CHAPTER IV
WATER SITUATION AND TECHNOLOGICAL APPROACHES ON WATER MANAGEMENT

In this chapter, the researcher has analyzed information gathered from documents and other relevant reports including questionnaires, interviews, and public forum discussion as well as the water situation analysis on Ban Na Mai community. Based on the analysis and evaluation, the significant issues are proposed as follows:

- Social background
- Community water situation
- Need of water use in the community
- Approaches on technology and proper water management for the community

4.1 Social background

In 2010, the data collected from questionnaires of 149 household representatives, with the total population of 586 people, and the sample size of 20 local residents in Ban Na Mai community. The results illustrated the social background of the community and the analysis on general information of the sample sizes as follows.

4.1.1 Occupation: The main occupation is agriculture-related. It is found that 144 household, accumulated to 96.65% of the population, are involved with cassava farming, sugarcane farming, rice farming, and husbandry. The rest of the populations, accumulated to 3.35%, are involved with agricultural employment and trading.

4.1.2 Land possession and land use

Most local residents in Ban Na Mai community have their own lands accumulated to 94.94% or considered as 14,711 rai of land used for agriculture. Furthermore, some local residents have rented land for agriculture. The most popular crops primarily are cassava, and sugarcane, and rice consecutively. The rest of the land is used as residence or empty space. Nevertheless, it is quite noticeable that most agriculture lands in the area lack the abundance on the soil quality as well as water quantity for agriculture. Therefore, it has caused some diseases in plants including rice thrips and mealy bug. These diseases have damaged the production process. With this reason, Huaikrachao District Agriculture Office has asked community to reduce the land use for rice farming while increase the water resources based on the agricultural support plans. Yet, it is found that the production was still low in certain years due to the water shortage and insect disease. Therefore, the local residents have adjusted certain plant species and applied the technology knowledge from Huaikrachao District Agriculture Office in order to adapt to the proper production system. It would be suitable with weather condition and resistant to drought such as biological fermentation and neem extracts.

4.1.3 Economic system

The data from questionnaires and interviews on household economical background in the community showed that the primary household incomes were from agriculture and husbandry. The primary crops were cassava and sugarcane, found to be grown in 11,721 rai, bringing in income approximately 150,000-200,000 baht/household/year. However, the income from husbandry in 39 household was found to be 95,300 baht/household/year. On the other hand, income from non-agricultural activities including other employments and trading was found to be around 15,000-20,000 baht/household/year, and approximately 62,757 baht/household/year consecutively. Based on this information, it was found that the main incomes of the community were dependent upon water management system primarily. Nowadays, the local residents are interested in husbandry especially chicken farming which has generated high incomes. The production process has affected water use in the community. Therefore, the altered production process requires the proper water

management system to be in accordance with local conditions in order to reduce water shortage while increase the quality of life in the community.

4.2 Community water situation

There are several factors affecting current water situation in the community. According to the information gathered in the community, those factors are as follow.

4.2.1 Weather condition: The general weather of Ban Na Mai community is in tropical areas. With a short period of dry condition causing 3 seasons including summer, rainy, and winter. Nevertheless, Suphan Buri Rice Research Center has reported that:

Summer: Summer starts from the middle of February until the middle of May. When the Northeast monsoon ends, the winds from the South will take control. Therefore, the general weather is torrid and the average temperature at the end of April reaches the highest point at 43 °C.

Rainy season: Rainy season starts in the middle of May until November. This is the time when Southeast monsoon covers the areas in Thailand. Therefore, there is rainy during September with the high humidity. Yet, the highest average precipitation is found in October.

Winter: Winter starts from November until the middle of February. The Northeast monsoon takes the breeze from China to cover certain parts in Thailand. Therefore, during this time, Kanchanaburi province is quite cold and dry during November until January. The lowest temperature is measured at 13.1 °C in December.

4.2.2 Quantity of rainfall

Since Ban Na Mai community has no rainfall measurement station, therefore the researcher has to use the data from other closer measurement station from Thai Meteorological Department and the Royal Irrigation Department. The data had been recorded for 30 years gathered from 4 rainfall measurement stations including Phanom Thuan Telegraph station, Amphoe Muang Kanchanaburi province station, Hin Lab Plantation station, and Amphoe Bo Phloi station, Kanchanaburi province. Nevertheless, these stations are considered quite small. Therefore, the Arithmetic mean method is considered the most accurate method used to obtain the average rainfall quantity. During 1979-2009, the data illustrated, with the total of 30 years, the average monthly rainfall was found to be equivalent to 970.71 millimeter/year (Table 4.1).

Table 4.1 Average monthly rainfall during 1979-2009

Source: Royal Irrigation Department, 2010

Nonetheless, the highest rainfall quantity is able to identify the relationships between the rainfall and the runoff values in order to estimate the water quantity that will happen in the area as well as to plan water management in the future (Werapol Taesombath, 1986). Besides the analysis on the rainfall frequency, the tendency of annual rainfall, partly the rainfall variance could be found from the calculation of the rainfall probability, which is mostly a circulation. The relevant factor is the change in world weather caused from human activities which are very influential and mainly causing the tendency of drought and frequency of heavy rain. For instance, the occurrences of La Nina and El Nino have affected the drought situation that is happening at the moment.

The forecast on rainfall, the future runoff, the assumption on changes based on different weather are used to assess the effects on water quantity in reservoirs. Additionally, the analysis on effects of water management is taken into

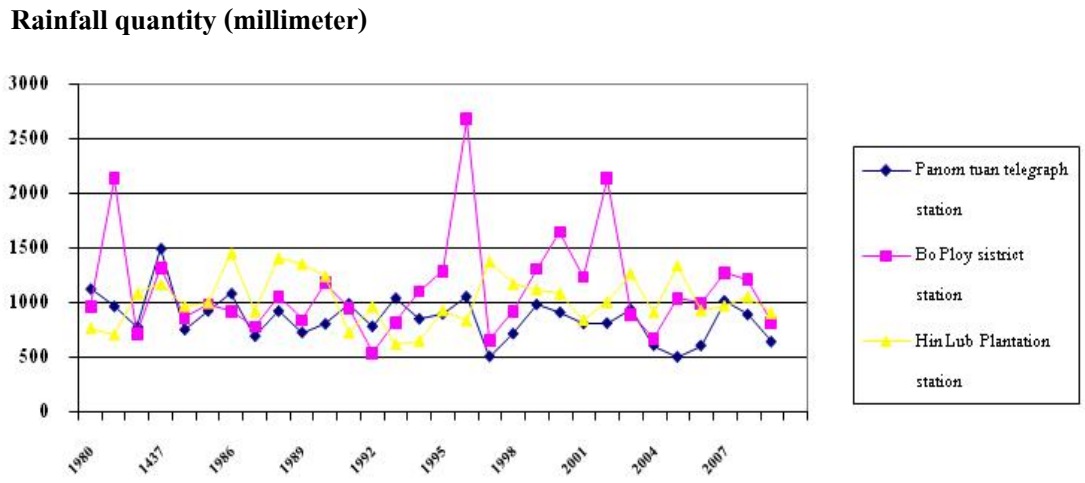
consideration. For instance, the areas in Eastern part of Thailand, Rayong and Chonburi province, which are primarily the industrial areas. In 2005, there was an event, when there was no rainfall, causing reservoir management system to fall apart. There was a big disagreement between the use for agriculture and industry during drought crisis caused from climate change (Sujarith Koonthanakulwong and Viraj Chatnarong, 2009).

