Further analyses were carried out to find out the level of coliforms, dissolved oxygen and BOD. Results of these parameters will help us to evaluate possible organic pollution and microbiotic life present in the water. Levels of nitrates, ammonia and phosphate were analyzed to estimate pollution caused by fertilizers. Coliforms and dissolved oxygen tests were also conducted on-field.

Analyzes on coliforms were carried out to estimate waste water pollution and presence of harmful bacteria in the water resources. Coliforms are not necessarily harmful to humans but are used as indicators for pathogens which can present a threat to human health by causing a variety of serious diseases including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses (Manahan 1991).

When comparing the two applied methods, on-field and laboratory test, results vary more than expected therefore it is clear that some mistakes have been done. Some factors affect the Dissolved Oxygen content in the water of which temperature and agitation are the most relevant ones. On field and lab test were carried out at different temperature and agitation state, and these facts can explain the different results. Since samples were stored a few days before they were analyzed in the lab, micro organisms could have consumed the dissolved oxygen. Anyway difference between results seems to be very big, therefore we assume that further mistakes could have been done.
The lab test was performed by Thai colleagues in the university labs while we had to continue the field work in the village. We gave priority to the field work in favour of the lab test so we were not there when the test was carried out.

Regarding the coliform analysis, other parameters have influenced our results. When doing the on-field test we already realised that the working conditions were going to affect our results. Even though we boiled the equipment before using it and looked for a clean environment, we did not succeed in carrying out the test in as sterile conditions as desired.

When analyzing our results we will consider the values from the laboratory as more valid because they were obtained in a cleaner environment with better equipment and without time constraints.

2.11 Inconsistency of data

While describing each of the methods applied in the field we also discussed some of the problems that occurred to us when conducting the methods. In this section we will discuss some of the more general problems that brought inconsistency to our data collection.

Interpretation

The communication in the field between Thai and Danish students and Danish students and local villagers was done with help from one interpreter. Translation makes interviews take a long time and we sometimes found respondents being bored and on few occasions they left before the interview was over. In group interviews the translation of a group discussion can never be complete, but always only a summary. This can leave out information that, at the time of discussion, might not seem important, but eventually could be relevant. These facts along with doubts on the right translation on specific technical terms can cause distortion of data. However, it is difficult to take these things into account since we might not know if any important information have been left out or translation have not been correct.

Selection of respondents

Most of our respondents in the baseline survey were chosen by the headman and several of our key informant interviews and the WUC group interview respondents were chosen because of their position in the village. This fact can affect the conclusions we want to draw from these interviews.
The headman's selection of respondents can be based in an interest of giving a good impression of the village and not show his village as a village of conflicts. The same interest can be the case for the WUC group and some of the key informants. When we invited farmers to a group interview the subjects of discussion were very different from other interviews. These persons were not selected by anyone but showed up on their own initiative. This resulted in different conclusions on the reasons for shortage of water in the village. It is not necessarily reason to exclude any informants from our conclusions in this report but we will be aware of the source of which we are drawing our conclusions on and will be discussing the different conclusions.

3. Introduction to the village

The aim of this chapter is to put forward some results and information we gathered during and before the field work, which may be essential for the further understanding of the discussion and conclusion. It will also answer many questions about the context in which our study was carried out.

3.1 Farming systems and livelihoods

There are two main farming systems applied in the village: subsistence paddy rice agriculture and intensive longan fruit production for commercial purposes (see picture below). Outside the rice season soy bean, chilli pepper and other vegetables are grown in the paddy fields.

Traditionally the villagers had subsistence farming with small fruit orchards and rice fields. They were practicing shifting cultivation where the production took place according to the natural cycle of rice and grew only during rainy season when the water necessary for rice cultivation was abundant (farmer group). Previously the water level in the rivers was much higher all year round than today, according to informal conversations with villagers. The water was used for rice irrigation only in the rainy season.

Around 1985 the first longan orchards were introduced in Mae Tia Lum. The area expanded to 310 rai until 2001 and is occupying more than half of the agricultural area in the village. This was partly motivated by outsiders' interest in buying land for longan production and the need for the villagers to get money to pay back the loans taken for investing in longan. Along with increase in supply of longan to the market the prices has fallen from around 120 Baht pr kg in 1985 to 15 Baht pr kg today (farmers group). Even though there is a price guarantee from the state owned Bank for Agricultural and Agricultural Cooperatives on 15 Baht/kg (BAAC) the villagers go through middlemen where they can get cash despite of the fact that the middlemen does not pay as much as the BAAC (farmers group). Despite the bad business villagers do not intend to sell their orchards. In the election campaign of February 2005 they have been promised better price guarantees for their products by all parties and they want to wait and see if the politicians keep their promise (farmers group).

Since introduction and expansion of longan, villagers had to give up shifting rice cultivation and grow their rice more intensively in the same plots. At the same time the villagers have changed from subsistence farming to commercial farming with the introduction of cash fruits. These changes in production system have lead to reliance on agrochemicals for both longan and rice cultivation since intensive use of fields degrades soil fertility. Livelihoods of the villagers have changed substantially during the last decades and they have become very reliant on the output of crops. Most of the farmers in the baseline survey (18 out of 20) either grow longan and/or work as labour in the longan fields. The investment in longan is expensive since the longan does not give any output until after 5-6 years and the farmers therefore have to rely on income from other sources (farmer group, transect walk). Villagers added longan production into their livelihood strategies in order to increase their income and improve their lives. However, dependency on the market has made their livelihood more insecure than if they cultivated traditional subsistence crops.

3.2 Household and Drinking Water Sources

There are three sources of drinking water: village well, village tank and rain tanks.

The village well (see picture) is a traditional source and used to supply the village with water throughout the year (woman group). According to our baseline study it is the main source of drinking water in the rainy season. During the dry season it is the least used resource of drinking water due to very low water table in this period (chart 1). The quality of the water from this source is questioned by some villagers, but in general it is considered fairly good (baseline study). The main disadvantage of this resource is its distant location from the village homes. Although it stands in the middle of the village, it is a hard physical work to carry water from the well.

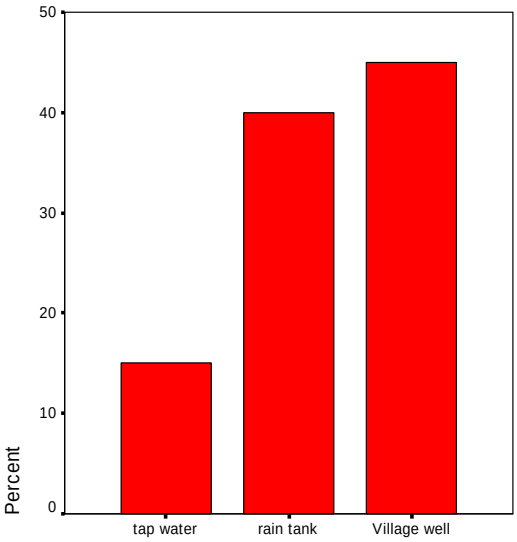
There is a village water tank providing tap water for every household, which is filled with water from upstream. The feeding pipe is connected about 300-400 meters above the first dam, however, it is unclear whether the water is taken from the river itself or from a mountain spring. There is contesting data: villagers claim that the water in the tap comes from a mountain spring; while a

T.A.O. officer from the lower village, who is in charge of the drinking water in Mae Tia Lum, claims that the water comes from the main stream. Due to time constraints the source has not been cross checked by direct observation.

Introduction of the tap water system in 2002 was a significant change in the livelihoods of the village. Convenience of supply determined the preference for the river as the source in the dry season, when rain water is not available and when the water table in the well is very low.
Even though villagers question the quality of the tap water, and consider well water and rain water to be cleaner, the tap is the main source of their drinking water in the dry season (chart 2).
The village tank was meant not only to provide steady supply of household and drinking water, but also to treat the water from particle pollution, such as suspended solids, solid organic matter, etc. However, a year after the installation of the tank, its filter at the inlet was destroyed by the water pressure. Thus tap water is supplied to the village untreated (women group).
Some villagers use two filtering devices at the tap: a sponge filter (introduced in 2004) and a sand filter. A sponge is attached to a tap, and a sand filter is a concrete container with layers of stone, rough sand and fine sand (Women group and observation).

The third source of drinking water is rain. In 1995 The Ministry of Public Health introduced a campaign for rain water tanks (see picture) to provide an alternative source of drinking water in the rainy season, when the water from the river has a high content of suspended solids and solid organic matter. The rain water is collected by connecting a pipe from the roof into the tank. Usually the water is collected after the rain has cleaned the roof in the beginning of the rainy season. Villagers consider rain water to be the cleanest.

No observation or record of boiling drinking water has been collected, but we observed villagers drinking water straight from the tap. This fact was backed up by one villager, but it does not necessarily mean that everybody does it.



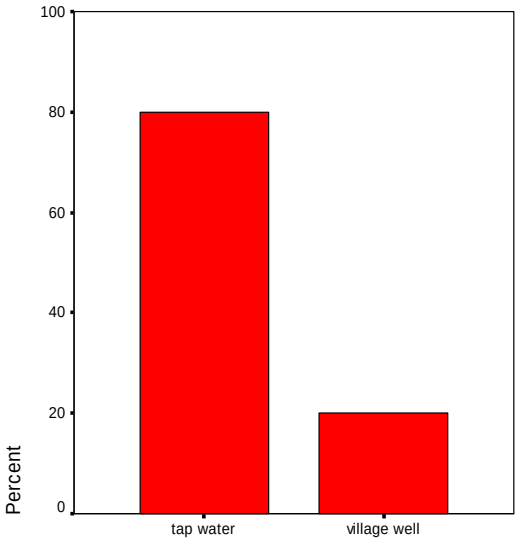
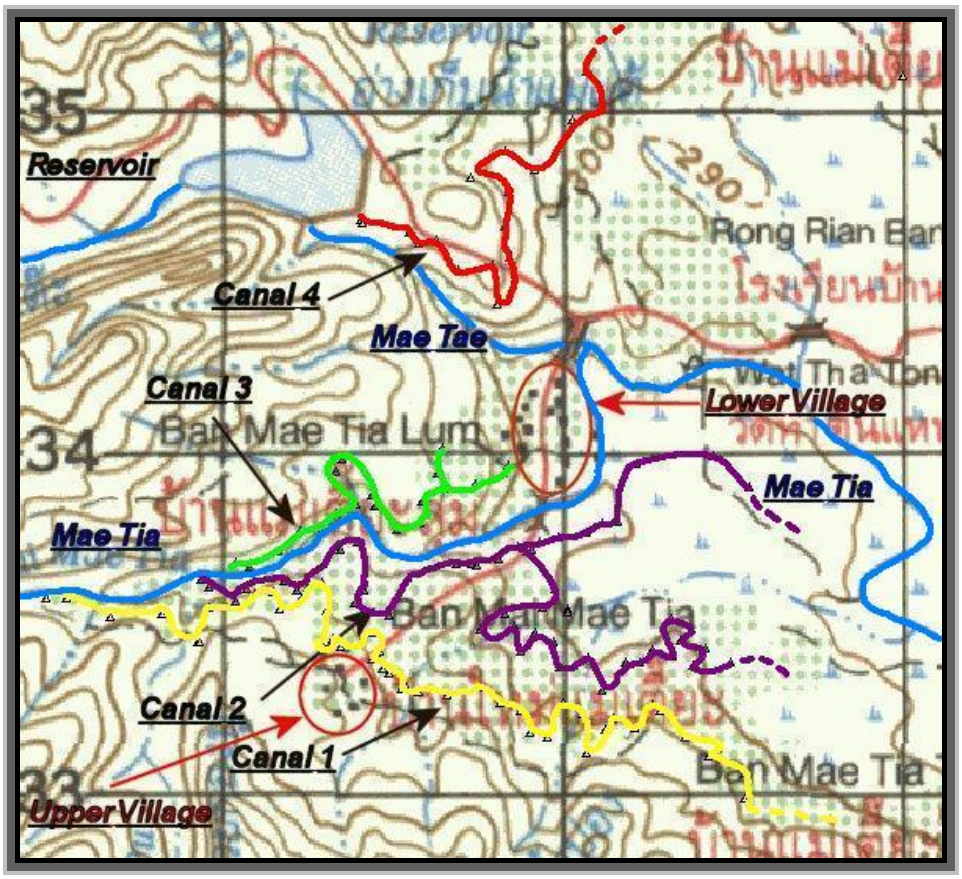


Chart 1: Drinking water sources, rainy season (Baseline survey) *Chart 2: Drinking water sources, dry season (Baseline survey).*

3.3 Irrigation infrastructures

The map below shows the irrigation infrastructures of Mae Tia Lum, the rivers and the village.



There are three small dams in Mae Tia River; one at the inlet point of every canal. The upper dam was built by the irrigation department and is the newest one. The dam as well as the canal that starts just nearby the upper dam (canal 1), are concrete made; although some canal stretches are just a furrow. The canal supply water for ten villages (3560 families) and is 16 km long. In Mae Tia Lum water of this canal is mainly used for longan orchards and only some paddy fields. The state of the concrete in this canal seems to be very good, there are no cracks or drips and the observed gates are working properly.

