IMPACT OF SHWE HLAN BO AND HTEE TAW MOE RIVER PUMPING PROJECTS ON THE FARM HOUSEHOLDS OF BENEFICIAL AREA IN SINTGAING TOWNSHIP

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A thesis submitted to the post-graduate committee of the Yezin Agricultural University as a partial fulfillment of the requirements for the degree of Master of Agricultural Science (Agronomy)

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The thesis attached hereto, entitled **"Impact of Shwe Hlan Bo and Htee Taw Moe River Pumping Projects on the Farm Households of Beneficial Area in Sintgaing Township"** was prepared under the direction of the chairperson of the candidate supervisory committee and has been approved by all members of that committee and board of examiners as a partial fulfillment of the requirements for the degree of **Master of Agricultural Science (Agronomy).**

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DECLARATION OF ORIGINALITY

This thesis represents the original work of the author, except where otherwise stated. It has not been submitted previously for a degree at any other University.

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DEDICATED TO MY BELOVED PARENTS,
U KYI SOE AND DAW YIN THAN

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ABSTRACT

Land and water are the most important natural resources in agriculture. Myanmar has great potential to extend cultivated area but water is the most important input for agricultural production. This study was carried out with two objectives: to observe the changes of agricultural aspects in the beneficial area of Shwe Hlan Bo and Htee Taw Moe River Pumping Projects, and to assess the livelihood of rural farm households in the beneficial area. A total of 160 respondents were interviewed by using structured questionnaires. The respondents were drawn using stratified random sampling technique in the head-end, the middle and the tail-end of pump irrigation area. It was clearly observed that types of land holding of the households were significantly changed from upland to lowland and orchard. Rainfed area and the cultivated area irrigated by self-irrigation schemes significantly decreased after constructing river pumping stations because of available water from pumping stations. After getting irrigation facility, rice growing households increased double and their average cropping intensity increased in the study area. Yield of some crops increased with irrigation facility and consequently main income from farming also increased. Accordingly, livelihood status of the households in the study area improved and infrastructure for community development partially improved through the development of agricultural aspects after getting irrigation water. There was not much negative impact on environment till the study period according to the perception of respondents.

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I
INTRODUCTION

1.1 Background of the Study

In Myanmar, the agriculture sector is one of the sectors that contribute to the economic development. Myanmar's economy has been dominated by the agriculture sector with around 25.6% of GDP and its share of export earning is about 24.4%. At the same time, agriculture sector provides employment more than 61.2% of work force (Ministry of Agriculture, Livestock and Irrigation [MOALI], 2018a). The development of agriculture sector mainly depends on how efficiently the scarce resources are being utilized. Sustainable economic development can only be achieved if the country's scarce resources are allocated in their best use.

Land and water are the most important natural resources in agriculture. Agricultural products are important to feed the growing population sufficiently. So, agriculture sector must be improved by increasing the cultivated area or by increasing the production per unit area through optimal use of available water resources and other agricultural inputs such as land, labour and capital.

The kings of Myanmar fully recognized the importance of providing adequate water for agricultural production. Special attentions are given to the establishment of irrigation networks for paddy cultivation. In the year 379 in Myanmar calendar (a thousand years ago), the diversion systems in Myanmar were improved and established with better irrigation technologies and have remained successful to date. In the same year, tank and canal irrigation systems were also constructed. Subsequent to the entry of the British into Myanmar and attendant colonial period, a Public Works Department was established to maintain buildings and construct new irrigation facilities in 1861. The activities relating to irrigation were solely handled by the Public Works Department (Soe & Kyi, 2016).

After the independence, various irrigation projects have been implemented. In Myanmar, canals, tanks, wells, and pumps are some of the different types of irrigation. Among them, canals and pump irrigation supply water for more than 50% of the total irrigated area. The most substantial increase in irrigated area was in pump irrigation followed by canal-type irrigation system (Soe & Kyi, 2016).