Therefore, nowadays the weather forecast on drought and the frequency of rainfall are analyzed by certain relevant occurrences such as El Nino and La Nina. The effects from El Nino and La Nina, once the El Nino has become very severe, the rainfall value in Thailand would be lower than average and the temperature would be higher than normal. For instance, the severe El Nino occurred in 1997-1998, Thailand faced with the severe drought situation with the temperature higher than normal all over the country. The effects from La Nina, happened in 1999-2000, Thailand faced with frequent raining than normal and the temperature during winter had dropped, broke the record in December 1999. The areas with lesser and higher volumes of rainfall were mostly in front of the mountain as called as the air contact side. For instance, in rainy season, the Southeast monsoon has covered Thailand bringing the humidity from the sea and hit the mountain range. The humidity is afloat along the range of hill, then transforms into clouds and rains in front of the mountain. On the other hand, the back of the mountain faces with the end of the wind, therefore it is less rainy. For instance, the areas facing the wind in front of the mountain range are Thanontongchai mountain range and Tanowsri mountain range. However, the areas in the West of Tak and Kanchanaburi provinces are rainy. The areas that hit the end of the wind behind Tanowsri mountain range such as Petchburi and Prachubkirikan provinces are less rainy. The variance of rainfall could be found in Figure 4.1 (Irrigation officer in Royal Irrigation Department, interviewed on December 12, 2010).

The average rainfall is analyzed from the frequency of occurrence, the probability of flood in the future, or chances of floods in different forms by using the probability distribution theory (Werapol Taesombath, 1986). The information is gathered from Amphoe Bo Phloi station, Kanchanaburi province which is close to the

study area. The frequency analysis is performed based on Gumbel Distribution in order to assess the highest volume of rainfall in different periods of time that has occurred in 2-1,000 years. The annual highest rainfall quantity between 1-5 days is shown in Table 4.2.

Figure 4.1 Annual water variance of Phanom Thuan Telegraph station, Amphoe Bo Phloi station, Hin Lub Plantation station, Kanchanaburi province between 1980-2009



Source: Royal Irrigation Department, 2010

Table 4.2 Highest rainfall quantity between 1-5 days, Amphoe Bo Phloi station, Kanchanaburi province, with Frequency in Years

Highest rainfall quantity (day)	Average value (mm.)	The highest rainfall quantity (millimeter) with Frequency in Years								
		2	5	10	25	50	100	200	500	1,000
1	94.00	85.94	135.90	168.98	210.78	241.78	272.56	303.23	343.69	374.26
2	123.80	110.57	192.98	247.55	316.48	367.63	418.39	468.97	535.70	586.14
3	148.10	130.97	237.15	307.45	396.28	462.17	527.58	592.75	678.74	743.72
5	180.60	160.00	288.26	373.18	480.48	560.08	639.09	717.81	821.67	900.17

Source: Royal Irrigation Department , 2009

The variance of rainfall observed from the closer rainfall measurement station was found to be obviously different in certain years. The year with heavy rains, especially in 1996 and 1997 were found to have less rainfall quantity. Nevertheless, the study areas were under the influence of Southeast monsoon and typhoons.

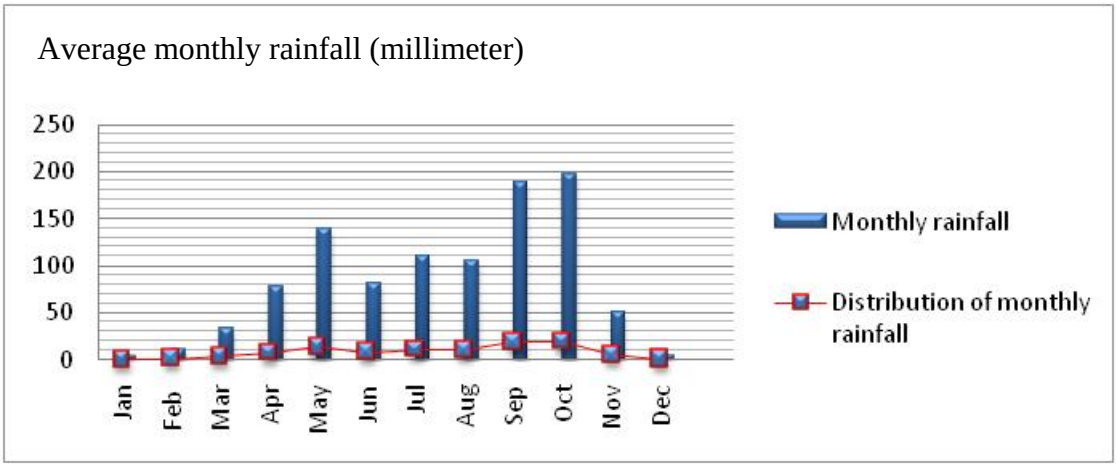
Generally, rain starts falling until it reaches the highest point, and then gradually drop (Manoo Srikajon, 1986).

Related to the rainfall dissemination, Table 4.3 illustrated the months with highest rainfall quantity between April – May, and September – October. However, the months with lowest rainfall quantity were between December – March, which is dry condition. Then, the rainy season started during April – May, which was the cultivation period. The rainfall would drop during June – July, which was the period when agriculturists have faced the annual drought period. The rainfall quantity over the study areas was influenced by the Southeast monsoon, occurring between May – October, as well as the cyclones from the Bay of Bengal during June.

The general storms that pass by were cyclones, tropical storms, and depressions. The central and the Northeast parts were influenced by storms during May, June, and September. Normally, rainfall were influenced by the Southwest monsoon. There were rains during May and June, which were the beginning of rainy season for annual rice farming. In certain years, there was less amount of rainfall or none at all, causing damage to rice farming. During June – July (mid of rainy reason), there was drought period approximately 3-4 weeks. Some years, if the drought persisted, it would affect agriculturists greatly since the growing crops lacked water. Therefore, the drought situation would occur causing water shortage for agriculture.