Canal 2 splits up into two sub canals before it reaches the lower village: Canal 2-1 and 2-2. It starts downstream from canal 1 and has been built in a more primitive way. Besides Mae Tia Lum more villages are supposed to use the channelled water. However, the observed flow was barely visible at the point where the sub canals left Mae Tia Lum township. The dam nearby the inlet has been made from stones and concrete and it looks weaker than the first one. The canal is just a furrow on the ground and therefore water drips and leaks are more common than in canal 1. Percolation may have an influence in water flow as well.

Villagers claim that canal 3 is owned and used by the former headman and his relatives. However it is unclear whether it is his private property and what his legal rights for construction and exploitation are. He claims that there are 50 farms using the irrigation canal and he is the manager of the canal. The inlet of canal 3 is few meters downstream from the dam by canal 2. There is a bifurcation at the end of the canal and canal 3-1 leads to paddy rice fields and canal 3-2 leads to longan orchards. The dam at the inlet to the canal is made of concrete and stones. The canal has no concrete stretches and there are some leaks.

The reservoir was build by the irrigation department and the aim is to store water during the rainy season and use it in the dry season. Another characteristic and, perhaps, a problem of the reservoir is that the sediment brought by the river stays in the reservoir and gradually fills it up, thereby decreasing its holding capacity (Water headman in lower village and WUC). The villagers, advised by the Ping river watershed committee, are constructing check dams along the river stream above the reservoir to hold back the sediments before they reach the reservoir.

Interestingly, even though the measured flow at inlet was higher than at outlet, the water table of the reservoir fell (observed difference between first and last day). We assume that a mistake could have been done when measuring the flow but are also aware of the fact that there is a percolation rate and high evaporation due to the high temperatures. These facts could explain the figures, which do not seem to make sense.

Canal 4 is leading water from the reservoir to the orchards in Mae Tia Lum and other villages nearby. It is concrete made and some stretches are just a furrow in the ground. The present condition of the canal is quite good. Leaks are rare and gates leading to private irrigation canals are working properly. Outside Mae Tia Lum township there was no more water in the canal. Percolation may be a problem in the non concrete made stretches.

	Mae Tia inlet	Mae Tae inlet	Mae Tia outlet	Canal 1	Canal 2	Canal 3	Canal 4
Water flow (m^3/s)	0,2313	0,0359	0,0918	0,0994	0,094	0,0236	0,02

Table 1: Water flow measurements in the rivers and canals

Some farmers make ponds by their fields in order to store water to ensure the supply when the resource is not available. Most of the ponds are found in the lowland of Mae Tia Lum which indicates that the farmers in the lowland have not got guarantee for constant supply.

3.4 Irrigation practices

There are different irrigation practices in Mae Tia Lum depending on terrain, crop and economic resources. In this section we will describe these irrigation practices along with an explanation on their efficiency.

Villagers who are growing rice use a terracing or contouring system where water flows down the hillside and is channelled to each plot. We observed that most of the paddy fields are rain fed; however, some farmers use water from canals.

Farmers who have longan orchards in the hilly terrains of the upper village usually water their trees with a system similar to the terracing for the rice. Water is conducted or pumped to the highest spot

of the orchard, from where it flows downhill filling the individual basin of every tree (see picture on the left) and continuing to the lower ones. The remaining water ends in another canal or in the river. The needed investment is very low because the orchards are usually placed below the canal level and therefore no pump is needed. The hilly areas are located at the head of the canals, which means that these farmers are the first ones to get water. The main disadvantage is that run off erodes the soil (Bjorneberg and Sojka 2002) and a lot of water is wasted by this run off.

Another irrigation practice applied in Mae Tia Lum is basin irrigation. Water is pumped from a canal through a mainline with many hydrants. The farmer connects a hose to a hydrant and fills the basins around it and afterwards he moves on to the next hydrant and so on. The pipes are PVC made and this system is used in hilly areas as well as in lowland. Depending on heat, wind, and soil permeability, much water may be lost before it can benefit the plants (Losada 2001) but on the other hand it is less likely to cause soil erosion.

In a few orchards we observed farmers watering the longan trees with mini sprinklers placed by the trunk. This irrigation system requires a higher investment but it provides water in a more uniform way. This leads to an efficiency increase in the water use because percolation is reduced but much water can be lost when there is strong winds or because evaporation (Losada 2001). The main drawback is that the investment is higher because the equipment is more expensive.

3.5 Water committee organization

In order to simplify the water management, the Ping River watershed has been divided in upper and lower watershed. In each of them members from R.I.D., the province administration, the Tambon offices and the watershed committee are represented. The watershed committee has 50% of the power and the other three institutions together have the other 50% (informal conversation with Dr. Sidtinat, CMU).

The next level is the subwatershed or network committees. There is one of these committees for every tributary from Ping River and the aim of the committee is to agree upon the water that the

different water users committees can consume in order to ensure the water supply for lowland farmers (Dr. Sidtinat, CMU).

The last level in the water management process is the water user committee. There are no common rules or norms for the water users committees; each committee sets up its own regulations and the only requirement is that these rules have to be approved by the R.I.D. The committee has to agree upon the committee organization and member duties, the irrigation shifts and order of priority, price of the water, what the money is used for and sanctions for offenders (R.I.D. interview).

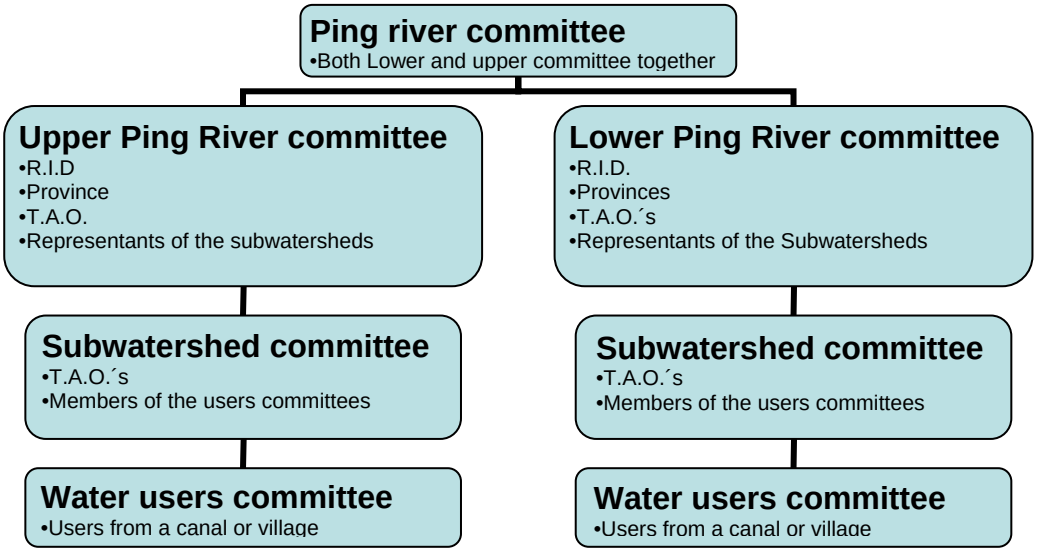


Figure 1. Organizational chart of water management and who is represented in each level.

Water users committees in Mae Tia Lum

Three committees are managing the water in Mae Tia Lum: two for canals number one and two in Mae Tia River and the third one for the canal number four starting in Mae Tae reservoir. The third canal has no committee.

The water headman and assistants are elected by the users every fourth year (WUC). Every member can become headman but according to WUC it is not a desired position because it means extra work and is usually bad paid. However the WUC acknowledge that it gives an advantageous position.

Prizing, available time for irrigation, fees and other regulations are different for every committee. They only agree upon what to use the money for, namely 70% for committee wage and 30% for maintenance. None of the interviewed headmen had any records about water use by the different farmers but according to R.I.D. no law or rule says that they should have it. R.I.D. also organize workshops for farmers where they are taught how to save and use water for irrigation, but none of the farmers we were speaking to mentioned these workshops.

4. Discussion

This chapter discusses our empirical findings of the project. The discussion is divided into three main sections, one for each of the main themes in our objectives: water quality, quantity and management. This discussion then leads to a conclusion of the report.

4.1 Water quality

Prior to the field work there were no indications of the problems related to water quality. Nevertheless, this aspect of the water resource was included into our investigation as a factor crucial for assessment of resource availability. Besides, agricultural intensification in the region could have brought along certain chemical pollution.

The baseline study has brought up an indication of health problems, which could be related to water quality. However, the indication of health problems was of low occurrence and of no explicit linking to water by the villagers. Two respondents reported occurrence of diarrhoea and linked it to food poisoning. The baseline study did not show any obvious quality problems. Villagers were generally satisfied with water quality but some of them reported that they did not have alternatives.

Women group interview and informal conversations produced data different from the baseline study. Kidney stones and diarrhoea are the most common diseases among the villagers and they acknowledged that water was a cause of their diseases.

Diarrhoea

In order to cross check if water could be a reason for the stomach diseases, we took water samples. The three drinking sources were analyzed (Rain tank, village tank and village well) and coliform levels in all of them were surprisingly high; almost 20 times higher than allowed by Thai legislation (Thai Ministry of Public Health 1981).

	Village tank	**Village well**	**Rain tank**	**Threshhold**
Total coliform bacteria(MPNindex/100ml)	40	40	40	2,2

Table 2: Results for coliforms in drinking water

Although not all types of coliforms are harmful to humans, coliforms are indicators for the presence of pathogens. Pathogens can present a threat to human health by causing a variety of serious diseases including infectious gastrointestinal illnesses which lead to diarrhoea (E.P.A. 2005). It is not possible to measure the level of every single pathogen, because there are many different types and each type requires a different analysing method. By these measurements we can affirm that water could be the cause of the stomach problems for the villagers. Even though our confidence interval would be big because of the applied methods the probability of being above the threshold is very high.

Common sources of coliforms in rural areas are the household wastewater and manure so the livelihood strategies upstream and in Mae Tia Lum can affect the villagers' health. The villagers' indication that the cause of the stomach problems is only food poisoning and not water could be based on the fact that they have no alternative water sources and thereby will not acknowledge that their only water resources are polluted.

Kidney stone

The incidence and prevalence rates of kidney stone may be affected by genetic, nutritional and environmental factors. According to some authors, dry and hot climate, high incidence of gastrointestinal diseases and peculiarities of nutrition increase the risk of kidney stone (Tarasov 1976; Martynenko 1974).

According to the villagers' perception, water pollution can be a reason behind kidney stone in Mae Tia Lum (women group). NGO's working in Karen villages has also reported incidences of kidney stones among the hill tribe (Karen Hill Tribe Trust 2003). According to some reports there is a relation between water quality and kidney stone and they claim that salinity is one of the causes of kidney stones (Rafique et. al. 2003 and Mirshina 1996).

To asses this risk we analyzed the water in terms of electrical conductivity and TDS which indicate salinity level. None of them are likely to cause kidney stone in Mae Tia Lum village at the time we were in the village. As it is shown in the table below the TDS and electrical conductivity levels are far below the thresholds. According to WHO standards, TDS in drinking water should not exceed 500 mg/l and the electrical conductivity should be below 250 µS/cm.

	Village well	Rain tank	Village tank	threshhold
Electric conductivity (µS/cm)	130	100	70	250
Total Dissolved solids, TDS (mg/l)	60	40	30	500

Table 3: results on EC and TDS in drinking water

As mentioned, many other factors increase the probability of kidney stone occurrence; therefore it is difficult to find an explanation for this case. However, we were told in the baseline study that water contains more sediment in the rainy season, so this is a factor to consider. Mae Tia Lum is also located in the lowlands where temperatures are usually very high, and this could be one of the possible reasons for the occurrence of kidney stone, but a deeper research is needed to affirm this.

Agrochemicals

Some villagers claim that agrochemicals pollute their water (women group). The process of agricultural intensification has lead to a higher use of agrochemicals in the watershed, and in the woman group interview they blamed the upstream villages for causing pollution. Location of the village well is also a problem, because it is surrounded by longan trees (observation, baseline survey). The agrochemicals applied to these trees can easily end up in the well.

According to our measurements level of ammonia and nitrates are below the Thai legislation thresholds which are 0,5 mg/l and 4 mg/l respectively (Thai Ministry of Public Health 1981).
Phosphates level in our measurements is above the threshold indicating eutrophication potential, which is 0.03 mg/l (T.E.L.W.F. 2005). If eutrophication appears, the water would not be drinkable any more, however, we did not observe any eutrophication in the water.