Food production and rural community are the largest water users, using as much as 70% of total fresh water supply, and most of the water are used for irrigation. With 40% of food grown from irrigated lands, irrigation is of significant importance to food security, social and economic development, and social ability (MOALI, 2018a). Myanmar is a country endowed with abundant water resources. As an agro-based country, water utilization of the agricultural sector of Myanmar stands at 91% of total water use, while industry and domestic uses account for only about 9%. Myanmar has great potential to extend cultivated area but water is the most important input for agricultural production. Therefore, the government of Myanmar has been constructing many irrigation facilities especially in the areas where water is scarce due to erratic rainfall (Soe, 2011).

Production of the rice sector was not possible without the development of irrigation facilities. Ministry of Agriculture and Irrigation (MOAI) identified five priorities for irrigation development: construction of new reservoirs and dams; renovation of existing reservoirs for raising storage capacity and efficient delivery of irrigation water; diversion of water from streams and rivulets during high water levels into adjacent ponds or depressions and for storage with sluice gates; lifting of water from rivers and streams through pump irrigation; and the efficient utilization of ground water (MOAI, 2010).

Agricultural development strategy includes the encouragement of double cropping and multi-cropping through the expansion of irrigation facilities such as construction of dams and river-water pumping stations (United Nations Convention to Combat Desertification [UNCCD], 2005). Beneficial irrigable areas due to completed irrigation facilities by the Irrigation and Water Utilization Management Department (IWUMD) are 1.838 million hectares in which 1.584 million hectares of farmland by 581 numbers of dams and other irrigation facilities and 0.254 million hectares of farmland by 205 numbers of river pumping and tube wells. And then, 0.302 million hectares of irrigation area are by the other ways, totally beneficial irrigable areas are 2.14 million hectares.

Up to the end of June, 2018, 786 numbers of irrigation facilities have been completed by IWUMD at the respective regions and states throughout the country and further increasing irrigable areas of 2.14 million hectares, on net sown area of 13.36 million hectares and totally beneficial irrigable area is about 16% of net sown area of the nation (MOALI, 2018a).

The cropping pattern followed in the irrigated area is superior to that of un-irrigated area and the output of crop is invariably higher under irrigated land. Irrigation facility allows the farmers to use the land more intensively throughout the year with higher level of cropping intensity, which is not possible under un-irrigated land (Dhawan, 1998). Irrigation enables farmers to farm year-round and diversify their crops. This can increase food security and profitability by enabling farmers to grow a greater range and variety of commodities and benefit from seasonal price variations in the market. Diversification in both of agricultural production and income sources reduces the risks associated with crop failure: diseases, pests, extreme climate events, fluctuating market demand and commodity prices (Cunguara & Garrett, 2011). The highly inelastic supply of land and reduced net sown area, the future growth of agriculture will have to heavily rely on irrigation facility as it allows for multiple cropping on the same piece of land (Narayanamoorthy, Alli & Suresh, 2015).

There must be a positive balance of benefits against risks and costs of irrigation. A more secure and increased crop productivity, improved planning and timing of start of the cropping season and extended harvest season, raised number of jobs and income are some knock-on effects that show how irrigation facilitates economic transactions and improves livelihoods and the wealth and infrastructure of whole villages (Lankford, 2003).

Irrigated agriculture is crucial to the economy, health and welfare of a very large part of the developing world. It is too important to be marginalized as it is vital for world food security. However, irrigated agriculture often radically changes land use and is a major consumer of freshwater. Irrigation development thus has a major impact on the environment. All new irrigation and drainage development results in some form of degradation. It is necessary to determine the acceptable level and to compensate for the degradation. This degradation may extend both upstream and downstream of the irrigated area (Dougherty & Hall, 1995).

Studies in Asia and other countries have shown that investments in water for agriculture have made a positive contribution to the improvement of productivity and livelihood of rural people. But there are also unsuccessful cases, even generating externality costs. In Myanmar, there is hardly any study on the assessment of the impact of irrigation development on the socio-economic status of the farmers despite the fact that the government has undoubtedly made significant investments on irrigation development (Soe, 2011).

1.2 Problem Statement of the Study

In Myanmar, national economic development depends largely on the agricultural sector. The government invested enormous capital on irrigation development which is about seventy percent and the rest from private sector. Irrigation fees that pay from farmers are low which could not even cover operation and maintenance costs of irrigation system. In Sintgaing Township, many river pumping stations were constructed along the Dokehtawady River. Eight river pumping stations were completed and some are on-going.