Rainfall dissemination and changes as mentioned earlier are related to community crops farming. Months with the most rainfall dissemination were May; accounted for 13.7%. This explained that the rains were disseminated all over the areas. In the past, community started rice farming during April – May, and cultivated during September – October. Nowadays, the farmers change their rice farming period to July – August instead. There are high rainfall quantities during September – October. The cultivation then starts between December – January because there is a drought period during June – July, affecting the plantation. However, during April – May, the rainfall quantity are not so heavy, so the farmers start their farming including sugarcane and cassava primarily. Since these crops are resistant to drought, therefore the farmers only need mere abundance soils for their farming. However, if droughts persist in that area for a long period of time, it is necessary to water the plants for them to grow. (Figure 4.2)

Figure 4.2 Monthly rainfall distribution, Kanchanaburi province, during 1980-2009



Source: Royal Irrigation Department, 2010

Therefore, the rainy season is the period with high rainfall quantity. It is necessary to develop water resources and water management plans in order to lay down measures for a proper common water use. This would reduce the drought problem as well as decrease the effects on agriculture produce of the community. Since rainfall are significantly relevant to other farming subjects, lands with abundance or could be cultivated are totally dependent upon the rainfall quantity over that area. Rainfall quantity is essential to the production process of the community. The information on monthly changes of rainfall would yield the analytical benefits on the effective farming for the community.

4.2.3 Runoff water

According to the location and the distribution of community water resources, it was found that the reservoirs were in different sizes and located into different agriculture areas and housing. The information is gathered shown in Table 4.3 and the distribution of community water resources show in Table 4.3.

Table 4.3 Water quantity in Ban Na Mai community

Sizes	Cubic meter
3 Public ponds cover 5 rai of land with 3 meter depth	68,760
2 Public ponds cover 4 rai of land with 3 meter depth	36,390
80 Private ponds cover average sizes of 804 square meter, and 2 meter depth	128,640
800 Storage equipments for consumption and water use available for 149 household (rainfall)	119,200
Total	352,990

Source: Field survey, 2009

Remark: Community has one artesian well with the depth of 40 meter and water availability of 1.14 cubic meter/hour.

Figure 4.4: Distribution of community water resources

Runoff in the community is approximately 352,990 cubic meter and is stored during rainy season. During drought, the water is cloudy and inconsumable due to the soil quality. Simply stated, soils have its own characteristics yielding different storing capacity. However, soils quality in the study areas are comprised of Chan Tuk series : CU, Kula Ronghai series: Ki**,** and Si Khiu series: Si. All these three soil types have the sandy soil or sandy loam characteristics and during the depth of 0-20 meter, soils are composed of red sandy loam, with the characteristics of no attachment. Therefore, it lacks the storing effectiveness or keeping water in the long period of time.

According to the interview and data gathering, it was found that water would run out pretty fast during drought season in the community because of the hot and dry weather. Additionally, the soil quality was sandy soil causing water evaporation and quick leakage. Water quantity in the reservoirs during April – June was below 80 centimeter. Therefore, farmers needed to raise their animals. So, they needed to use water from the distribution of the Tambon Administration Organization, approximately 34 household, accumulated to 326 cubic meter.

4.2.4 Activities of community water use

The activities of community water use are consisted of consumption, general use, and agricultural purposes. Those activities include water use for husbandry and agriculture. The needs for community use are explained as follows:

(1) Water for consumption and general use

The needs for consumption and general use could be calculated from the actual use multiply by the numbers of population in that year, it would yield the value of water demand in one year. The community water use was found to be equivalent to 60 litre a day (Pramote Maikad, 1992). The demand for water consumption and use during one year (2009) of Ban Na Mai community, comprising of 586 people, was found to be equal to 12,868.56 cubic meter/year.

The water resources used for consumption were from community water supply, retrieved from the one artesian well, and one five- rai pond. The average total water was equivalent to 18,900 cubic meter/year (Ban Na Mai community, 2009). The

water were distributed to 96 household. However, the other 53 household used water from their own resources as well as the distribution of the government units. Regarding to the household water consumption, the farmers stored rainfall in different types of storage including knobs, jars, and water tanks. On the average, the water storage for consumption was around 800 cubic meter/household, totaled to 119,200 cubic meter.

(2) Water for agriculture

Water for agriculture was divided into two categories including water for farming and husbandry. Water for agriculture was calculated from the water use for farming at the present. Crops that farmers grow on the study areas were rice, cassava, sugarcane, and cashew nuts. The local farmers use rainfall primarily for their plantation until cultivation. The water used for farming could be found from the amount of crops planted and the value of water demand for each plant as illustrated in Table 4.4.

Table 4.4: Types of crops and the water demand for plantation, 2010

Types of crops	Water quantity for plantation	
	Amount of plants (rai)	**Water demand (cubic meter/year)**
Rice	2,040	6,546,813.70
Cassava	9,164	17,079,547.55
Sugarcane	2,557	5,052,696.68
Cashew Nuts	950	4,246,863.83
Total	**14,711**	**32,925,921.76**

Sources: Amphoe Huaikrachao Agriculture Office, 2010

According to the planting plans of the community, the planting period started between April – June, or July since it was getting closer to the rainy season. Once the soils were moist, farmers were able to start farming especially crops that were resistant to drought and consumed less water. The water demand for each plant that the farmers chose to grow in the community could be calculated by the quantity of water use starting from the beginning of farming until cultivation as shown in Table 4.5.

Table 4.5 : Crop calendar of Ban Na Mai community in 2010

Crops	Quantity (rai)	Months											
		Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Rice	2,040												
Cassava	9,164												
Sugarcane	2,557												
Cashew Nuts	950												

Sources: Amphoe Huaikrachao Agriculture Office, 2010

For water demand of plants could be calculated from (Irrigation Office section 15, 2011):

1. Land preparation and nursery: Land preparation and nursery is the period before plantation or land preparation for plantation. The soil structures were easily cultivated and the roots were simply expanding.

2. Infiltration rate (P): The rate of Infiltration rate depended upon the soil conditions. For instance, the depth of soil layers that were prepared before being watered and the groundwater levels such as clays with the shallow ground water would lose water density around 1-2 millimeter a day. However, if it was a sandy soil with the deep ground water, it might lose the water density as high as 7-10 millimeter per day. Water that leaked into the soils (before the Root Zone) and merged with the groundwater, generally the P value would be equivalent to 1 mm/day. However, the characteristic value of growing sandy soil would be higher. For the rice farming areas, the value would be P = 1 mm/day.