	Mae Tae	Mae Tia (inlet)	Mae Tia (outlet)	Village well	Rain tank	Village tank
Nitrates (mg/l NO_3- - N)	2,3	1,6	1,6	0,9	1,2	1,3
Amonia (mg/l - NH_3 – N)	0,2	0,3	0,4	0,1	0,2	0,1
Phosphates (mg/l-PO_4^{3-})	0,15	0,13	0,18	0,09	0,17	0,14

Table 4: results for agrochemicals in drinking water and rivers

Therefore no significant river pollution problem caused by upstream villages and pollution of the village well was detected by our measurements of the water. Pollution problems with agrochemicals are more likely to occur during the rainy season since rain washes off chemicals from the soil. To find out if there is pollution at other times of the year sediment samples were taken, but they were rejected at the laboratory. Consequently, we can not say if there is pollution caused by other agrochemicals like pesticides, herbicides and fungicides.

4.2 Water quantity

Introduction of cash crops seems to have changed not only the quality, but also the level of water in the streams. Cash crops or fruits trees require not only high chemical input, but also intensive irrigation in the dry season. Since most of the villagers rely on longan production as major income water is crucial for the sustainability of their livelihoods.

The irrigation practices applied in Mae Tia Lum are not as efficient as they could be. Especially the terracing irrigation system, which is used the most, uses more water for the irrigation than required. This system is especially used in the hilly areas where the fields lie in the Conservation zone and are without land certificate. Even though the illegal status of land does not seem to be a big concern to the villagers it can affect their willingness to invest money on more efficient irrigation systems. But more crucial is the fact that farmers have no incentive to do this since they pay for water per irrigation turn independently of the quantity they use. The efficiency of the irrigation practices in the village is therefore not likely to change.

Since the expansion of longan and the beginning of intensification of land use, irrigation of fields during the dry season has become a challenge for the villagers. The villagers started noticing a fall of water table in the river by 1998; the water in the streams kept decreasing, yet longan cultivation gradually expanded (farmer group). Water scarcity led to introduction of regulation and payment fees on water use, where each farmer pays money for irrigating his fields. Despite the regulations, conflicts over access to water evolved in the dry seasons of 2003 and 2004 between farmers in the beginning of the irrigation canals and others further down.

Despite the fact that the villagers are using much more water now than previously they mainly claim less rain and deforestation to be the reason for the shortage of water as shown in the graph below (baseline study).

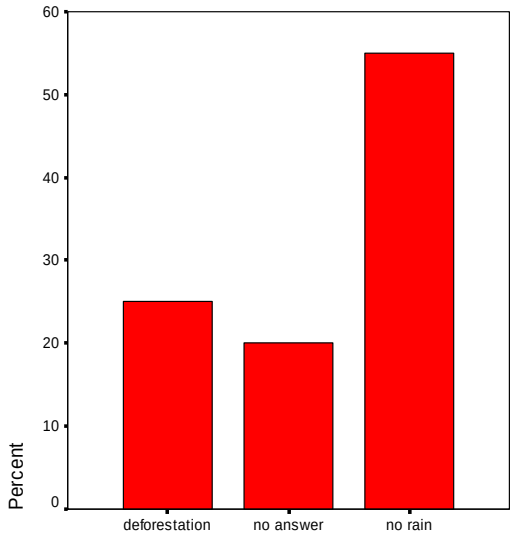


Chart 3: Reason for lack of water in Mae Tia Lum (Baseline study)

Less rain is claimed to be a reason for lack of water in the river since 1998 during the dry season. Most of the villagers claimed that the rainy season is shorter, with breaks and it is not raining as much as previously (baseline survey, farmer group, WUC). According to the data from the meteorological station in Chom Thong (appendix 7), which is app. 15 km from Mae Tia Lum, the average rainfall during the rainy and dry season is higher for the period 1998-2002 than for 1967-1997 (see the table below). This fact contrasts with the farmers' version. Neither shortening of the rainy season can be claimed as a reason for the water scarcity; rainfall data discredits this information (see table in appendix 7).

	1967-1997	1998-2002
Average rainfall in the dry season (mm)	99,8	127,4
Average rainfall in the rainy season (mm)	810,6	883,4

Table 5: Average rainfall during dry season (December-April) and rainy season (May- November)

According to our monthly rainfall data (appendix 7) there have been breaks in the rain during the rainy season since 1998, but no more than in the previous decades. However, rainfall duration is an important factor in determining percolation rate. In case of heavy precipitation in short periods the

moisture content in soil is lower, than if the same amount of precipitation was spread over longer periods. Daily records of rainfall are necessary to verify the villagers' claim about breaks in rainfall.

Deforestation up-stream is argued to be another factor causing shortage of water in the rivers (women group, informal interview, baseline study). This claim is supported by the T.A.O. office and the WUC. Deforestation can be claimed to cause less water flow in the rivers in the dry season since the forests' sponge effect is not there to hold back the water in the rainy season (Walker 2003). The shortage of water in the village appeared around 7 years ago whereas the most serious deforestation in Thailand as well as in Northern Thailand took place during the 70s and 80s (Lakanavichian 2001; Kaosa-ard 1999-2001). We have no figures saying that either deforestation or reforestation in Mae Tia Subwatershed has been taking place during the last 10 years. According to the SLUSE research group in Huai Manao and Hin Lek Fai further up the watershed there was an indication of reforestation in the area around the villages but the observations does not necessarily count for the whole watershed. We can therefore neither confirm nor deny the claims of deforestation from the villagers.

The informants supplying us with different information on the causes of the shortage of water were persons with different interests. The claim that less rainfall and deforestation are the causes was given by the WUC and most of the respondents in the baseline survey. These informants were either persons with interest in the water for irrigation or persons selected by the headman for the baseline survey. However, when we asked the farmer group they also claimed the expansion of longan orchards to be the reason for lack of water. These persons were invited over the loudspeakers in the village and only one of these persons was part of the baseline survey whereas the rest had not been interviewed so far. These persons were therefore "independent" in a sense that they were not selected by anyone, but showed up themselves, maybe because they wanted to give their opinion on the water situation in the village. We can not claim that either of them is right. All the factors can be a reason for the shortage of water in the dry season, but the expansion of longan has for sure made a huge impact on the demand/supply of water in the area.

Our measurements showed that the canals are taking 65,6% of the water from the rivers for Mae Tia Lum and other villages around in January. However, all measurements were taken within nine days, and therefore can not speak for the annual dynamics of the resource. But this percentage is due to

rise during the driest season in March and April. This means that a further expansion of the longan area would create even more difficulty to sustain the needed access to water for the farmers and thus be a cause of conflict. The low availability of water, along with the decreasing prices on the fruits, is reason why longan areas have not expanded in the last 4 years. But other factors are also influencing the choice of production system. Subsistence rice production is regarded as high social status indicator which is why no more rice fields are converted into orchards. Furthermore, the slash and burn practices are not possible any more because the only non agricultural land left around the village is inside National Park boundaries.

4.3 Water management

Questions of distribution of water have evolved with the increase in longan production in Mae Tia Lum. There is no lack of water during the rainy season, while in the dry season the resource available is not sufficient to satisfy all farms to their full need. Therefore careful management and fair distribution is essential to avoid conflicts between water users.

The majority of respondents of the baseline study have reported limited opportunities to irrigate their fields through out the dry season, especially in April. The degree of limitation varies considerably among the farmers. Factors determining access to water are physical factors, such as the distance between a field and an irrigation canal, the slope of the field, the quality of the water pipes, the power of the water pump, the water flow in the given period; as well as social factors, such as wealth of the farmer, the social position in the village, the relation to the villagers with influence, etc.

Some farmers, including both villagers and outsiders, experience little or no difficulties irrigating their fields in the dry season, while other farmers have suffered from lack of water to the extent that they lost their yield or even the whole orchard in the drought years (survey, in-depth interviews with farmer, informal conversation with the water headman of the canal 2). There is no clear correlation in the baseline survey between lost yield or lack of water and other indicators as e.g. land ownership or position in the village. Nevertheless several farmers have indicated that fields at the beginning of the irrigation canals usually do not lack water whereas farmers further down the irrigation canals do (farmers group, informal conversation). The problem is even bigger for villages

further down the canals. We observed that there was no water in canal 2 and 4 when they left Mae Tia Lum township, and this fact can cause conflict between villages.

As mentioned, every irrigation canal is managed by a committee, which is authorised by the users to decide about regulation and maintenance. The purpose of these regulations is to ensure the fair distribution of water and avoid conflicts. There seems to be a consistent system of pricing and fining for water use since it has to be approved by the R.I.D. (R.I.D. interview). However, when it comes to implementation, the rules appear to be much more flexible than the regulation requires. For example, according to the water headman from canal 4, some farmers are allowed to pay "less" for water if they have "low yield" although there were no written regulations on this. Furthermore, another flaw of management is the fact that the committees do not keep records of water use and payment by individual users. Despite our request for records of consumption, no documents were available. The only document that was kept was a list of users. Such lack of records opens opportunities for flexibility in administration which can lead to loose management and conflicts over the limited resource.

This administration makes the process of management intransparent but none of the villagers we talked to had outspoken problems with the management. The water headmen are elected every fourth year and this can lead to acceptance of the management since there might be a new headman within 4 years, and then somebody else will have advantage of the management. This does not mean that there is no discontent among the villagers and can indicate that the chosen respondents for the baseline survey could have been chosen because of their opinions or their loyalty to the village and its image. On the other hand even though the flexible management makes administration intransparent it leaves room for persons who lack money for irrigation. However the intransparency makes it unclear if everybody has the opportunity to pay less for water.

We tried to estimate water consumption of the village for agricultural purposes but none of the canal headmen or farmers had any records about irrigation time or pumped flow for the different orchards. In the WUC interview we got an average estimation of water consumption per tree and irrigation turn for the dry season. They affirmed that every farmer irrigates three times per month if possible and every time the farmer applies the volumes of water per tree showed in the graph below.

They argued that despite the estimate, the figure is very close to reality and farmers do not exceed this figure for the good of all the villagers.

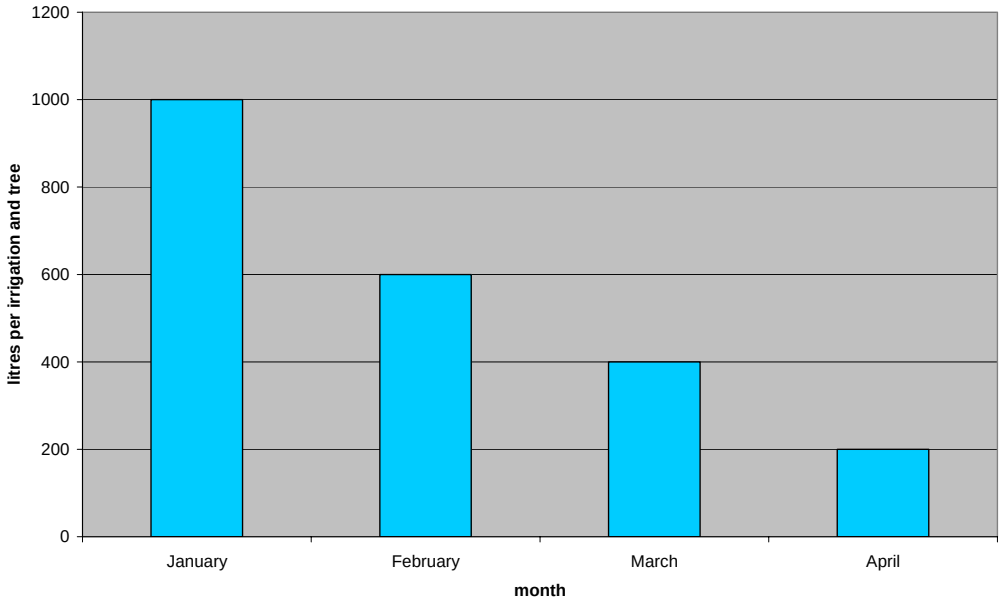


Chart 4: Estimated water consumption pr tree pr irrigation turn in Mae Tia Lum (WUC)

On January 24th we measured the flow at the inlet point of a longan orchard from a farmer who was watering the trees for the third and last time in January. We found that the farmer was actually applying 6581 l of water per tree which is more than six times more than estimated by WUC. The farmer had no idea of how much water he was applying.

One measurement may not be representative for the whole village but it shows that there is no consistence in the WUC and farmers data and none of them has control of the water demand and use.

It seems that no formal or informal institution is in charge of guiding and advising activities of the water user committees. Officially R.I.D. is still responsible for monitoring water management in the subwatershed, however, due to on-going restructuring within the department, its main focus now is on big scale construction and infrastructure maintenance. The water user committees appear to lack cooperation, guidance and expert assistance from governmental bodies on management skills.

5. Conclusion

To round up the discussion of all the aspects of the water resource in Mae Tia Lum, we attempt to answer the main research question in this final chapter.

The villagers perceive drinking water quality as acceptable, however, our measurements show pollution caused by manure and household waste water. The quality is also likely to be affected by the agricultural pollution during the rainy season due to run off. In its turn, water quality could be linked to health problems in the village, such as diarrhoea and kidney stone. The quality aspect can therefore have a critical impact on the livelihoods of the villagers in terms of health and ability to work and create income. Currently used filters are rather basic and do not treat water for micro-biotic pollution. If a source of clean water is not available for the village, one solution could be installation of treatment devices in the supply system.