It is needed to access the impact of River Pumping Stations on agricultural aspects, socio-economic status of farm households and environment. Among eight river pumping stations, the expected and net beneficiary irrigated areas of Shwe Hlan Bo and Htee Taw Moe River Pumping Stations are larger than others. These two river pumping stations delivered irrigated water in 2010 and 2014, respectively. Therefore, this research was carried out with the following objectives.

1.3 Objectives of the Study

1. To observe the changes of agricultural aspects in the beneficial area of Shwe Hlan Bo and Htee Taw Moe River Pumping Projects
2. To assess the livelihood of rural farm households in the beneficial area

CHAPTER II
LITERATURE REVIEW

2.1 Importance of Irrigation in Rice Sector of Myanmar

Rice is staple food crop for Myanmar. Production of rice is intended not only for local consumption but also for contributing to needy countries over the world. According to the 2018 data, rice growing area was 7.26 million hectares and paddy production was 28.09 million metric tons (MOALI, 2018a). Myanmar has been known as a rice producing and exporting country since time immemorial. It has also recognized that Myanmar has great potential to export rice. The land use data indicated that Myanmar has still opportunities to horizontal expansion for rice production.

Paddy is a staple diet of Myanmar people and it also provides foreign exchange earnings. Seventy percent of the total population resides in rural areas and their main livelihoods depend on agriculture. Increasing new cropping areas through land development, cultivation of multiple cropping to enhance the cropping intensity and water source for crops are practiced in collaboration with farmer.

In Myanmar, total monsoon rice areas are 6.16 million hectares in 2017-2018. Among them, 0.82 million hectares of total monsoon rice areas are grown with various irrigation facilities. In 2017-2018, summer rice area is 2.71 million hectares (Department of Agriculture [DOA], 2018).

2.2 Irrigated Area in Myanmar

There are 786 numbers of irrigation facilities at the respective regions and states throughout the country. It was shown in Table (2.1) and (2.2). Completed, ongoing and planned river pumping projects on various rivers were shown in Table (2.3).

2.3 River Pumping Stations in Sintgaing Township

Eight river pumping stations have been completed and some are on-going in Sintgaing Township situated along the Dokehtawady river. Among them, two river pumping stations, Shwe Hlan Bo and Htee Taw Moe were selected for this study because expected and net beneficiary irrigated areas of these two river pumping stations are larger than others. Expected irrigated areas of Shwe Hlan Bo and Htee Taw Moe are 1214.58 hectares (3000 acres) and 607.29 hectares (1500 acres), respectively. In 2017, Shwe Hlan Bo river pumping station delivered to 362.35 hectares in rainy season, 607.29 hectares in summer season and 121.46 hectares in winter season. Htee Taw Moe river pumping stations delivered to 291.50 hectares in rainy season, 323.89 hectares in summer season and 80.98 hectares in winter season.

Table 2.1. Completed irrigation facilities and its related beneficial area in Myanmar

SN	Type of Irrigation Facilities	Number	Beneficial Area (ha)
1	Dam and Weir	342	903106
2	Tank	71	44422
3	Sluice	168	196911
4	Pump Irrigation Project	202	150545
5	Ground Water Irrigation Project	3	3561
	Total	786	1298545

Source: MOALI, 2018b

Table 2.2. Completed irrigation facilities in Myanmar

SN	State and Region	Dam	Weir	Tank	Sluice	Pump	Ground Water	Total
1	Kachin	-	5	-	-	5	-	10
2	Kayah	5	10	17	-	3	-	35
3	Kayin	2	1	2	7	8	-	20
4	Chin	1	-	-	-	-	-	1
5	Sagaing	29	10	2	1	31	2	75
6	Tanintharyi	-	1	-	20	11	-	32
7	Bago	39	13	-	14	23	-	89
8	Magway	55	10	2	1	30	-	98
9	Mandalay	48	15	36	-	36	-	135
10	Mon	5	-	-	11	4	-	21
11	Rakhine	14	-	-	-	9	-	23
12	Yangon	9	1	-	35	24	-	69
13	Shan	9	28	4	-	2	-	43
14	Ayeyarwady	6	1	-	79	16	-	102
15	Nay Pyi Taw	12	12	8	-		1	33
	Total	235	107	71	168	202	3	786