3. Crop water requirement: Crop water requirement was the water demand of plants (Consummation Use or Evapotranspiration), the water quantity that plants needed to nurture its trunk or other structures, and evaporation. Water requirement was the actual amount of water used in combination with the lost water due to the Evapotranspiration and the Percolation.

According to the demand of water use for agriculture in the study areas, it was found that the rice farming with the size of 2,040 rai required water consumption around 6,546,813.70 cubic meter, the cassava farming with the size of 9,164 rai required water use at 17,079,547.55 cubic meter, the sugarcane farming with the size

of 2,557 rai required water consumption at 5,052,696.68, and the cashew nuts farming with 950 rai required water use at 4,246,863.83 cubic meter. The total demand for water use in the study areas was found to be equivalent to 32,925,921.76 cubic meter.

On the other hand, the demand for husbandry would be found from the quantity of water use multiply by the numbers of animals. The animals in the community were comprised of cows, buffaloes, and chicken. The water consumption for these animals was as followed (Pramote Maikad, 1992):

(1) Cows and buffaloes	50	Litre per day
(2) Chicken	0.15	Litre per day

The water demand for husbandry, for instance, 838 cows and buffaloes would require water consumption approximately at 18,402.48 cubic meter/year. On the other hand, the water demand for chicken farming would be equivalent to 84,710.70 cubic meter. The total water demand for cows, buffaloes, and chicken was equal to 103,113.18 cubic meter (Table 4.6).

Table 4.6: Water demand of animals of Ban Na Mai community in 2010

Types of animals	**Water demand for husbandry**	
	Numbers of animal (amount)	**Water demand (cubic meter/year)**
Cows and Buffaloes	838	18,402.48
Chicken	1,543,000	84,710.70
Total	**1,543,838**	**103,113.18**

Source: Amphoe Huaikrachao Livestock Office, 2010

The demand for water use in different activities in the community was divided into 2 categories including 1) demand for consumption and use; which was the household use, accumulated to 12,868.56 cubic meter/year and 2) demand for agriculture such as rice, sugarcane, cassava, and cashew nuts farming, accounted for 32,925,921.76 cubic meter/year, as well as the demand for husbandry such as cows, buffaloes, and chicken, added up to 103,113.18 cubic meter/year. All in all, the total

water use in different activities in the community was found to be 33,041,900.50 cubic meter (Table 4.7).

Table 4.7: Water use in three activities of Ban Na Mai community in 2010

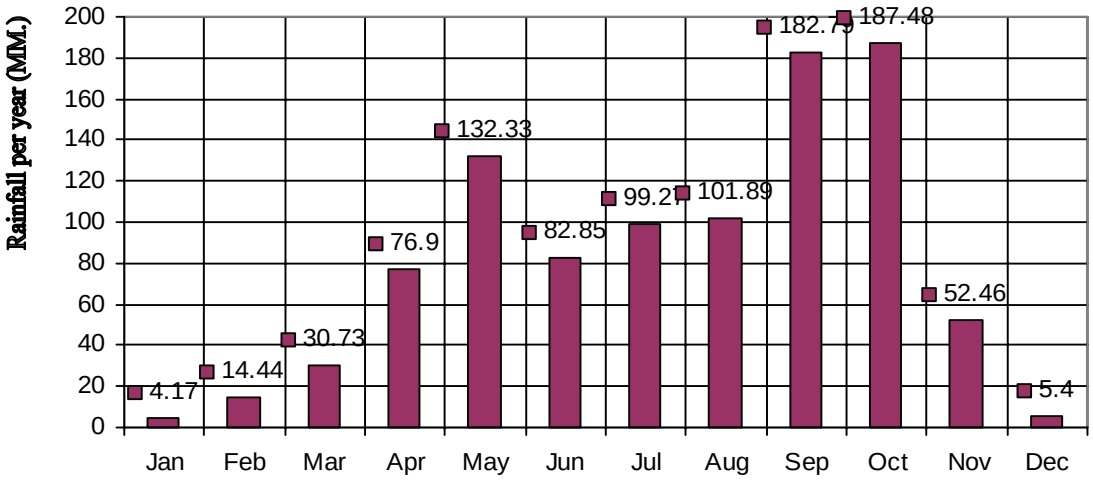
Activity of water use	Quantity of water demand (cubic meter)
Water for agriculture	33,029,034.94
Water for consumption and use	12,868.56
Water for Ecosystem 22%	8,127,509.63
Total water quantity	**41,169,413.13**

Source : Field survey, 2010

4.2.5 Community water management

The data collection from interview and documentation have illustrated that the community has used rainfall stored during rainy season in the month of May – October. The total demands on community water use for professions and consumptions were totaled at 41,169,413.13 cubic meter. Ban Na Mai community was situation outside the irrigation areas. Therefore, the primary water resources were from rainfall in the month of May, with the heavy rainfall during September – October (Figure 4.4).

Figure 4.4: Average monthly rainfall during 1979-2009



Source: Royal Irrigation Department, 2009

The quantity of water rainfall that was stored as the surface runoff in several place in the community was found to be approximately 352,990 cubic meter as categorized into two different purposes of use including:

1. Water use for consumption: In the past, the community used water from the shallow wells or water stored large water reservoirs. Later, the water supply system was developed in the community in 2006. It was aimed to solve the shortage of clean water for consumption and use through the construction of one artesian well with the depth of 40 meter. Additionally, water from public water resource with the size of 5 rai of land was brought to use for the production of water supply in the community. The management committees were set up to look after the water use, water consumption charges, maintenance and upholding water pipelines, and also the water allocation in response to the community needs. Presently, water used for water supply production could be used from February to March. During April, there was a timeline for water use from 6.00 – 8.00 am, and 4.00 – 6.00 pm. However, the villagers who lived outside of areas that water supply system were available, then there were constructions of water resources for household use.

2. Water use for agriculture: Since Ban Na Mai community was situation outside the irrigation areas, therefore most agriculturists had to cultivate their crops during rainy season with the use of rainfall stored for the crop plantations. The stored water would be used during drought season. There were constructions of water pumping stations. The cultivation started only during rainy reason. There were no agricultural activities during drought season since the water quantity was low and not sufficient for the needs. Additionally, the local conditions were dry, the weather was hot and not suitable for the agriculture.

On the other hand, water use for husbandry was retrieved from water resources constructed by the villagers. Especially, the farming entrepreneurs mostly constructed ponds with the size of 1 rai of land with the capacity of 5,600 cubic meter (the depth of pond was approximately 3.5 meter). The accommodation of one farm with approximately 20,000 chickens, with 5 times of chicken breeding per annum, would require the water use of 5.490 cubic meter.