Livelihood strategies, in terms of production systems, have a significant impact on supply and demand of water for irrigation. Paddy rice cultivation, despite of high water consumption, does not cause shortage of the resource. Analysis brings forward a clear causal relationship between land use intensification and decrease in water supply. The more longan orchards were planted, the less water there was in the streams.

According to rainfall analysis, the amount of rainfall and duration of rainy and dry seasons have not changed in the last decades. Nevertheless, due to insufficient data we are not able to state conclusively whether rainfall and deforestation, as claimed by the villagers, have any role to play in water supply for irrigation. The claims are grounded in the knowledge of local hydrological cycle and in villagers' observation of the impact deforestation has on hydrological cycle. But these claims are not supported by consistent data. However, the data obtained indicates a potential for interesting findings, and further research could clarify whether deforestation and rainfall should be considered in evaluation of water availability. We acknowledge political importance of such research, because if it rules out these two factors, it could decrease risk of conflict between the highlanders and the lowlanders over supply of water.

In order to restore sustainable water use, the present irrigation practices needs to be more efficient or cut down to a degree, which would allow the water resource to remain in the quantity and

condition that serves the needs of both human population and ecosystems. Defining such degree is the greatest challenge, which would require extensive research, including environmental and social impact assessment. This task lies far beyond our research project.

Resource scarcity appears to be caused mainly by change in land use and mismanagement in the village, which means that the main cause lies in the village, and therefore it can be tackled by the villagers themselves. Limited land available, along with water scarcity and decrease of price has ceased expansion of longan orchards by 2001. The situation seems to have stabilized, since longan production and, consequently, demand for water does not increase. Optimization of the water management is a way to improve access to the resource.

Issues of supply and demand are closely linked to how the resource is managed and distributed. Management itself can be a sign of resource degradation and the need to account for it. Analysis of management and supply of water shows that encrease of longan production was followed by decrease of land available, decrease of water available, steady fall in product price, and introduction of strict regulation of water use for irrigation. Unequal access to the resource among the users and user groups during the scarce periods has led to loss of yield in some farms which makes livelihoods more insecure. It also indicates that there is potential for conflict among the users.

Lack of information on water consumption, lack of records and flexible regulation make their operation intransparent. A reason for intransparency could be to cover misuse of power. The data obtained only indicates presence of mismanagement and potential for conflict. In order to improve the management strict control over farmers' water consumption, incentives to use efficient irrigation systems, even distribution and transparency in administration is recommended. Further research into management and distribution could focus on sustainability of resource utilization.

Assessing sustainability of water consumption and of water management is essential to our objectives because unsustainable management leads to depletion of a resource. If the amount of available water and its quality does not satisfy the demand for agricultural production and household consumption, adjustment to the resource scarcity would stimulate changes in livelihood strategies. New sources of income would have to be pursued, be it introduction of new production systems or giving up farming and turning into rural or urban labour.

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Glossary

Agricultural zone: deforested area suitable for agriculture

Agrochemicals: Chemical compounds applied in agriculture to enhance plant growth or to prevent diseases and pests; usually fertilizers, pesticides, herbicides and fungicides.

BOD: The amount of oxygen required by aerobic microorganisms to decompose the organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution. Also called biological oxygen demand.

Coliform: A group of bacteria that are normally abundant in the intestinal tracts of human and other warm-blooded animals and are used as indicators (being measured as the number of individuals found per 100 millilitre of water) when testing the sanitary quality of water.

Confidence interval: A confidence interval gives an estimated range of values which is likely to include an unknown parameter. The width of the confidence interval gives us some idea about how uncertain we are about the unknown parameter

Conservation zone: Land laying in a National Park, Wildlife Sanctuary or Watersheds Areas.

Dissolved Oxigen: Amount of gaseous oxygen (O_2) actually present in water. Aquatic life depends on oxygen to breathe, as does all life. Oxygen becomes dissolved in water when tiny air bubbles are trapped by churning river rapids or waterfalls and also as a byproduct of photosynthesis by aquatic plants. Those rivers that have excess amounts of nutrients can become low in dissolved oxygen from overuse by microorganisms. Levels below 5 mg/L will begin to place stress on aquatic biota and below 2 mg/L will cause death of fish.

Eutrophication: Condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae. Algal blooms hurt the system in two ways. First, they cloud the water and block sunlight destroying the river bottom ecosystem and second, when the algae die and decompose, oxygen is used up and aquatic living beings die.

Evapotranspiration: the combined water vapour put into the air through evaporation from water on earth's surface and plants giving off water to the atmosphere.

Gastroenteritis: An inflammatory condition of the stomach and intestines leading to nausea, vomiting, abdominal pain and diarrhea. Usually of bacterial or viral origin.

Hydrant: A discharge pipe at which water can be drawn from a water main or other source for the purpose of irrigating.

Kidney stone*:* a hard mass developed from crystals that separate from the urine and build up on the inner surfaces of the kidney.

Livelihood strategy: the overarching term used to denote the range and combination of activities and choices that people make/undertake in order to achieve their livelihood goals.

Longan: An Asian evergreen tree *(Euphoria longan)* having a small round tropical fruit that grows in bunches from approximately one inch (2,54 cm) diameter. It has a thin brown outer skin that covers a white almost translucent meat surrounding a single dark brown stone or seed.

Outsiders: People who grow longan in Mae Tia Lum but do not origin or live in the village.

Pathogen: Any disease-producing agent or microorganism.

Rai: Surface measurement unit in Thailand 1 Rai = 0,16 ha

Royal Project Foundation: Are initiatives supported by His Majesty the King of Thailand aiming at improving and developing the quality of life of the Thai people.

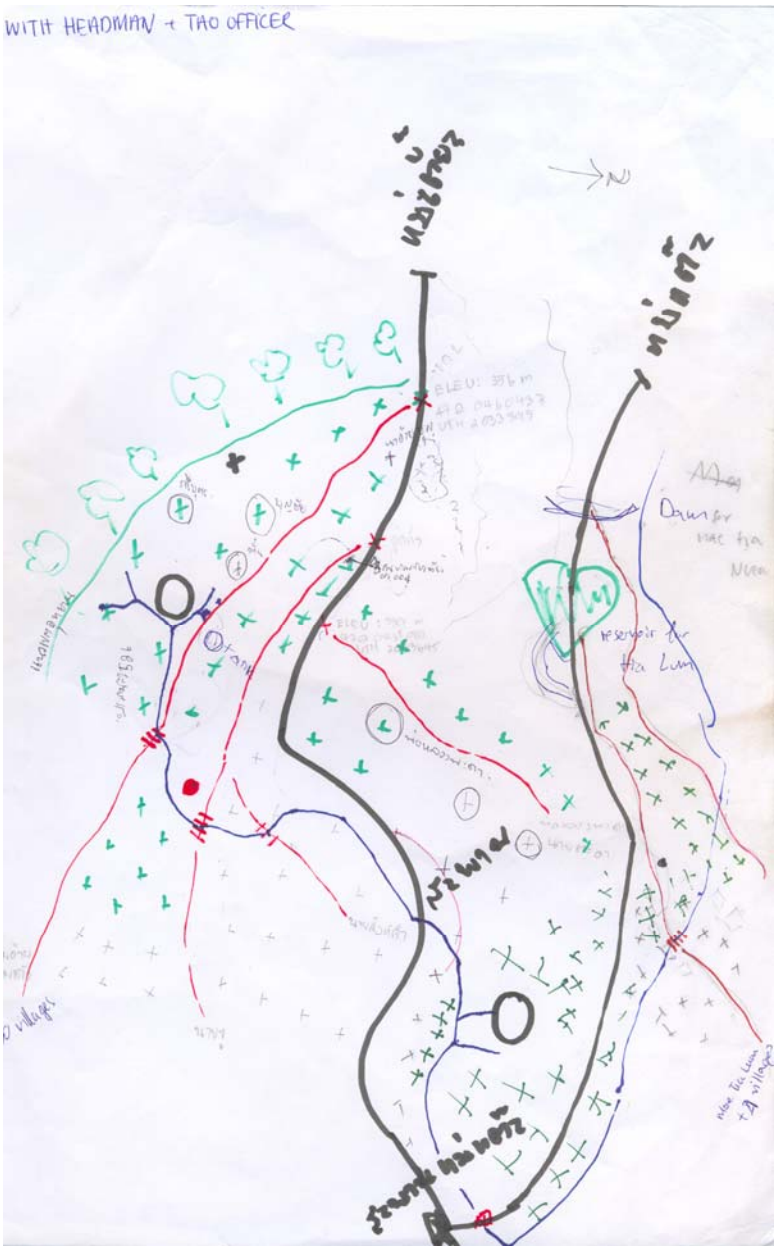
Salinity: The amount of dissolved inorganic solids, or salts, in the water.

T.A.O. (Tambon Administration Organization): It is a new form of Thai ocal government. Each T.A.O. comprises of three important components: the TAO council, the TAO executive committee and the TAO office.

Total Dissolved Solids (TDS): The concentration of dissolved inorganic chemical constituents in water. It is usually measured to estimate the salinity level of the water.

Appendices

Appendix 1: Map from Transect Walk



Appendix 2: Questionnaire

This appendix is a revised version since the original questionnaire also contained the questions in Thai. The only changes done in the questionnaire is deletion of Thai and lesser distance between the questions.

Questionnaire

General information on livelihood strategies in Mae Tia Lum based on categorization regarding different land uses.
Categorization: Big farms (more than 5 rai), medium farms (between 2 and 5 rai), small farms (less than 2 rai), villagers no land.

General information about respondent

1. Name:
2. Sex: M __ F__
3. Age :__
4. What is your ethnicity:
5. Have you gone to school: Y __ N __
    a) If yes what education do you have: Primary __ secondary __ High School__ University or number of years __
6. Are you born in this village : Y__ N__
    a) If no, how many years have you lived here:__
    b) Why did you move here:
7. What is your main occupation:
    a) Farmer__
    b) labour in the fields__
    c) temporary off-farm work __
    d) other _____
8. Did you ever changed your main occupation: Y__ N__
    a) If yes from what: farmer__ temporary off-farm work __ Permanent off-farm labor__ other__

Household members

9. Who are members of your household:

No.	Relationship to respondent	Age	Education (Primary, Secondary, High school, Uni or number of years)	Occupation	Position in the village	Do they stay in Mae Tia Lum (tick if yes)
1						
2						
3						
4						

5						
6						
7						
8						

Economy of household

10. What is the incomes of your household (please rank them):
    a)
    b)
    c)
    d)
    e)

11. Do you loan money : Y__ N__
    a) If yes, from who do you loan money__
    b) For what ___
    c) How much__

Agriculture

12. Do you own land: Y__ N__
    a) If yes, where is it located on the map
    b) How much land do you own:__ rai
    c) What do you grow on your land:
    d) How many rai of each crop: rice___ Longan___
    e) Do you have land certificate for all of your land Y__ N__
    f) What kind of land certificate do you have___
    g) If no land certificate, why not _____

13. Have you ever sold any of your land in this village: Y _ N _
    a) If yes, how many rai :__
    b) Why did you sell your land: need for money__ no labour __ low output__ Shortage of water__ Low input capacity (fertilizers etc)_Other__

14. Have you ever bought land in this village : Y __ N__
    a) if yes, how many rai:__
    b) does the person you bought it from live in this village: Y__ N__

15. Do you rent land: Y__ N__
    a) If yes, how much land __ rai
    b) What do you grow on this land:
    c) How much do you pay for renting this land:___/month or year

If the respondent do not cultivate anything jump to <u>drinking water</u>.