Source: MOALI, 2018b

Table 2.3. Completed, ongoing and planned river water pumping projects on various rivers

Name of River	Ayeyar-wady	Chin-dwin	Than-lwin	Sit-taung	Mu	Dokehta-wady	Others	Total
No. of Projects	86	22	6	29	24	27	196	390
Command Area (ha)	118749	39358	3474	11150	13072	7632	109280	302715

Source: IWUMD, 2018

There are 6 sets of 160-kilowatt motor + 20 cusec pumps at Shwe Hlan Bo river pumping station and 2 sets generated from 12 to 24 hours daily according to the demand of the farmers. At Htee Taw Moe river pumping station, 4 sets of 185-kilowatt motor + 20 cusec pumps were set up and delivered irrigated water to left and right canals with two weeks interval. Depending on the requirement of the farmers, 2 or 3 sets generated 18 hours per day (IWUMD, 2017).

2.4 Role of Irrigation

Historically, irrigation initiated as a method for improving natural production by increasing the productivity of available land and thereby expanding total agricultural production especially in the arid and semi-arid regions of the world. Crop production, asset creation and expansion of development frontiers were got due to irrigation access and availability. In Asia, rapid expansion of irrigated areas in the recent past, coupled with availability and access to new technology such as high yielding varieties (HYV), fertilizers and tube well and water extraction mechanisms in the late 1960s and 1970s were major elemental factors for the success of the green revolution. Better access to irrigation infrastructure facilitated intensification of cropping practices and inputs used, thus paving the way for the modernization of the agricultural sector (Bhattarai, Sakthivadivel & Hussain, 2002).

Irrigated agriculture is one of the critical components of world food production, which has contributed significantly to maintaining world food security and to the reduction of rural poverty. At the worldwide scale 307.96 million hectares are irrigated land. Most of the irrigated area locates in emerging/developing countries 245.87 million hectares (79.84%) and the total irrigated areas of developed countries are 51.76 million hectares (16.81%). Least developed countries had the lowest irrigated area only 10.32 million hectares (3.35%) (International Commission on Irrigation and Drainage [ICID], 2018).

Irrigation is often considered as the engine of agricultural growth as it takes part in an important complementary role in the process of crop cultivation. Various studies in India and elsewhere in the world corroborated that irrigation facility makes significant difference in productivity of crop and crop output (Hussain & Hanjra, 2004; Narayanamoorthy & Deshpande, 2005; Narayanamoorthy & Hanjra, 2006;). This happens because of various reasons. Productivity increased through better varieties and other bio-chemical technologies by getting irrigation facility. In irrigated area, not only cropping pattern but also output of the crop can change positively compared with un-irrigated area.

Farmers' land use pattern throughout the year is more intensive and cropping intensity increase in irrigated land (Dhawan, 1998). Under un-irrigated land, although crop can get risk in output due to moisture stress, it is much less in irrigated land.

Importantly, given the highly inelastic supply of land and reduced net sown area, the future growth of agriculture will have to heavily rely on irrigation facility as it allows for multiple cropping on the same piece of land. Irrigation may lead to poverty reduction through increased yields, increased cropping areas and higher value either by raising employment; cutting prices in an imperfectly open economy or if there are high transport costs (Rao, Ray & Subbarao, 1988). Yields increasing by irrigation can mean improved food supplies which lead to better nutrition levels. Irrigation can also help to decrease adverse consequences of drought. As irrigation can generate a stable flow of income through increased intensity of cropping, improved yields and more stable yields across seasons and years, it may also enlarge employment opportunities (Food and Agriculture Organization [FAO], 2000).

2.5 Impact of Irrigation

2.5.1 Cropping pattern and cropping intensity

Krishnakumari and Swaminathan (1990) examined the changes in cropping pattern, crop combination and crop diversification and the outcomes in Tamil Nadu, India. The result showed that the changes were mainly due to agricultural inputs as good varieties, fertilizer, pesticides, irrigation facility and tractor use while government also can influence cropping pattern through legislative and administrative measures. Matsuda (1994) mentioned that irrigation facility managed by farmers and choice of cropping pattern was strongly related.