In conclusion, the management of water use in the community was done on the individual basis. They aimed to develop the quality of their lives. Since the

majority of the villagers there were not well off, they had no budgets to build their own water resources, along with the attitude of maintaining water sources in their own lands that were costly, therefore they believed that large empty lands would be beneficial in making a living (Community's member, interviewed on April 8, 2011).

4.3 Need of water use in the community

Based on the community information, Ban Na Mai has covered the area of 16,763 rai and situated in shadow. According to the past, present and at the future information on water situation, it was found that there were problems from water shortage every year, especially drought problem, shortage for domestics, consumption, and agriculture. Mostly, the rainfall were primarily demanded in all areas. At the present, the population rate and community occupation have increased. In conclusion, the main reasons were:

1. There were insufficient amounts of water resources for domestics and consumptions such as public ponds or artesian wells. Regarding to the artesian wells, there were some restrictions on depth, the undrinkable water, and the limited amount of water (Community's member, interviewed on October 10, 2010). The local villagers used water from the artesian wells and public ponds supplying community water. Therefore, this service did not quite cover the whole community.

2. Since water used to make a living was from the water resources that the villagers built on their own. Mostly, it was small, shallow, and lacked maintenance on effective dredging because mostly the villagers were poor. Certain household had restricted land use. Therefore, the water resources were not well taken care of in order to store water effectively.

3. The community lacked a large size of water resources to store sufficient water for a whole-year use. Because of the existing water resources and the tendency of increase in water demands, it was found that the areas lacked the appropriation to be developed.

Pubic water resources in the community that could be used for domestics and consumptions were only two sources including the artesian well and one public pond with the size of five rai of land. Nowadays, these water resources were not able to supply water throughout the community. However, the other 4 public ponds with the capacity of 82,230 cubic meter could be used for husbandry and domestics for the villagers who lived close by. The public water resources were built on lands donated from the local people. Thus, the water resources were not distributed all over the area. Those villagers, who did not have the water supply system, then built their own water reservoirs on their own lands for the household use. This was done to substitute water supply system that was not available all over the place as well as to reduce the excavation of artesian wells which was quite costly.

Related to the governmental issues, the information was retrieved from the processed and documental data, therefore the government conducted the questionnaires in order to learn about the villager's problems. The problems were sorted in order based on its significance. The first problem that needed to be solved was the water shortage for domestics, consumption, and agriculture. There were several units involved with this problem-solving attempt including the Administration Organization, the Department of Fisheries, the District Agriculture Office, and other relevant units. These organizations were trying to come in and develop the water resources in the community. The conclusions were as followed:

1. The Department of Fisheries provided financial supports to build 2 water resources with the use of 3 rai of land for the agricultural purposes in 2005.

2. Amphoe Huaikrachao District Office supported the reduction in cultivated lands with the substitution of water resources instead by providing certain amount of budget. The villagers put in 2,500 baht for their parts in 2002.

3. Tambon Administrative Organization supported financial budgets for the pond excavation by asking the local villagers to donate the 3-5 rai of lands and turned it into public water resources. Currently, there are 3 public ponds available for agricultural purposes.

4. The distribution of water during drought was performed. Each household was given 200 litre of water and water containers during drought season. At

the present, water is not distributed equally to all villagers due to the restriction on the service buses that do not meet all the demands of the villagers.

Concerning to the government operations, it was found that the water shortage problem was not yet solved and the villagers still suffered from these difficulties including:

1. Water for domestics and consumptions: The 96 household were covered with the water supply system for their domestics. Since the condition of community water supply was rough and undrinkable, therefore the other 53 household needed to build water resources for their domestics. Regarding to the water for consumption, the villagers have their own containers including knobs, jars, and water tanks. On the average, water for household consumption was roughly around 800 litre per household. During the severe drought period, between April – June, it is the time when water become undrinkable for domestics purpose since the quality of water become thick and cloudy white.

2. Water for agriculture: The development of water resources from the governmental units has some restrictions on budgets. Since it is not sufficient and do not meet the demands of the villagers. Only certain numbers of villagers were given helps.

The attempts in solving these problems from the governmental units and the villagers were missing the participation. They did not take part in planning the development and they lack the connections between works from each unit. Therefore, the attempts were done on individual basis, not co-operated.

- **Trends of future water consumption and use**

Relating to the data collection from the calculation of water demand in Ban Na Mai community in order to analyze the future trends, the research has divided the future water use based on different activities at the present such as water for consumption and use and water for agriculture.

During 1999-2009, the numbers of population in the community have increased and decreased differently based on the rate of birth, death, and relocation. It

did not include the rate of students who study outside the community, who worked in other areas, and the outsiders who came in to take advantage on lands. The calculation on the rate of increase in population was conducted based on the calculation from the National Statistical Office.

Population growth rate is the fractional rate at which the number of individuals in a population increases, often expressed as a percentage of the number of individuals in the population at the beginning of that period. As the formula:

$$\text{Growth rate} = \frac{\text{Population at end of period} - \text{population at beginning of period}}{\text{population at beginning of period}} \times 100$$

The change in population over a unit time period is expressed as a percentage of the population at the beginning of the time period.

That is: Growth ratio = Growth x 100%

The rate of increase in population in the area was found to be 0.12% per year, suggesting the trends of future increase in populations as shown in Table 4.8.

Table 4.8: Population number of Ban Na Mai community, 1999-2009

Community	Numbers of population in the year 1999-2009 (persons)										
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Ban Na Mai community	570	577	580	582	584	585	586	593	586	577	586
Rate of increase (%)											0.12

Source : Filed survey, 2010

The future trends of population increase could be estimated from the numbers of population in the year 2009 as the calculation database, and the year 2019 as a target year. Concerning to the estimate on population from the year 2010 – 2019, it was believed that the population during 2010 – 2014 would be increased approximately 4 people per year (Table 4.9).

Table 4.9 Population increase expectation of Ban Na Mai community in 2010 – 2019

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Population (persons)	590	594	598	602	606	611	616	621	626	631

Remark : Population Data in the year 2009 as the year to start calculating

Thus, the researcher merely used the statistical population data from the local Sub-district Administration Organization and Huaikrachao Civil Registration Office primarily. The quantity of water use in the community was found to increase 88 cubic meter per year. During 2015 – 2019 (Tambon Wang Pai Administrative Organization, 2010), the rate of population increase was expected to be approximately 5 people with the increase in water use at 110 cubic meter per annum as illustrated in the following table.