16. Have you ever changed the crops on your fields:__
    a) If yes, how long time ago:__

b) From which crop:__
c) To which crop :__
d) Why __

17. Which of the following do you apply to your fields: (Which kind do you use)
a) fertilizer : rice _____ longan _____

b) pesticides: rice _____ longan_____

c) fungicide: rice_____ longan _____

d) Herbicides: rice_____ longan_____

18. Do you get any subsidies for your agriculture: Y__ N__
a) For which crops :__
b) How much ___

19. Do you practice rotational cultivation : Y ___ N ___

20. How many times have you lost a relevant part of your yield because of lack of water :__

21. Are there any traditional rituals concerning the management of water: Y__ N__

a) Who is responsible for this management:__

b) If you don't follow the rituals, what happens :__

Irrigation systems

22. How many rai of your fields do you irrigate:__ rai

23. Where do you get water from:
a) canal 1 __
b) canal 2 __
c) canal 3__
d) Mae Tia river__
e) Mae Tae River__
f) Canal from Mae Tae reservoir __

24. How many days are there between your irrigation turns in the driest season: __

25. How many days are there between your irrigation turns in the (normal dry season)__

26. What determines how many days you are allowed to water your fields__

27. For how many days and nights do you take the water: Day_____Night_____

28. How do you get the water for your fields:__

29. For how long time do you pump the water continuously during all these days :
    a) all the days without a break__
    b) certain number of hours per day/how many__
    c) other _____

30. Do you pay for watering your fields: Y__ N__
    a) If yes, how much:__ pr. day/each time
    b) Who collects the money:__
    c) What is the money used for:__

31. Who is managing the irrigation system you are using:__

32. What is your perception of the management of the irrigation canals : Effective __ Good __ Moderate __ Not effective __ Poor __
    a) Why do you have this perception___

33. Do you lack water for your fields: Y__ N__
    a) If yes, which months do you lack water__

    b) Why do you think you lack water for your fields : Bad management of irrigation__ No rain__ Too many farmers in village__ Upland uses too much water __ The outsiders use too much water __ Other__

34. Do you think other farmers are stealing water for their fields: Y__ N__

Drinking water

35. Where do you get your water from in the rainy season: Village well __ Private well__ Mountain spring tap by your house__ River__ Other__

36. Where do you get your water from in the dry season: Village well__ Private well__ Mountain spring tap by your house__ River__ Other__

37. Have you changed your source of drinking water: Y__ N__
    a) If yes, how long time ago:__
    b) Why__

    c) If the answer is pollution, how did you know the water was polluted:__

38. Do you sometimes lack water in the household (which months):

39. Do the members of your household sometimes get sick from the water: Y__ N__

40. What do you think of the water quality in the household: Very good __ Good__ Moderate__ Not good__ Very bad__
    a) Why do you have this perception__

41. Is there anybody controlling the drinking water: Y__ N__
    a) if yes, who:
    b) What is the regulation __
    c) What happens if you break the regulation__

42. What is your perception of the management of the drinking water: Effective__ Good__ Moderate__ Not effective__ Poor__
    a) Why do you have this perception:__

43. Do you lack water for your household: Y__ N__
    a) if yes, why do you think you lack drinking water: Bad management of water __ No rain__ Too many people in the village__ Upland uses too much water__

Notes
Education:
Primary school:7-12 years old
Secondary school: 12-14 years old
High school: is also vocational school
University

Appendix 3: Historical timeline for longan and water

Year	Until 1985	Until 1990	Until 1995	Until 1998	Until 2001	Until 2004
Longan area	Upper village app. 3 rai of longan Lower village app. 3 rai of longan Owners: villagers	Upper village app. 25 rai of longan Lower village app. 20 rai of longan Owners: villagers	Upper village app. 35 rai of longan Owners: villagers 30 rai & outsiders 5 rai Lower village app. 40 rai of longan Owners: villagers	Upper village app. 85 rai of longan Owners: villagers 60 rai & outsiders 25 rai Lower village app. 70 rai of longan Owners: villagers 60 rai & outsiders 10 rai	Village in total: 310 rai of longan 160 rai owned by villagers 150 rai owned by outsiders Upper village 90 rai of longan	Same numbers as 2001 since there is no more land to use.
Longan events	Price: 120 B/kg. Land use change: from fruit orchards (consumption).	Price: 60 B/kg. Land use change: from fruit orchards (consumption).	Price: 60 B/kg. Land use change(LUC): from fruit orchards (consumption) and fallow area.	Price: 30 B/kg. LUC: Slash and burn of conservation forest. Villagers invest in longan (slash and burn, agrochemicals etc.) but cannot pay back the loan. They sell the land to outsiders & get a good price for the land since longan prices so far has been good until this year. This year they start paying for water.	Price: 30 B/kg. LUC: Slash and burn of conservation forest. Middlemen press price down. Start using potassium chloride also outside season.	Price 15 B/kg. BAAC gives 15 B/kg price guarantee but farmers need cash so they sell to middlemen fro 12 B/kg and the middleman earn 3 B/kg. This area produce 300.000 kg of longan a yaer – 150.000 kg each season (2 seasons a year). Election: Thaksin and opposition promise to give better price guarantee to farmers. Therefore they don't sell their land.
Water events	Enough water Long rainy season. Lots of small streams with water. Few longan orchards.	Enough water Long rainy season. Lots of small streams with water. Few longan orchards.	Enough water Long rainy season. Lots of small streams with water. Few longan orchards.	Less water Reason: Royal Project: use a lot of water with big pipes. Expansion of longan orchards. No conflict because they make strong regulations by making queue. Hard work for water headman		2003-2004: rainy season short and with breaks. Conflict among farmers in dry season. Solved: no, it's just too bad for lower areas.

Appendix 4: Water quality timeline

Year	1985	1987	1990	1992	1995	2002	2004	2005
Source of drinking and house-hold water	Main: Village well		Lower village: tap system Upper village: ponds in longan orchards and village well in dry season	Until 1992 Rain water Collected In small containers	Health care Project To store Rain water In big tanks	Upper village: Tap system and begin to use big rain tanks	TAO installs Sand filters At inlet of The village Water tanks For both villages, 2 inlets From Mae Tia	Both upper and lower village mostly use tap water, Some still use Village well
Water quality	Very Clean, Enough Fish for Fisheries	Health care Volunteers from the Ministry of Public Health Check water quality And health every month	Water filters: - cloth - sand filter At the tap Observation Of yellow And red sediment In tap water	Observation Of wounds On fish			Sponge Filter At the tap	- in rainy season a lot of sediment and organic matter, - not enough water for fisheries, - wounds on fish - Health care volunteers Check water quality and health every month - tap is comfortable, But village well is cleaner
Perceived reason of pollution	Pesticide Pollution From Longan Farmers In MTL And Cabbige Production Up-stream			Pesticide pollution				
Health								Maleria Kidney stone Gallstone Diarrhea

Location	Method	distance (m)	time (s)	counter from…	…to	cts/min	average cts/min	speed (m/s)	cross section (m^2)	water flow (m^3/s)		water flow (m^3/s)
				139641	140298	657						
Mae Tia (inlet 1)	flowmeter			140291	141145	854	771,33	0,3455	0,0400	0,0138		
				141145	141948	803					Mae Tia=	0,2313
				133129	135311	2182						
Mae Tia (inlet 2)	flowmeter			135311	137461	2150	2170,67	0,9722	0,2237	0,2175		
				137461	139641	2180						
				129995	130417	422						
Mae Tae (inlet 1)	flowmeter			130417	130893	476	491,67	0,2202	0,1250	0,0275		
				130893	131470	577					Mae Tae=	0,0359
				131468	131981	513						
Mae Tae (inlet 2)	flowmeter			131989	132527	538	544,00	0,2436	0,0342	0,0083		
				132527	133108	581						
				141968	142584	616						
Canal1 (inlet)	flowmeter			142584	143219	635	632,00	0,2831	0,3510	0,0994		
				143219	143864	645						
				156300	156778	478						
Canal 2-1	flowmeter			156778	157224	446	490,00	0,2195	0,0945	0,0207		
				157224	157770	546					Canals in Mae Tia=	0,2169
				160000	160835	835						
Canal 2-2	flowmeter			160835	161652	817	829,67	0,3716	0,0576	0,0214		
				161652	162489	837						
Canal2 (inlet)	leaf	4,5	4,55					0,9890	0,0950	0,0940		
Canal3 (inlet)	leaf	1,9	5					0,3800	0,0621	0,0236		
Canal4 (inlet)	leaf	25	120					0,2083	0,0960	0,0200	Canal in Mae Tae=	0,0200
				146774	147760	986						
Mae Tia (outlet)	flowmeter			148191	149222	1031	1035,3333	0,4637	0,1980	0,0918	Outlet	0,0918
				149222	150311	1089						

Available water	0,2672	
Water consumption	0,1753	65,6 %

Appendix 6 : Water Quality Analysis Results

Location	1	2	3	4	5	6	7	8	9	10	11	12	Water quality standards	source
Turbidity (NTU)	5,1	4,7	4,2	4	5	6,7	2,5	3,7	21,9	2,6	2	2,8	5	EPA
Air Temperature (C.)	21	23	26	25	23,5	20	24	26	23	22	22	21		
water Temperature (C.)	14	16,4	16,8	17,3	17,9	17,3	20	20	18	19	20	18		
Electric conductivity (µS/cm)	70	110	100	80	70	30	60	70	210	130	100	70	250	WHO
Total Dissolved solids, TDS (mg/l)	30	50	50	40	30	10	30	30	110	60	40	30	1000= health hazard, under 500 desirable	WHO
Total solid ,TS (mg/l)	124	148	136	124	112	80	108	96	216	104	60	128		
Suspended solid , SS (mg/l)	8	12	14	4	2	14	4	10	18	2	6	6		
pH	6,4	6,7	7	6,8	6,7	6,7	6,7	6,9	7	7,1	6,8	7,2	desirable 6,5-8,5	WHO
DO (mg/l)	3,8	3,6	3,6	3,4	3,5	3,5	3,6	3,4	3,7	2,5	1,7	1,9	desirable 4-6	WHO
DO (mg/l)							8,2	7,5	7,5	5,8	7,4	7,6		
BOD (mg/l)	7,8	7,2	5,4	8,9	7,2	7,6	8,4	5,9	10,1	4,2	3,6	4,2		
Nitrates (mg/l NO3- - N)	1,5	1,4	1,6	1	1,7	2,7	2,3	1,6	1,6	0,9	1,2	1,3	4	thai legis
Amonia (mg/l - NH3 – N)	0,2	0,1	0,3	0,2	0,1	0,2	0,2	0,3	0,4	0,1	0,2	0,1	0,5	thai legis
Phosphates (mg/l-PO43-)	0,31	0,16	0,11	0,15	0,19	0,13	0,15	0,13	0,18	0,09	0,17	0,14		
Alkalinity (mg/l)	40	58	46	40	50	18	24	28	92	34	32	26		
Total coliform bacteria(MPNindex/100ml)	70	70	140	110	150	110	110	110	230	40	40	40	2,2	thai legis
Total coliform bacteria(MPNindex/100ml)							150	92	200	420	11	92		

Location

1 (Huai Ban Hin Lek Fai at Ban Hin Lek Fai)

2 (Mae Tia Stream at Ban Hin Lek Fai)

3 (Mae Tia Stream at Lower Ban Hin Lek Fai)

4 (Mae Tia Stream at Huai Som poi bridge)

5 (Mae Tia Stream at Lower Ban Hin Lek Fai)

6 (Mae Tia Stream at Lower Ban Khun Noon)

7 (Above the revervoir)

8 (Upper Ban Mae Tia Lum village)

9 (Lower Ban Mae Tia Lum village)

10 (Shallow well in Mae Tia Lum village)

11 (Rain water)

12 (Drinkable water from tank)