Seetisarn (1977) mentioned that the most important factor influencing the existing cropping pattern in Chaing Mai Valley was the availability of water. Market and desire for higher income among farmers were also important determining factors of changing cropping pattern.

The enhancement in cropping intensity is possible because of availability of better irrigation facilities and increased use of new agricultural technologies (Singh, 1990). Increase in cropping intensity indicates increased agricultural development of a region (Singh, 2015). Kalaiselvi and Sundar (2011) studied the variations in cropping intensity in India and concluded that the highest cropping intensity was found in states of northern region while lower cropping intensity were observed in dry regions depending on rainfall.

According to the result, the cropping intensity was dependent on irrigation facilities. Panigrahy et al. (2004) found that the cropping pattern in Bhatinda district was shifted towards rice-wheat and cotton -wheat rotation. Authors observed that intensity of cropping had increased over time due to enlargement of the area under rice cultivation. Karunakaran and Palanisami (1998) found that cropping intensity had significant relationship with irrigation intensity in Tamil Nadu. Irrigation via dug well and tube well were found to had more positive relation with cropping intensity.

Ashraf, Kahlown and Ashfaq. (2007) analysed an evaluation of the impact of three small dams, namely, Jawa, Jasaka and Dhok Sanday Mar on agriculture and groundwater development in the Pothwar region of Pakistan. This study pointed out the availability of water, the land use, crop intensities, and crop yield have increased after construction of the dams.

2.5.2 Crop diversification

Crop diversification is the practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations and/or intercropping. It is perceived as one of the most ecologically feasible, cost effective and rational ways of reducing uncertainties in agriculture especially among smallholder farmers (Joshi, 2005). Basavaraj, Gajanana and Satishkumar (2016) observed that the number of crops grown by irrigated farmers was more than by non-irrigated farmers. This was also true in the case of household crop richness. Further, the average size of holding of irrigated farmers was large (12.8 acres). High returns were obtained from the larger size of holding, irrigation facilities and the associated number of high-value crops for irrigated farmers. Birthal, Jha, Joshi and Singh (2006) indicated that the extent of irrigation is the significant factor responsible for crop diversification.

Mahmud, Rahman and Zohir (1994) described that although many non-cereal crops (e.g., potatoes, vegetables, onions and cottons) are more profitable (both in economic and financial terms) than modern rice cultivation, expansion of these crops remains limited because of the associated high risk as well as incompatibility of the existing irrigation system to produce non-cereals in conjunction with rice. However, it has been increasingly recognized that, under non-irrigated or semi-irrigated conditions, better farming practices and varietal improvements of non-cereal crops will be more profitable and could lead to crop diversification as a successful strategy for the future growth and sustainability of Bangladeshi agriculture.

Studies on crop diversification in the literature are diverse and focus on its impact either on income or overall production. For example, Guvele (2001) concluded that crop diversification reduces variability in income in Sudan. Kar, Singh and Verma (2004) found that crop diversification in upland areas serves as a good measure to mitigate drought, as well as increasing water use efficiency, whilst also increasing the overall yield of the system in India.

To improve the productivity and profitability of small-scale irrigated farms, it is necessary to understand their reality, including the factors impeding their profitability and the context in which they operate with respect to socio-economic characteristics and government policies (Sitóe, 2005).

2.5.3 Concept of crop diversification

Crop diversification can be a useful means to increase crop output under different situations. Crop diversification can be approached in two ways. The main form and the commonly understood concept are the addition of more crops to the existing cropping system, which could be referred to as horizontal diversification. For instance, crop diversification can be defined as cultivation of field crops in rice fields or growing various types of other crops in uplands. However, this type of crop diversification means the broadening of the base of the system, simply by adding more crops to the existing cropping system utilizing techniques such as multiple cropping techniques coupled with other efficient management practices. Multiple cropping systems have been able to increase food production potential to over 30 t ha^{-1}, with an increase of the cropping intensity by 400-500 percent.

The other type of crop diversification is vertical crop diversification, in which various other downstream activities are undertaken. This could be shown by using any crop species, which could be refined to manufactured products, such as fruits, which are canned or manufactured into juices or syrups as the case may be. Vertical crop diversification will reflect the extent and stage of industrialization of the crop. It has to be noted that crop diversification takes into account the economic returns from different crops. This is very different to the concept of multiple cropping in which the cropping in a given piece of land in a given period is taken into account.