Table 4.10: Rate of water use in different activities during 2010 - 2019

Year	Population (person)	Rate of water use (cubic meter) (60 litre/person/day)	Rate of increase (cubic meter)
2010	590	12,956.40	88
2011	594	13,044.24	88
2012	598	13,132.08	88
2013	602	13,219.92	88
2014	606	13,307.76	88
2015	611	13,417.56	110
2016	616	13,527.36	110
2017	621	13,637.16	110
2018	626	13,746.96	110
2019	631	13,856.76	110

Source: Field survey, 2010

According to the rate of water use during 2010 – 2014 was approximately 88 cubic meter per annum, during 2015 – 2019 was expected to be approximately 110 cubic meter annually, and the water use for consumption in 2019 was expected to be

13,856.76 cubic meter, with the increase of 988.20 cubic meter from 2009.

The future trends of water consumption in the community were used to analyze the water demand and water use in the future which were likely to increase. It yielded the effects on certain restrictions in water use in some areas. Nowadays, household water consumption and use were dependent upon rainfall and public ponds from the water supply system, which did not meet the demands. The researcher believed that there should be a proper water management and taking the untouched public water to use for the mutual benefits. This could be done effectively in order to reduce costs in searching and developing new water resources for the future expansion.

- **Future trends for agriculture use**

The area conditions are in rain shadow with no irrigation system. Water use for agriculture is primarily from rainfall. Therefore, the expansion and livestock areas become impossible because the crop farming in the future depend essentially on the existing water quantity and the selection of technology for proper water management system.

Relating to water use for agriculture and husbandry, the areas outside irrigation zone must rely on rainfalls primarily for their agriculture. Therefore, the harvesting time would be during rainy season starting from the end of April – October (Table 4.11). Consequently, water quantity that community demanded was only available in certain months. The analysis on water demand from the graph illustration proved that water demand for agriculture at the present days are between July – November which are a heavy rainfall period. The moisture in soil would be used to nurture the growth in plants. Therefore, the plants would lack water during drought between June – July, and December – March.

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Table 4.11 Rate of Monthly water use of Agriculture during 2010-2019

Activities/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
water for agriculature	2,404,713.87	498,263.80	863,096.20	1,998,812.81	2,485,544.86	2,488,128.59	4,318,266.50	3,931,679.17	4,214,890.68	4,126,104.44	3,244,015.11	2,352,405.72
water for livestock	8,733.63	8,170.17	8,733.63	8,451.90	8,733.63	8,451.90	8,733.63	8,733.63	8,451.90	8,733.63	8,451.90	8,733.63

Source : Filed survey, 2010

The local residents would be able to choose different types of plants to grow such as corns and other grains. This might increase the agricultural activities in the community. Furthermore, the future trends have showed the sign of change in plantation to growing rubber trees instead since it could yield more returns (Community's members, interviewed on December 15, 2010). Nonetheless, if there is a project development and sufficient quantity of water to meet the demands, this would increase the effectiveness in land use, quantity, quality, and the variety in the area.

Relating to water use for plants, each plan require different amount of water consumption variedly during the period of cultivation and growth. It would require the high amount of water quantity during the blossom. The plantation period in Ban Na Mai community took place during rainy season. While growing, plants were able to use moist from soil and oxygen for their rising. However, the water demand depended upon the diversion of its type, weather condition, types of soil, and how to grow them (Pramote Maiklad, 1981). Therefore, the monthly water quantity for agriculture would vary differently.

Therefore, there is an assumption that the study areas could be expanded to make full use of land. Generally, the local residents could grow crops in all over the areas with full potential to work in accordance with the tendency of market demands. Each household was given 1 rai of land, with the total areas for agriculture at 16,064 rai of land. The areas were divided into 1) the areas for rice and agricultural plants farming on the upland, which are quite appropriate to plant rice and other agricultural crops; 2) the areas for crop calendar in the highland, which are appropriate to grow agricultural crops. Currently, these areas were used to grow sugarcane and cassava as well as to feed animals.

The water quantity needed for plants farming were comprised of rice at 2,564 rai of land with the use of water at 12,411,796.35 cubic meter; mango at 950 rai of land with the use of water at 4,246,863.83 cubic meter; cassava at 9,500 rai of land with the use of water at 18,099,119.62 cubic meter; and the corns for husbandry at 250

rai of land with the use of water at 1,073,071.28 cubic meter. The total water demand was found to be equivalent to 41,960,756.64 cubic meter. Therefore, the proper water management suitable for the community had to take the calculation of water demand into consideration. It should also come with the proper water management approaches (Table 4.12).

Table 4.12: Plants and quantity of water demand for future agriculture

Types of crops	Water quantity for agriculture	
	Crops quantity (rai)	Water demand (cubic meter/year)
Rice	2,564	12,411,796.35
Cassava	9,500	18,099,119.62
Mango	950	4,246,863.83
Sugarcane	2,500	4,940,063.24
Watermelon	300	1,189,842.33
Corns for husbandry	250	1,073,071.28
Total	**16,064**	41,960,756.64

Source: Field survey, 2010

Concerning to the husbandry, the villagers are more interested in chicken farming business these days, because of the higher returns and the guaranteed prices from the trading companies. Therefore, chicken farming has become popular and likely to increase more. In 2009, there were approximately 379,029 chicken raised per year. However, after the study in 2010, there were 1,543,000 chicken raised per year. The increase rate has gone up 4 times. Then, it is expected that there would be more chicken farming business and in 2011 because of the support from chicken trading companies and the rewarding returns.

In conclusion, at the present days, the water demand in the community exceeds the actual water quantity according to the analysis of water demand for consumption and agriculture.

1) Household water consumption at the present days was retrieved from water supply system contributing to 96 households with the average use of 200 litre /person/ day. The calculation on water demand from population-based study during

1999 – 2010 demonstrated that the number of populations have increased only 0.12%. Therefore, the analysis on trends of future water demand based on the populations indicated that there was no difference in water consumption between present days and future. Simply stated, it yielded no effects on water demand in the community if there was a support on efficient and effective water use available for the whole community.

2) According to water for agriculture, it was found that the populations in the community had the agricultural areas approximately 14,711 rai of land for agriculture use, with the water consumption at 32,925,921.76 cubic meter. If the community were able to expand the land use for agriculture purposes covering the whole areas in accordance with the trends of water demand in the market, then the total agriculture areas would be approximately 16,064 rai of land, with the water consumption at 41,960,756.64 cubic meter.

The data on water consumption for husbandry has illustrated the total community husbandry at 1,543,838 animal, with the water demand at 103,113.18 cubic meter. The calculation and analysis on increasing trends of husbandry was expected to be more than 100% in 2011, and expected to increase 3-4 time of the statistics in 2020. Therefore, it would imply that the water demand in community for husbandry would be more than 563,747.68 cubic meter/ year.