Appendix 7: Rainfall records in Chom Thong

Thai Year	Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
2495	**1952**	0,0	75,9	115,1	93,1	179,1	204,9	133,7	9,5	0,0	15,5	90,4	0,0	917,2
2496	**1953**	102,7	156,4	155,3	213,2	80,2	279,0	158,1	74,3	0,0	0,0	0,6	48,5	1268,3
2497	**1954**	26,8	158,4	50,1	73,8	188,3	183,9	208,7	5,9	7,0	0,0	41,2	5,1	949,2
2498	**1955**	123,5	93,4	256,3	33,5	165,8	213,9	75,1	132,6	0,0	0,0	41,7	0,0	1135,8
2499	**1956**	32,3	208,9	18,8	158,9	76,5	320,3	196,6	53,8	1,8	0,5	13,2	0,0	1081,6
2500	**1957**	20,5	50,7	170,2	160,8	180,1	208,0	149,6	5,0	0,0	18,4	0,0	99,4	1062,7
2501	**1958**	98,1	108,8	186,5	71,9	145,0	153,5	160,7	11,2	0,0	14,2	0,0	3,2	953,1
2502	**1959**	48,0	136,9	117,6	204,3	61,2	409,9	2,8	0,0	0,0	62,7	0,0	0,0	1043,4
2503	**1960**	0,0	241,5	57,3	129,3	146,4	118,1	216,0	0,0	0,0	0,0	14,0	54,2	976,8
2504	**1961**	34,0	105,8	92,0	59,0	142,8	179,0	237,7	0,0	0,0	0,0	0,0	0,0	850,3
2505	**1962**			35,6	194,9	83,8	422,6	205,3	0,0	0,0	0,0	0,0	0,0	942,2
2506	**1963**			50,3	16,7	200,0	142,7	224,1	37,5	41,5	0,0	0,0	20,2	733,0
2507	**1964**	7,5	176,8	6,1	119,8	186,0	289,1	275,2	15,9	0,0	0,0	0,0	0,0	1076,4
2508	**1965**	31,3	121,5	36,9	19,5	176,4	123,3	119,2	30,0	0,0	0,0	63,0	15,0	736,1
2509	**1966**	0,0	240,2	20,1	48,0	183,7	123,0	93,5	0,0	0,0	0,0	0,0	0,0	708,5
2510	**1967**	96,2	116,3	38,5	116,0	135,0	208,5	44,0	119,0	0,0	0,0	0,0	0,0	873,5
2511	**1968**	76,0	115,7	75,6	64,6	54,5	94,2	154,2	67,1	0,0	6,6	0,0	0,0	708,5
2512	**1969**	16,2	222,3	46,1	49,5	252,3	343,9	61,5	50,6	26,8	0,0	0,0	65,3	1134,5
2513	**1970**	68,1	259,7	96,3	65,3	192,2	185,9	142,0	54,8	62,7	0,0	0,0	0,0	1127,0
2514	**1971**	50,9	262,6	29,8	175,8	256,9	166,4	80,1	9,1	14,6	0,0	0,0	0,0	1046,2
2515	**1972**	139,1	28,7	38,1	110,8	126,8	210,2	66,5	82,6	34,1	0,0	0,0	85,4	922,3
2516	**1973**	0,0	143,0	104,3	141,0	267,9	256,1		60,1	0,0	0,0	0,0	0,0	972,4
2517	**1974**	75,7	201,3	14,1	113,0	47,0	156,7	228,1	125,4	0,0	146,6	0,0	0,0	1107,9
2518	**1975**	0,0	72,9	151,8	53,9	235,9	229,8	160,1	2,3	23,5	0,0	0,0	0,0	930,2
2519	**1976**	43,5	147,3	118,2	59,5	118,5	91,1	217,8	26,6	0,0	111,0	0,0	0,0	933,5
2520	**1977**	88,6	90,9	86,9	63,2	204,2	354,9	104,4	13,6	85,2	21,2	66,5	0,0	1179,6
2521	**1978**	8,6	143,0	36,0	372,2	114,3	224,6	69,5	0,0	0,0	0,0	0,0	7,0	975,2
2522	**1979**	20,9	123,4	223,0	123,8	58,8	165,3	117,0	0,0	0,0	0,0	0,0	14,2	846,4
2523	**1980**	9,5	280,5	117,0	79,6	165,8	126,2	86,7	39,0	26,5	0,0	0,0	0,0	930,8
2524	**1981**	36,7	155,4	68,0	73,2	89,8	104,0	111,6	190,4	41,0	0,0	0,0	17,8	887,9
2525	**1982**	79,0	211,8	87,2	29,9	46,7	178,0	51,0	14,1	0,0	0,0	0,0	0,0	697,7
2526	**1983**	8,3	112,6	105,6	27,4	122,8	81,3	167,6	213,5	9,0	0,0	2,5	0,0	850,6
2527	**1984**	46,7	52,7	126,1	85,3	70,1	188,3		1,5	0,0	16,4	0,0	0,0	587,1
2528	**1985**	108,0	141,6	83,3	105,1	20,4	335,2	149,8	262,9	6,4	0,0	0,0	0,0	1212,7
2529	**1986**	43,2	144,9	56,9	88,2	136,3	98,3	69,9	11,9	37,8	0,0	8,0	36,8	732,2
2530	**1987**	55,0	32,2	103,6	38,8	160,3	234,3	48,7	221,1	0,0	0,0	0,0	18,0	912,0
2531	**1988**	96,8	159,1	184,0	151,3	78,7	122,5	236,1	98,1	0,0	0,5	0,0	8,1	1135,2
2532	**1989**													
2533	**1990**	12,1	133,0	65,8	24,7	138,4	101,5	95,7	32,0	0,0	0,0	0,0	4,6	607,8
2534	**1991**	29,8	50,0	75,5	62,5	200,4	73,3	72,0	36,2	2,1	0,0	23,9	0,0	625,7
2535	**1992**	17,1	6,9	26,8	12,3	151,2	248,1	154,0	40,4	79,5	1,5	0,0	0,9	738,7
2536	**1993**	70,4	134,9	19,0	68,6	83,6	163,5	182,3	0,0	0,0	0,0	0,0	147,6	869,9
2537	**1994**	110,7	142,9	167,5	119,9	204,1	125,5	35,0	14,0	22,7	0,0	0,0	6,1	948,4
2538	**1995**	39,9	220,1	28,8	181,8	227,1	243,1	49,3	29,1	0,0	0,0	37,9	0,0	1057,1
2539	**1996**	58,4	51,8	99,8	77,3	130,6	212,4	145,4	41,0	0,0	0,0	0,0	44,8	861,5
2540	**1997**	117,1	16,6	16,7	81,3	142,4	166,0	128,7	0,0	0,0	0,0	0,0	0,0	668,8
2541	**1998**	14,0	45,1	36,8	51,9	200,5	69,1	23,4	62,4	0,0	25,7	49,7	20,2	598,8
2542	**1999**	60,2	280,2	80,7	63,0	172,9	158,9	278,8	114,7	11,9	0,0	7,1	30,0	1258,4
2543	**2000**	86,7	283,7	89,6	33,6	119,4	156,0	154,4	0,0	25,3	3,7	0,0	85,8	1038,2
2544	**2001**	6,3	130,8	26,3	68,0	138,9	163,4	208,7	35,3	16,4	11,9	23,8	0,0	829,8
2545	**2002**	42,4	192,7	61,2	17,1	302,0	315,1	99,8	182,4	74,9	9,5	0,0	31,3	1328,4

Appendix 8: Daily Activities for Javier Fernández Soriano

	Morning	Afternoon	Evening
Tuesday 11th	CMU	CMU	
Wednesday 12 th	CMU	CMU	
Thursday 13th	Leave for Base Camp	Leave for Village	Introduction to Headman & Group meeting (GM)
Friday 14th	Transect walk with village headman	Transect walk with T.A.O. officer	Village meeting
Saturday 15th	Testing Water quality equipment	New Year Celebration /informal conversation	GM
Sunday 16th	New Year Celebration /informal conversation	Water quality analysis and water flow measurement	GM and New Year Celebration
Monday 17th	On-field water test	Preparation of Questionnaire	GM
Tuesday 18th	Questionnaire and 1st water committee group interview	Water committe group interview and Water analysis	Leave for Base Camp
Wednesday 19th	Midterm Presentation	Midterm presentation	Off
Thursday 20th	Day Off	Day Off	Leave for village
Friday 21st	Illness	WUC group interview	Questionnaire and GM
Saturday 22nd	Visit to the check dam construction	GPS and flow measurement	Farmer group interview and GM
Sunday 23rd	Questionnaire	Questionnaire & prep. of village meeting	Village meeting
Monday 24th	Water Flow measure by reservoir and GPS	On-field water test	Leave for Base Camp
Tuesday 25th	Leave for Chiang Mai	Group meeting	
Wednesday 26th	CMU	CMU	
Thursday 27th	CMU	CMU	
Friday 28th	CMU	Final presentaion CMU	

Appendix 9: Daily Activities for Vlada Fuks

	Morning	Afternoon	Evening
Tuesday 11th	CMU	CMU	
Wednesday 12 th	CMU	CMU	
Thursday 13th	Leave for Base Camp	Leave for Village	Introduction to Headman & Group meeting (GM)
Friday 14th	Transect walk with the headman	Transect walk with T.A.O. officer	Village meeting
Saturday 15th	New Year Celebration /informal conversation	New Year Celebration /informal conversation	GM
Sunday 16th	New Year Celebration /informal conversation	New Year Celebration & Prep. Of Questionnaire	GM and New Year Celebration
Monday 17th	Preparation of Questionnaire	Preparation of Questionnaire	Questionnaire check and GM
Tuesday 18th	Questionnaire	Questionnaire	Leave for Base Camp
Wednesday 19th	Midterm Presentation	Midterm presentation	Off
Thursday 20th	Day Off	Day Off	Leave for village
Friday 21st	Questionnaire	WUC group interview	Questionnaire and GM
Saturday 22nd	Questionnaire & prep. of group interview	Questionnare	Women group interview and GM
Sunday 23rd	Questionnaire	Interview with a farmer	Village meeting
Monday 24th	Interview with an outsider	Interview with outsiders	Leave for Base Camp
Tuesday 25th	Leave for Chiang Mai	Group meeting	
Wednesday 26th	CMU	CMU	
Thursday 27th	CMU	CMU	
Friday 28th	CMU	Final presentaion CMU	

Appendix 10: Daily Activities for Pernille Lausen Hansen

	Morning	Afternoon	Evening
Tuesday 11th	CMU	CMU	
Wednesday 12 th	CMU	CMU	
Thursday 13th	Leave for Base Camp	Leave for Village	Introduction to Headman & Group meeting (GM)
Friday 14th	Translation of Thai students research	Transect walk with T.A.O. officer	Village meeting
Saturday 15th	New Year Celebration /informal conversation	New Year Celebration /informal conversation	GM
Sunday 16th	New Year Celebration /informal conversation	New Year Celebration & Prep. Of Questionnaire	GM and New Year Celebration
Monday 17th	Preparation of Questionnaire	Preparation of Questionnaire	Questionnaire check and GM
Tuesday 18th	Questionnaire	Questionnaire	Leave for Base Camp
Wednesday 19th	Midterm Presentation	Midterm presentation	Off
Thursday 20th	Day Off	Day Off	Leave for village
Friday 21st	Questionnaire	WUC group interview	Questionnaire and GM
Saturday 22nd	Questionnaire & prep. of group interview	Interview with water headman -lower village	Farmer group interview and GM
Sunday 23rd	Questionnaire	Questionnaire & prep. of village meeting	Village meeting
Monday 24th	Water Flow measure by reservoir	Interview with water headman assistant	Leave for Base Camp
Tuesday 25th	Leave for Chiang Mai	Group meeting	
Wednesday 26th	CMU	CMU	
Thursday 27th	CMU	CMU	
Friday 28th	CMU	Final presentaion CMU	

Appendix 11: Synopsis

INDEX

Introduction

This paper investigates water resource management in the village of Ban Mai Mae Tia Lum in Northern Thailand. The village is situated in the lowlands of the Mae Tia subwatershed in Chiang Mai province and is located outside of Ob Luang National Park in a conservation zone. The villagers belong to the ethnic group of Karen and are producing upland paddy rice for household consumption and longan fruit for sale.

The research interest has been stimulated by the increasing tensions over the access to water resources between "outsiders" and villagers. Local villagers seem to experience pressure in terms of either insufficient supply or poor quality of water. The exact cause of the tension remains unclear and constitutes the overall research question.

Aim

The aim of our research project is to understand the nature of the tension over the water resources and the causes of it.

In order to achieve this aim, a thorough study of all aspects of village's life is intended, namely, livelihood strategies and patterns of water use.

The overall problem formulation of our report is:

<u>What are the villagers' livelihood strategies; how have these developed in recent years and how are they influenced by the National Park and National Reserved Forest areas?</u>

Objectives

Attempting to understand the cause of tension over water resources, we set the following objectives:

1) *to study livelihood strategies of the village;*

Understanding of the villagers' livelihood strategies can explain how, where and what they use water resources for, what is their perception as to the level of quality and supply;
methodology of livelihood research includes a variety of tools, which include survey and different kinds of interviews with the villagers.

2) *to study social and institutional context of the local water resource management;*

Understanding of formal and informal institutions of the village and their role in the land distribution and ownership can also shed light on the issue of water resource distribution.
Since outsiders cultivate land in the area, investigation of the relationship between the villagers with the outsiders, and social conflict over access to water resource can give a perspective on the factors determining demand, supply and quality of water.

3) *to study relationship between agricultural practices and supply/demand of water;*

Knowledge of the cultivated crops and applied agricultural technologies can help to draw a pattern of water consumption for irrigation and assess sustainability of the consumption. Examination of the irrigation practices will help us to assess water demand and supply for agricultural consumption.

4) *to assess relationship between water quality, agricultural practices and supply/demand of water;*

Knowledge of the quality of drinking and irrigation water and how it affects or is affected by agricultural and household consumption can lead to understanding of the causes behind insufficient supply of water.

Methodology

This section will contain the different methods we are planning to use to conduct our study and answer our research questions.

Transect walk

In order to get an overall picture of the village's history, organization and institutions, livelihood strategies, agricultural practices and geographical boundaries, we intend to interview the Headman of the village.

The interview will take form as a *transect walk* where we will walk through the study site which will give us an overview of the village as a hole and where we can identify, discuss and register the problems and opportunities of the village (Chambers 1997:117).

The headman of the village knows the people of the village and should be able to point out informants, show people, social groups, household characteristics (social mapping, see Chambers 1997:136) and inform us about the water resource management in the village.

We will do a transect walk with the headman since it is our first time in the village and it can give us a general view of the village and also identify the problems of the village.

We hope that the Headman also guides us as to other key-informants.

Method

By using the transect walk we will let the informant (the headman) control the talk; this means that he will be the one conceptualising what we see in the village.

We will let the headman show us the village and make a map of the village while we are walking around. We will let him determine the concepts that will form this map; that is, e.g. let him determine how the households are "ranked" or grouped (names, education, health, occupation or wealth) or how the area of land is conceptualised (village vs. agriculture or differences in cultivated areas etc.). This might give us an idea of what is important in the village (local criteria, see Mikkelsen 1995:75).

It is interesting to notice what he fails to talk about when we are walking around in the village. If all of the households are not drawn on the map, we will ask into this (who are living in the drawn houses and who are living in the "forgotten" houses).