Besides the above, crop diversification can be defined by some other terminologies. There are terms such as crop substitution and crop adjustment. It is necessary to indicate here that crop substitution and adjustment are linked to the main concept of crop diversification and are strategies often used to maximize profit of growing varieties of crops. In various countries, the level of diversification will also be different. Diversification at farm level will involve growing of several crops for achieving self-sufficiency, but it may be a totally different approach at the national level. Crop diversification at national level will demand more resources and require selection and management of a specific crop or a group of crops sold freshly or value added to achieve higher profits. There are several advantages of crop diversification, 1) comparatively high net return from crops, 2) higher net returns per unit of labour, 3) optimization of resource use, 4) higher land utilization efficiency, 5) increased job opportunities. In order to achieve the above benefits, the process of diversification should be changed from very simple forms of crop rotations, to intensive systems such as relay cropping and intercropping or specialization by diversifying into various crops, where the output and processing etc., could be different. This process could be similar at farm level and national level (FAO, 2001).

2.5.4 Social change

Irrigation can transform not only society but also land and landscapes (Taylor, McClintock & McCrostie Little, 2003). Taylor expressed three waves of development which characteristically occur through irrigation development. Firstly, existing pastoral farmers move to improve their traditional farming base. Secondly, new-generation farmers enter into major irrigation investment. They increase stock numbers and productivity but generally stay with the same production base. Thirdly, widespread changes in land use and farm ownership take place which include conversion to dairying and other intensive land use options.

Sharma, Samyuktha and Deepa (2008) mentioned that irrigation schemes generally stimulate population growth, help arrest population decline and by so doing help maintain the rolls of rural schools. It may also provide increased employment to the area provided the new land uses contribute more on farm jobs than existing forms of agricultural production. Combined, these factors help maintain social networks and sustain community vitality. Farmers with assured irrigation are able to put aside cash to provide for their children’s schooling and college.

2.5.5 Environment

Kerr and Kohlaralli (1999) presented that although large irrigation projects are taken as a useful tool in boosting the economy of developing world, they have negative environmental impacts including waterlogging and salinization of soils, increased incidence of water-borne and water-related diseases, resettlement or changes in the lifestyle of local populations, and increases of agricultural pests and diseases resulting from the elimination of dry season and the creation of a more humid microclimate. Irrigation has a considerable economic and social impact. However, some practices compromise short-term sustainability of production systems by irreversibly deteriorating natural environment. Normally the activities carried out for the purpose of social and economic development should not put at risk the environment and natural balances.

Majoro, Mukamwambali, Shumbusho and Hagenimana (2016) described that irrigation system has positive and negative effects. Among positive impacts, it comprises the increase in agricultural production thereby ensuring food security which results in poverty and hunger reduction. The reservoir formation in Rwanda for irrigation purpose has also brought new genus clarias fish species. Regarding the negative impacts, the irrigation system has created several changes in the host environment. Among them, biological changes include the destruction of the existing fauna and flora. With regard to the physical environment changes, irrigated area is regularly submerged which implies the presence of micro-organisms responsible for diseases.

Hasnip, Mandal, Morrison, Pradhan and Smith (2001) reported that the impact of irrigation on the environment should be analyzed at two levels. This is to determine whether this system of agricultural modernization is unsustainable due to poor design and/or management of irrigation infrastructure, or irrigation *per se.* The direct impacts of the construction and subsequent operation and maintenance of irrigation on the natural capital stock can be assessed in terms of change in the status of natural capital for productivity and sustainability of resource use, both within the command area and downstream. Positive impacts include an improvement in agricultural productivity as a result of improved control of soil moisture, and increased farmer ability to invest in land improvements that enhance sustainability.

2.5.6 Livelihood of farmers

Huang, Rozelle, Lohmar, Huang and Wang (2006) studied the impact of irrigation on grain production and incomes, and on poverty alleviation particularly in poor area of China. The observations in this study were divided into rich and poor households. The study found that overall revenue from irrigated plots was 79% higher than that of non-irrigated plots. Moreover, farmers in rich and poor areas earned higher revenue from their irrigated crops but the higher revenue was more in poor areas. Since the incomes of poor area relied more on cropping, the income of farmers in poor area increased relatively more than farmers in richer area. Thus, the study provided evidence on the importance of irrigation in past and future poverty alleviation efforts in China. The study also showed that the majority of the villages that invested in new irrigation had positive returns even after accounting for increases in capital and production cost.