All in all, the water shortage reasons for Ban Na Mai community were caused not only from the activities on water use in the community, other relevant factors were weather conditions, types of soil, and how to grow the plants. The area condition of Ban Na Mai was dry with hot weather condition. Mostly, there were sandy soil and loamy sand causing high demand in water activities in the community since the demand for professions were higher than the actual amount of water quantity in the community.

The current situation in the community has displayed the increasing trends of water consumption in the future, there should be supported on efficient and effective water use available by knowledge on water demand in the community and effective approach the water management .

4.4 Approaches on technology and proper water management for the community

According to the collection of different concepts on technology and proper water management for the conditions of the community areas, it was found that the study areas were out of the irrigation zone and situation in the Thachin river basin. Thus, there were some restrictions on water management in the areas. For instance, the study areas were in the less rainfall areas with the minimal numbers or rainfall per annum. The conditions of the areas lacked the large and effective water resources, the water quantity, as well as the potential in irrigation management such as the areas for water reservoirs, meteorological conditions, and irrigation engineering conditions. All in all, the approaches on proper water management from the Royal Irrigation Department were comprised of 2 courses (Irrigation engineer Royal Irrigation Department, interviewed on October 20, 2010; Royal Irrigation Department, 2009)

- The diversion of water from Lum Ta Plean sub-river basin
- The construction of electronic water pumping station

1. The diversion of water from Lum Ta Plean sub-river basin

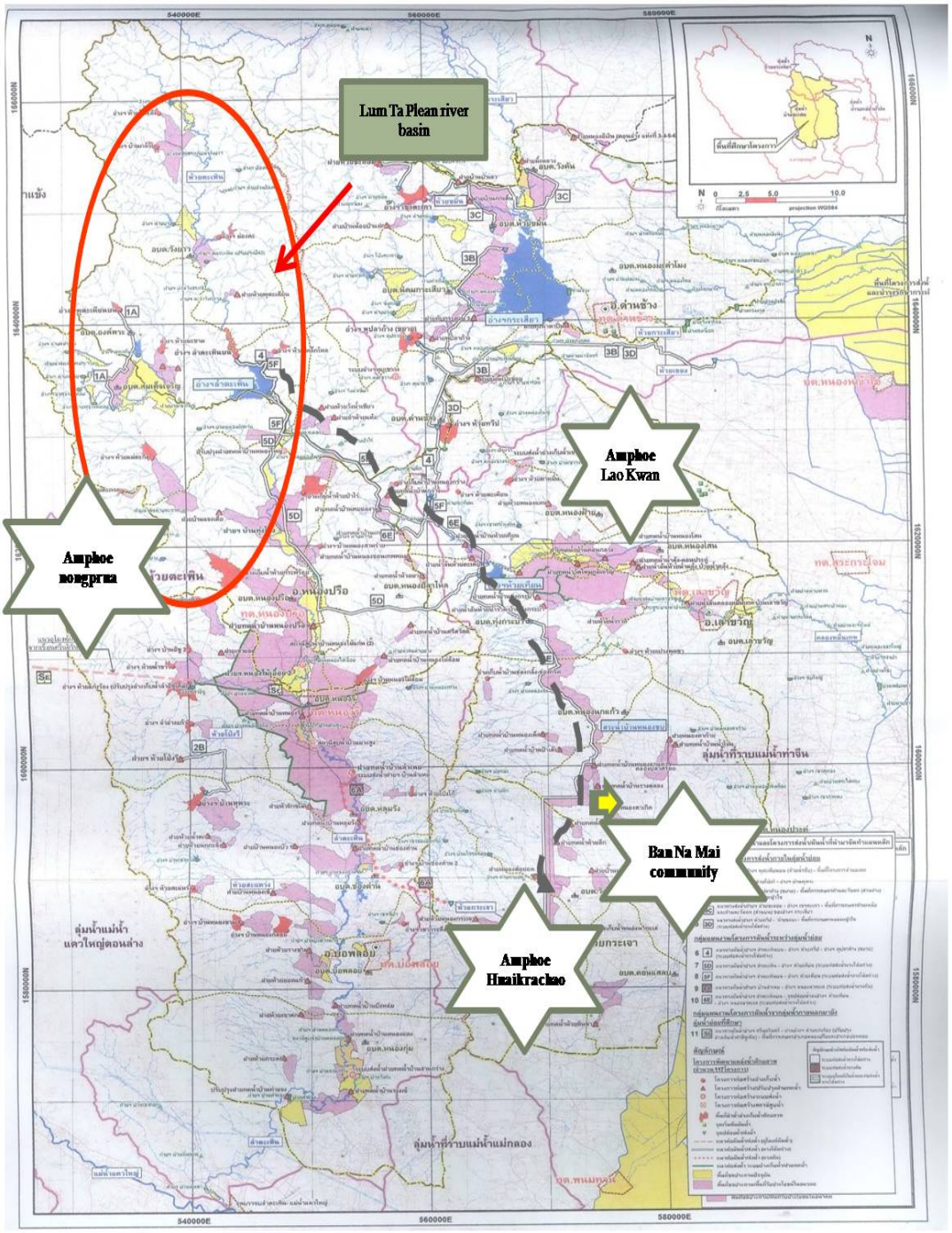
The water diversion from Lum Ta Plean sub-river basin were suggested by constructing dam in several sub-river basins such as Lum Ta Plean river basin and Ban Lum Hear river basin. The water management was done in several ways including the building of water reservoirs in the highland so that the water would flow down onto the plain. This would reduce the costs on transferring water into agricultural areas in the community. Additionally, the construction of small dam near the foothill water reservoirs was suggested. The assembly of the catchment to diverse water during rainy season and to release water into the designated areas as taken into consideration. This would release water down from the highland according to the force of gravity.

In the areas that demand water use, it was necessary to have the drainage basin similar to a small dam with the capacity of more than one million cubic meter.

Regarding to the water distribution, there was a release of water into the stream, the building of small dam, the construction of water transfer equipments from small dam such as water pumps, water pipelines, and waterways in order to make use of water effectively.

The benefits of water diversion from Lum Ta Plean river basin were to reduce the dry areas and to help the villagers bring in water into the areas, so the proper production process could be planned accordingly. However, Water diversion from Lam Ta Ploen sub-river basin was just the ideas gathered from the study as to guidelines for proper shortage solution in the areas. However, this project might not be actually implemented since there was high investment, along with the compensations on land and other belongings, as well as other possible environmental effects.

Figure 4.6 The diversion of water from Lum Ta Plean sub-river basin.