We will approach this transect walk with some issues we want to discuss with the headman, but since it is more a "conversation" than an interview there will be no structured guide on what to talk about.

Methodological problems

We shall be aware of the position of our informant. First of all the informant is the leader of the village and thereby representing the village. The headman could though be pleading some of the villagers cause and fail to inform us of other problems in the village. If the headman is a farmer, the transect walk might emphasize specific problems in relation to agriculture, which we will have to be aware of.

But despite these biases we find a headman of a village to be a good entrance to the village.

For issues of discussion with the headman see appendix 1.

Questionnaires
We intend to conduct a survey on household livelihood strategies and their water use in the village.
Survey is a quantitative-qualitative social research method, which allows for rapid collection and statistical analysis of qualitative data (Neuman 2000:247ff). We are strictly limited by the time available for our empirical data collection which is why we apply this method.

Method
There are 110 households in the village and we will conduct the survey on 10-15 % of the households in the village based on the random sampling technique (see Neuman 2000:200ff). We will do face-to-face interviews with the households to make sure we get responses to all our questions. At the same time it gives us a chance to observe the household and respondents reactions to the questions. Our purpose is to identify general patterns in the villager's livelihood strategies and use of water. We will find out what their preferences regarding water use and livelihood strategies are and their perceptions of the socio-economic context they are in. We can then find out how changes in livelihoods have affected agricultural practices and water use.

Methodological problems
By doing face-to-face interviews we can affect the respondent in different ways. The way the question is posed and the tone it is posed in can affect the response. The respondent might also feel forced to answer incorrectly if we are posing questions that are sensitive to him/her. This can also happen if there are more than the respondent present during the interview (e.g. other family members).
Questionnaires can be difficult to process and code. Especially open-ended questions can be had to code whereas closed-ended questions are easier to code. By only using closed-ended questions important personal things might be lost in terms of feelings and beliefs (Neuman 2000: 269), but we are trying to overcome this problem by mixing open- and closed-ended questions.

Semi-structured in-depth interviews
We intend to make in-depth interviews to key-informants in the village.
In-depth interviews can be applied to obtain in depth knowledge on selected households' livelihood strategies. They will help to orient ourselves in the operational context and problems of the area and also allow us to narrow our research focus to a specific problem area.
This kind of data can give valuable deep insight into a problem. Although it does not allow for generalisation, this method is useful in our research when we seek to identify existing perceptions of problems.

Method
The semi-structured interview is chosen since we would like some general information on how people understand the water related problems in the area. It can also be considered a sort of *follow-up interview* since we will use the information given from the questionnaires and through this, structure the interview.
There are different ways of choosing informants, but we are planning to use the information we get from the headman and through the questionnaire, to pick out informants.

Potential key informants

- head master of a local school (on social composition of the village, institutions)
- a representative from the state administrative unit – municipality, he might be called a district officer or PR (public relations) officer.
- An officer from a technical, water supply department.
- An officer from an agricultural/forestry department.
- NGOs working in the area (agricultural and environmental NGOs).

These informants can provide information and statistical retrospective and perspective data about infrastructure, organisation, regulation, institutions and policy implementation in their sectors respectively.

Methodological problems

When performing an interview, several methodological problems have to be considered. We have to be aware of the respondents' credibility in terms of e.g. exaggeration or bad memory but the respondent might also have a motive for providing wrong answers (Casley and Kumar 1988:22). If respondents find any problems with water management in the village we will have to make sure that it is a real problem.

Another problem can be the context the interview is made in. The respondent has to feel comfortable in the settings (who is present, where is the interview taking place) other wise he might not provide full answers to our questions. It could be an idea e.g. to go to the fields alone with the farmer so he feels "at home".

For more methodology on interview with outsiders see appendix 2.

Group interviews

Having gathered general patterns, we intend to select a few households for group interviews on their livelihood strategies and agricultural practices in relation to water use.

We will conduct group interviews with two groups, and the group for an interview on household water use will be females, those most active and possessing most power in household managing. The focus group for the interview on agricultural water use will be males, as the ones with experience and knowledge and actively involved in the cultivation.

This method will be able to save us time from making individual interviews and can open some doors to problems that we wouldn't have heard about through individual interviews, and could be a way of cross-checking our former key respondents in the individual interviews (Chambers 1980:9).

At the same time the group interviews should enable the villagers to express the reality they are living in. That is, that they are the ones who know their problems in the area best, and they are thereby the best informants on how they understand their situation.

Method

We will have to choose a representative section of the population in the village. In each group should be around 8-10 persons. Since there might be differences in the power relations in the village, we might have to split the groups into two, but hopefully the transect walk with the headman will give us a clue about this.

We will choose a representative section of the villagers through the indicators that the headman gives us. Our transect walk with the headman should give us some indication on how the

households in the village are socially ranked or grouped. By using the locals' indicators for ranking or grouping we are able to identify a more broad section of the village (by their own ranking of the villagers) and thereby get a more representative group of people in our interview. At the same time our questionnaire should be able to help us get an overview of the people in the village and their livelihoods, and it could also help us choose persons for the group interview.
To conduct a group interview we will have a general topic to be discussed, which is water resource management in the village.

Methodologically problems
An overall problem when applying this method is the problem with the interpreter. We do not understand Thai, so if a discussion takes place it can be difficult for us to follow the discussion, since many people can be speaking at the same time. Nevertheless we hope to gain some important information, and will have to inform the interpreter that it is important to get as much of the discussion as possible interpreted. We might be able to have more than one interpreter.
The interviews might show power patterns in the village, which can be identified by noticing who is talking and listened to and who is not. This can be a problem in the group interview as a hole, since some of the person's opinions might not be heard. To overcome this problem we might have to divide the groups into two (but hopefully not, due to lack of time).
The differences between persons in the group can help us identify who we could do follow-up interviews on, to let the results of the group interview show as representative a picture of the village as possible.
It might also turn out to be a problem when the people in the group has to make a ranking, seasonal calendar or something else together, since they might not have the same opinion on the topics. A solution to this problem could be to let them all make their own or just concentrate on the discussion where they try to find consensus and we can then emphasise on the different perspectives represented.

For issues of discussion and tools see appendix 3.

Evaluation of the irrigation system
It's known that villagers have a problem with the accessibility to water and that the main part of this resource is used in agriculture. We think that they could have low efficient irrigation systems and therefore they would be managing water in a bad way. In order to evaluate the irrigation system we are going to measure some parameters and look carefully for damages and failures in the system.

To simplify the analysis we have divided the system in three elements: Water source, Transportation system and target area.

- Water source: We are going to look at water variations during the year and during the day, so that we can find out how stable this sources are. We want also to find out what is the estate of the reservoirs, wells or pools if there are any. Next step will be to analyze why the sources are not maintained.

- Transportation system: Parameters that affect the water supply are: state of the canals, pipes, gates, concrete, pumps (if any) and distance from source to target area. With the intention of getting a better view of the water transportation system we would like to locate with a GPS device the most relevant elements and damages in the water grid.

- Target area: First of all we want to find out who owns the plots in order to get a better view of the agricultural system (outsiders, villagers, companies…) Afterwards we would like to determine how uniform is the application of water and how efficient farmers are at using the water resources. Water flow in canals will de measured and compared with the crop water demand. With both figures we will find out if they are using more or less water than the crop requires. Methods for estimating the uniformity and Water flow in canals are described in appendix 5.

The crop water demand will be determined with CROPWAT. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO. Knowing data about climate, soil and crop the software can calculate the evapotranspiration for each field and crop. We are going to collect these data as well as analyze soil samples in order to be able to determine the soil type. The software and methodology has been more precisely described in appendix 5.

Water quality assessment

As it was said in the introduction we would also like to find out how the water quality/drinkability affects the livelihood strategies in our village. We think that upland farmers could be polluting the water with fertilizers, herbicides and other products and this could be the reason for confrontation between villagers and outsiders. Are the villagers lacking drinkable water? Is the water suitable for agriculture? These are other question that we want to answer during the trip.

Along with social research, we intend to gather data on physical, biological, and chemical parameters of water supply and demand of the village and its agriculture.

Water quality analyses are going to be done with help of the Thai student and equipment of the Chiang Mai University. We would like to examine the water quality in terms of smell, taste, and cloudiness, conductivity, nitrates content, nitrites content, ammonia content, total number of coliforms and number of fecal coliforms. The analyses that are going to be carried out in our village depend on the available equipment.
For detailed information see appendix 6.

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Appendix 1

Issues for discussion with the headman of the village.

We will as mentioned try to emphasize on issues we find relevant according to our research area in our transect walk.
These issues are as following:
1. *Differences in the households* e.g. occupation. This will give us an overview of different interests in the village. The teacher might not have the same interests in water resources as the farmer. It might also show if there are people migrating to work outside the village (all or part of the year).
2. *Agriculture and agricultural practices*. This will show us where they are cultivating, what and how they are cultivating and maybe identify where the "outsiders" are cultivating.
3. *Water resource management*. This could help us get an idea of where they get the water for the households from and where they get the water for the irrigation from.
4. *Public administration*. This will help us identify if there are any social arrangements in the village, that will be committees or councils, which are administering e.g. public goods in the village or in between villages. Here we will emphasize on the water resource management in particular.

Appendix 2

Guideline to interview with the "outsiders".

After the interview with the headman and interview with some of the farmers, we should be able to identify who the outsiders are and we should be able to identify some of the problems related to water between the villagers and the outsiders. We will find out if there are any social relations between these two groups. They might be competitors accusing each other of using too much water or they could have some cooperation with the irrigation systems.
We would like to hear the outsiders' point of view considering the water issue to look at the water management from more than one angle.

Method
Since we do not know who the outsiders are, yet, the method to use to get information from the outsiders are difficult to decide on. We do consider making a few *semi-structured interviews* with some of the outsiders (key informants) and there are some specific questions we already now know would be interesting to ask about. We do know that there are problems related to access of water in the area and there we can make some general questions now. These questions will be outlined a little later.
The final interview-guide will not be finished until we have more details on the problems related to water in the area. The questions that we need to ask the outsiders are depending on the specific situation in the area and are therefore not possible to make now.
Our method, with semi-structured interview, is chosen since we would like some general information on how the outsiders understand the water related problems in the area. It can also be considered a sort of *follow-up interview* since we will use the information given from the villagers as a baseline for the interview. This does not mean that we will take the villagers point of view as the final truth, but only as one point of view on the water issue.
A way to structure the interview is to use some of the same questions that we asked the focus groups about and use agricultural related questions as we did with the interviews with farmers. This

could give us some comparable data on the different interpretations of the water management in the area.
The semi-structured interview can, as we mentioned above, not be fully finished now, since we do not know exactly what the water problem is. We can though make some more general questions and themes that we want to ask into and these will be as showed in the following:

- How long have you been cultivating in the area?
- How big an area are you cultivating?
- What crops are you cultivating?
- Have you always been cultivating the same crops in your fields?
- Are your crops for subsistence or sale?
- What time of the year are you cultivating?
- Do you have irrigated or rainfed fields?
- How is the water resources managed (shared between users) in the area?
- Do you find that there are any problems with water - which? (Focus group question)
- What is the biggest problem for you? (Focus group question)
- Have there been changes in the water supply over a period of 10 years (if they have been cultivating in the area for that long)? (Focus group question)
- What changes have there been? (Focus group question)
- What changes has there been in the water supply during the year? (Focus group question)
- How do you prevent the problems in the water management from taking place? (Focus group question)
- Do you have any social relations with the village in the management of water – why/why not?
- Have the government put up some regulations on the water management?
- What do you think about the dam that might be built?

Methodological problems

To carry out an interview with the outsiders so that it generates general information about the outsiders' interpretations on the water management can be problematic in relation to representatively data. It could be difficult for us to find a representative section of the outsiders if we are not in the village where they (maybe all) live. So our selection of informants can be difficult.
We might be able to overcome the problem by going to the village where the outsiders are living, if they at all are living in the same village, and talk to the headman if possible. If the outsiders are not living in the same village, but are from a lot of different villages, a selection of farmers growing on different fields (different altitude, area of field, distance from the village or river) could be a an answer to our representatively problem.
Our positions as interviewers might also cause bias in the interview, since we are conducting a survey in the village where their (possible) competitors are living. This could affect their answers in some way, depending on how they understand our position in this survey. It will be our job to inform them that we are students learning and trying to get to the bottom of a problem.

Appendix 3

Issues of discussion and tools for group interviews with women and farmers

We will have some questions as a guide for the group interview to keep the interview within the scope of our research. Visual tools can make participants information more visible and public to the rest of the group so it can be discussed (Chambers 1997:154) of we will make use of some tools. These tools are the following:
Seasonal calendars (Chambers 1997:118) can show the differences in water supply during the year, e.g. in relation to the agricultural calendar. By making a visual drawing of the water supply by the group it is open for discussion and correction between the participants in the group.
Time lines (Chambers 1997:118) can show us trend in the water supply during a decade or more, depending on the relevant number of years. The time line can be related to cropping patterns, water use, land use and for instance show if the villagers find any differences in water supply since the outsiders came or since they started growing cash crops.
Ranking (Mikkelsen 1995:76) *of problems/opportunities* can identify how the villagers look at their livelihoods and what is concerning them.

Since we have two different groups, women and farmers, we will have to be aware of different perspectives on the same problem. The overall aim is to find out about the water resource management in the village; that is
what are the problems related to water,
how have it changed during a certain period of time and
how are they trying to prevent the problems.
The different methods we are planning to apply to these questions are the following:

	Problems related to water	Changes in water supply	Prevention of problems
Method	Ranking (of problems)	Seasonal calendar and time line	Ranking (of opportunities)

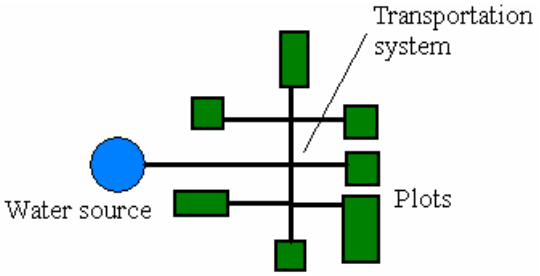
We will try to apply the same question to the two groups and then let them decide how to answer and draw the answer to the question.
The questions will be asked as follows:
1. “Please state the problems with the water resource management in the village – and rank the problems (what is the biggest and smallest problem)”.
2. “Which changes has there been in the water supply over a period of 10 years – draw a calendar”.
3. “Which changes has there been in the water supply during the year – draw a calendar”.
4. “How do you prevent the problems from taking place – rank opportunities”.

The visual tools in the different groups could be compared and the differences between the groups should be able to give us an overview and an understanding of the general problems in the village and how they are dealing with them.

Appendix 4

Evaluation of the Irrigation System

An irrigation system is divided into three elements: Water source, transportation system and target area (field, plot…).
The first stage in our research will be the observation and evaluation of these elements.



The water source could be a river, a reservoir, a pool or a well. They could also have more than one water source. In order to determine the stability of the sources we should estimate the water level variations during the year and during the day, meaning high and low tight in the river and water's height variations in reservoirs, pools and wells. In the last three cases we are going to look for leaks and cracks.

As far as we know water for agriculture is transported in canals and sometimes in rudimentary pipes. In order to estimate the state of the transportation system we are going to follow the canals from the water source until the target area and look at the concrete state, leaks, cracks and gates that are not working properly. With the intention of getting a better view of the water transportation system we would like to locate with a GPS device the most relevant elements and damages in the water grid.
An important factor to take into consideration in our research is the distance between water source and target area. The longer the canals are the less efficient the transportation will be.
Pumps are another element to take into account in the transportation system. They are a big investment for the farmer, therefore we can find out what is the profitability of the agricultural system looking at the quality and quantity of pumps. It would be also interesting to find out from where they get the energy for the pump.

The target areas are the plots. Observing the whole area around the village we should be able to estimate which plots have better accessibility to the water and how many of them are cultivated during the dry season. To better define the problem to water accessibility we have to determine how many plots are owned by villagers and how many by outsiders.
Another important parameter to estimate the water use efficiency is the irrigation uniformity, meaning how even the water is distributed on the plot. Flat plots use to have high uniformity because the water height is the same in every point of the field. Plots with a gentle slope have very bad uniformity, meaning that there are areas lacking water and other have surplus of water.

The second stage of the research will be the measurement of different parameters. Like water flow distance of the canals and irrigation uniformity.
The distance is going to be measured with the GPS device for long distances and with a measure tape for short distances. Uniformity is going to be measured by estimating how much percentage of the plot is not covered with water after a certain period of time after the irrigation. Many different

researchers have tried to find equations to determine the uniformity (Christiansen, Low-quarter,…), but all of them are based in theoretical models or are only useful for sprayer or dripping irrigation systems. Therefore we think that a good way to compare the uniformity is just dividing the area covered by water by the total area so that the optimal uniformity value would be 1 and the worst value woul be 0.

Uniformity = area covered by the water / total area

The flow is defined as the amount of water that flows through a section of river or canal in a certain period of time. The units are litre per second, cubic metres per second, cubic metres per hour, etc… This is probably the most difficult parameter to measure.

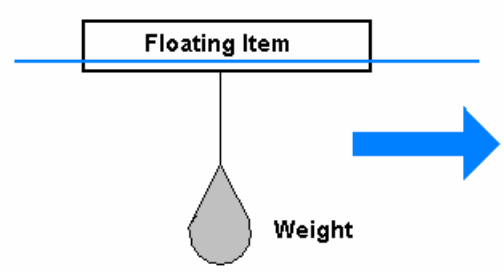
Flow in a canal can be measured by different procedures like level gauge, gauging rule, pitot pipe, flowmeter etc… The most used and precise method is to implement a level gauge with a gauging rule in the canal bottom. The level gauge is made from concrete or other similar material and the water flow through the canal has to be stopped for some days to allow the building of this device. Another disadvantage is that it has to be tested before it's used to ensure the quality of the measurements and it would take more time. Therefore we have decided to use a less precise but easier method to estimate the water flow.

An easy way to determine the flow is to measure the area of a cross section and multiply it by the velocity of the water in this section. The biggest problem is how to measure the water's velocity. We could do it using a device called flow meter, which can measure the water's velocity in a given section, but since we are not sure if we will be able to get this equipment from KVL or Chiang Mai university we should find a better way to estimate this parameter.
The easiest way to do it is to count with a stopwatch the time it takes for the water to cover a certain distance and then dividing distance by time we can calculate the velocity. To make the water's velocity "visible" we will let a floating item on the water stream. It will move almost at the same speed than the stream and will be our reference point.

This method is easy to carry out but it has some disadvantages: in some cases it is not precise enough. As we said the velocity has to be measured in a cross section, using the method described above we are measuring the average velocity in a canal's stretch. The imprecision we are making is that we are assuming that the water level in the canal is constant in the whole stretch and it might not be. We can only consider an even draught in gentle canal slopes. As we could see in some pictures that the Thai students sent us, the slopes are gentle enough to ignore this error.

A second assumption we have to do is that the regime is permanent and uniform, meaning that the velocity is the same in every point of the considered section and at any time. These assumptions are usually done in hydraulic calculations because otherwise they would be very tough.

And last but not least we should take into consideration that the item we are using as reference point might travel at a lightly lower speed than the water stream. We will try do design it as good as possible to minimize the errors. One possible solution is to hang a weight from the floating item.

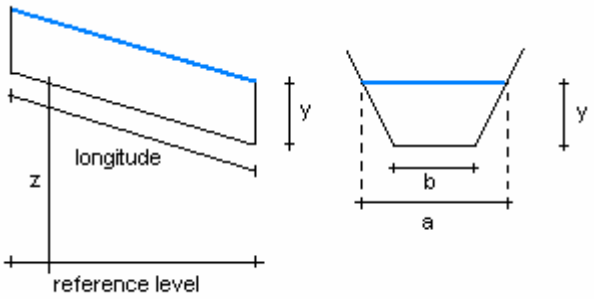


Once we know the area of the section and the velocity of the water we can calculate the flow using the following equation:

$$Q(\frac{m^3}{s}) = v(\frac{m}{s}) \cdot A(m^2)$$

Q = Flow ; v = velocity ; A = area

The area is going to be calculated measuring a, b and y. Knowing z in two points we can also calculate the slope.

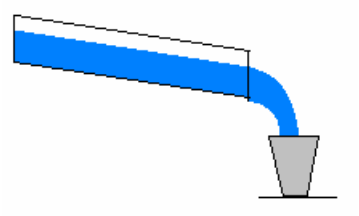


Another way to estimate the flow is to put a pot or a bucket in the end of the canal and count the time it takes to fill it. Knowing time and volume we can easily calculate the flow with this ecuation:

$$Q(\frac{m^3}{s}) = \frac{V(m^3)}{t(s)}$$

Q = flow ; V = volume ; t = time

This method can be used for small canals, for canals with a high flow we would need a very big bucket or pot.



The evapotranspiration values are calculated with CROPWAT (See appendix 6). It calculates the layer of water in millimetres that the plant demands every day. To be able to compare flow and water demand data we need to convert the flow units into millimetres. The conversion is:

$$L(mm) = \frac{Q(\frac{m^3}{s}) \cdot t(s)}{A(m^2) \cdot 1000}$$

L = layer ; Q = flow ; t = time ; A = field's area

In order to be able to calculate the area of the different fields we will use a GPS device to obtain the coordinates for the borders. We will use SURFER software to process the data and plot the maps.

Appendix 5
Determination of crop's water demand

As we mentioned above, we want to estimate the water demand of the different crops grown in the village. We will do this with help of CROPWAT software. CROPWAT is a decision support system developed by the Land and Water Development Division of FAO. Its main functions are:

To calculate:

- Reference evapotranspiration
- Crop water requirements
- Crop irrigation requirements

To develop:

- Irrigation schedules under various management conditions
- Scheme water supply

To evaluate:

- Rainfed production and drought effects
- Efficiency of irrigation practices

We are going to focus on the crop irrigation requirements and are not going to analyze nor evaluate other subjects.

CROPWAT is meant as a practical tool to help agro-meteorologists, agronomists and irrigation engineers to carry out standard calculations for evapotranspiration and crop water use studies. It

allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules under varying water supply conditions, and the assessment of production under rainfed conditions or deficit irrigation.

Calculations of crop water requirements and irrigation requirements are carried out with inputs of climatic and crop data. Standard crop data are included in the program and climatic data for Chiang Mai region can be obtained through the CLIMWAT-database. However we are going to look for a meteorological station closer to our village. It could be Chom tong. The development of irrigation schedules and evaluation of rainfed and irrigation practices are based on a daily soil-water balance using various options for water supply and irrigation management conditions. Scheme water supply is calculated according to the cropping pattern provided.
Soil analyses have to be done in order to find out the percentage of mud, clay and sand and then determine if the soil can be classified as Light, medium or heavy, which are the default soil types in CROPWAT.

Procedures for calculation of the crop water requirements and irrigation requirements are based on methodologies presented in FAO Irrigation and Drainage Papers No. 24 "Crop water requirements" and No. 33 "Yield response to water".

CROPWAT includes a revised method for estimating reference crop evapotranspiration, adopting the approach of Penman-Monteith as recommended by the FAO Expert Consultation held in May 1990 in Rome.

The program can be free downloaded from FAO's website.

Appendix 6
Methodology for Water Quality Assessment

As it was said in the introduction we would like to find out how the water quality/drinkability affects the livelihood strategies in our village. Are the upland farmers polluting the water? Are the villagers lacking drinkable water? Is the water suitable for agriculture? Is the water quality a reason for confrontation between different stakeholders?
Interviews and water quality analyses are going to help us to answer these questions.

To determine the drinkability of water the following analyses have to done:

- Smell, taste, and cloudiness
- Conductivity
- Nitrates
- Nitites
- Ammonia
- Total number of coliforms
- Number of fecal coliforms

To carry out most of these tests expensive and sometimes heavy equipment is required as well as chemical compounds that might not be allowed in airplanes. Therefore we need to know what equipment we will have at our disposal in Chiang Mai University to decide if it is possible to carry out the trials. We should also ensure that we will be allowed to take the heavy equipment like

autoclaves, ovens, spectrophotometers, etc… to the village or that the water samples can be taken to the University in a reasonable period of time to analyze them.

Therefore we sent an e-mail to the Thai student asking for the available equipment and analysing techniques that don't require heavy and expensive devices. We are still waiting for the reply.

However we will describe some methods and why we want to carry out these analyses.

- Smell, taste and cloudiness:

This is probably one of the easiest tests to carry out. Water should be taste-, smell and colourless. The best way to do this analysis is tasting, smelling and observing the water.

- Conductivity:

Conductivity is a measurement used to determine a number of applications related to water quality. We will use it to determine the mineralization: this is commonly called total dissolved solids. Total dissolved solids information is used to determine the overall ionic effect in a water source. Certain physiological effects on plants and animals are often affected by the number of available ions in the water.

Criteria: Water quality criteria have been established only for the mainstem of the Ohio River. The limit is 800 micromhos/cm or 500 mg/L total dissolved solids.

The specific conductance of a sample is measured by a self-contained conductivity electrode.

- Nitrates:

This analysis will help us to find out if upstream farmers are polluting the water with fertilizers.

The analysis is based on the capability of nitrates to react with brucine in an acid environment changing its colour to red. These colour can be detected by spectrophotometry.

Maximum concentration allowed: 50 ppm

Expensive equipment is required to carry out this analysis.

- Nitrites:

High values of nitrites usually mean that water has been polluted with waste water or other substances containing bacteria.

The method is based in the Griess reaction, that implies a change of colour.

Maximum concentration allowed: 0,1 ppm

A spectrophotometer is required.

- Coliforms:

There are many different methods to estimate the number of coliforms in the water. The most common one is called Most Probable Number. Since the Thai students are more used to carry out these kind of analyses we are going to ask them which method they thing is better for our circumstances.