Source :Royal Irrigation Department, 2005

2. The construction of electronic water pumping station

The construction of electronic water pumping station was aimed to transfer water along with the water pipelines. It was the idea from the demand of transferring water in canal 1 on the left (Ban Pai Sri) which was originated from Amphoe Phanom Thuan and Amphoe Ta Muang water pipelines, at Au Thong, the Kanchanaburi Province Royal Project. It was the demand of constructing a canal along with canal 1 left with origin of the canal was measured at 19 cubic meter, and transferring water on the right side. On the other hand, the newly-constructed canal was originated from Tambon Ta Loe, Amphoe Muang, Kanchanaburi Province. The origin of the canal had a capacity of 50 cubic meter, along side with the canal 1 left. The water was transferred on the left side. There were some constructions of 30 water pumping stations in order to pump water for use. The water quantity from the origin of the canal once flow over to Pai Sri community was found to be approximately 15 cubic meter. Meanwhile, the canal 1 left at Pai Sri waterways were found to be around 5 cubic meter, after considerting the potential of water quantity, water pumping each time would not carry out more than 1 cubic meter. Therefore, after transferring water into Nong Na Talay water reservoirs, it would require the pipelines measured at 1 meter to deliver the amount of water equivalent to 0.88 cubic meter. The potential of water quantity was sufficient to cover the agricultural areas (Royal Irrigation Department , 2009).

Regarding to the water transfer engineering, water was transferred by pumping water through the pipelines and release onto the ground. This idea was to pump water to Amphoe Huaikrachao as well as pump water into Nong Na Talay water reservoirs, then release into Tambon Wang Pai. Conversely, the new waterways could be explored. Simply stated, the conditions of lowland and short distance to the areas were found to be appropriate. If the construction was conducted on the twisting pathways, highland, or long distance to the designated, the costs and expenses would be high accordingly (Royal Irrigation Department , 2009).

The investment on water pipelines to transfer water along the pipeline systems was costly. The execution of project would support the agricultural areas approximately 200,000 rai of land. The newly-built canal was characterized as the

broken tooth with the length from the area from Ta Loe temple – 30th kilometer, Amphoe Panom Tuan, Kanchanaburi Province. The Royal Irrigation Department was responsible and deligate the Tambon Administration Organization to manage the construction system as well as the water management. The return on investment was expected to be in a short period of time since the construction of water reservoirs was not required. The execution on water pumping and transferring along water pipelines and releasing onto the ground was expected. Yet, the agriculturists had to have the water pipelines, waterways, or water reservoirs to meet their needs (Royal Irrigation Department , 2009).

Limitation

For one water pumping station cover only 1,000 rai that was not sufficient to cover the whole Amphoe.

Pros

1. The Royal Irrigation Department provided certain amount of financial supports on construction of water pumping station.
2. The prototype was available for learning on executions.
3. The design of the construction had to come from the participations of the mutual thoughts and decision-making of community.

Figure 4.7 Pumping, pipelines and pound Construction of electronic water pumping station

Source : Office of the Royal Development Projects Board, 2010.

The ideas of water diversion as well as water pumping station were the concepts on water management originated from the study of the Royal Irrigation Department. The management on execution was performed by the Tambon Administration Organization who was in charge as the collectors of all community water expenses. The community members themselves had planned the water activity planning, the preparation of water reservoirs to transfer to the agricultural areas, and the maintenance of water pathways, which could be done through: (Royal Irrigation Department, 2005)

- Dredging top soil canals as well as laying concrete canals before the season, pumping water every time.
- Chopping grass along the waterways.
- Dredging waterways on their own farmland.
- Assisting on uninstalling and connecting water hoses.
- Repairing and adjusting soil quality along the canals.

The idea of constructing electrical water pumping station was plausible since the Department of Irrigation had projects on expanding their executions closer to Ban Na Mai community. The Royal Irrigation Department had proposed the community to allocated lands for the construction of water pumping station. Then, the execution would be proposed to the Department of Irrigation as the response to land ownerships through the community participation. In the past, other executions were implemented without any participation, they were only aware of the project merely. Therefore, once the community has started the execution in building the electrical water pumping station, they would feel the ownerships within them.

The ideas of managing natural water resources to make use in accordance with the appropriateness and the sufficiency of water for community demands, especially for agriculture and husbandry. In the past, the agriculture was dependent upon rainfall primarily. Plants did not get enough water as it demanded; therefore the productions were not that well. Within the rainfall-influenced areas, the rainfall quantity was not sufficient to meet the demands causing damages to the productions constantly. This was because each type of plant required different water consumption

quantities. For instance, rice farming did not require so much of water quantity during the beginning, yet it demanded more quantity gradually until the last period when the rice had produced grains and it started to mature. The agricultural plants, vegetables, and fruits required different amount of water quantity, especially in each step of the maturity. Generally, plants required less amount of water at the beginning and demanded more when it started to bloom and flourish. Then, it demanded less amount of water when it reached the full maturity.

Therefore, the suitable technology according of water diversion and electronic water pumping station in accordance with the community demand was analyzed from the surface runoff from the water diversion from Lum Ta Plean sub-river basin. The quantity of surface runoff was approximately million cubic meter/year. During rainy season, the Lum Ta Plean water reservoirs had the amount of surface runoff at 6.77 million cubic meter and 3.84 million cubic meter at during dry season supplying for consumptions mainly (Royal Irrigation Department, 2009).

Concerning to the electronic water pumping station at the Mae Klong river basin, the analysis on correlations on monthly surface runoff quantity at Wang Ka Nai station was performed. The average annual water quantity was found to be 116.84 million cubic meter. During dry season, the water quantity was found to be at 97.01 cubic meter (Royal Irrigation Department, 2010). Yet, it lacked the approaches on appropriate water management system during water shortage crisis and the likeliness of fighting over water during drought still.

4.5 Conclusion

The water situations of Ban Na Mai community that has happened from the past until present effecting water shortage in the community were caused from the degeneration of the community surroundings. Additionally, water resources in the community were small. The natural or the man-made water resources were not sufficient. The results showed that the causes of water shortage are: 1) water supply of the study area was less than community’s demand 2) the water management was comprehensively implement in community 64% of the total household in the

community 3) the study area was lack of irrigation development 4) lack of opportunity for potential of water management in the community.

The past water management of the community had certain relationships and relevance on the existence of all villagers in the community. This has yielded effects on one and another and has the tendency of multiplying severity if there were not suitable approaches that work in accordance with the local conditions as well as the participation of local community. Therefore, there data gathering from the water situations in the community would be proposed in the public forum to order to gain insights of the local villagers to find suitable and sustainable solutions.