Faurès, J.-M., and Santini, G. (2008) also argued that well-targeted, local interventions in water can contribute to rapid improvements in livelihoods of the rural poor in Sub-Saharan Africa and help attain the Millennium Development Goals of eradicating extreme poverty and hunger. In fact, Faurès, J.-M., and Santini, G. (2008) identified better management of soil moisture and investment in water harvesting and small storage as two promising interventions in view of their poverty-reduction potential.

Another study of Tesfaye, Bogale, Namara and Bacha. (2008) observed the impact of small-scale irrigation on household food security in the case of Filtino and Godino irrigation schemes in Ethiopia. The study revealed that access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. The study also found that about 70% of the irrigation users are food secure while only 20% of the non-users are found to be food secure. Access to small scale irrigation enabled the sample households to grow crops more than once a year; ensure increased and stable production, income and consumption, and improve their food security status. The study concluded that small-scale irrigation significantly contributed to household food security.

Shah (2008) studied the relationship between irrigation and agriculture productivity. The study analysed the relationship between agricultural productivity and poverty alleviation in Chasham Right Bank Canal (CRBC), Pakistan. The result of the study showed that all the relevant variables (e.g. area under cultivation, per acre yield, cropping intensity, income, and consumption) have increased significantly. The study noted that CRBC has played a crucial role in increasing the agricultural productivity and, in turn, agricultural productivity has reduced poverty not only in the command area but also in the adjacent areas.

Hanjra, Ferede and Gutta (2009) examined the linkages between agricultural water, education, markets and rural poverty by reviewing many published studies. The study argued that linking agricultural water, education, and market interventions, which are so often implemented separately, would generate more effective poverty reduction and hunger eradication programs. The study found that the poverty trap in smallholder African agriculture can be broken by investing in agricultural water management and complementary rural infrastructure and related policies.

The impact of irrigation investment on poverty reduction in Tigray, Ethiopia was evaluated by Gebregziabher, Namara and Holden (2009) using propensity score matching (PSM) method. The study found that access to irrigation had significant poverty reduction impacts. The overall mean income and consumption levels of irrigators were significantly higher than that of rain-fed farmers. It also found that farm income is more important to irrigation households than non-irrigation households, and off-farm income is negatively related to access to irrigation.

2.5.7 Income distribution

Solanki (2003) analyzed equity issues and their socio-economic impact in a tribal dominated irrigation project of India**.** For a detailed study of irrigation equity, Kasharpura minor was selected and it was divided into three segments such as head-end, middle and tail end. Irrigation equity leads to overall socio-economic development in an irrigation project. The study found that the farmers located at the head of the minor were getting more water compared to other farmers but they misutilized the water and did not use water rationally. On the other hand, the middle farmers were getting water moderately and the tail end users suffered high scarcity. The result of the study revealed that the socioeconomic conditions in terms of cropping pattern, cropping intensity, farm income and farm and family assets were better in middle farmers followed by head and tail end farmers.

Several studies in the past have shown that the yield level of crops in field plots, away from the water courses, sharply declined across the gradients of the irrigation outlet, i.e., yield declines when moving from the head towards the middle and the tail-end locations, respectively. This is mainly due to disproportionate water allocation among the reaches. In addition to crop yields, labor, income and farm employment opportunities and livelihoods both hired as well as family labor income also declined sharply across the gradient of the irrigation channels (Bhattarai, Sakthivadivel & Hussain, 2002). Studies, in some cases, have also reported that the income of head reach farmers was more than six times higher than that of tail-reach farmers in a minor (Chambers, 1988).

Bhattarai et al. (2002) stated that the farm level income and crop production reduced at the tail-end, the quality of farm infrastructure and governmental services also deteriorate. More incidence of water related conflicts and quarrels and water related disputes and court cases are found in the tail-end locations than at the head- end locations. Thus, the overall earnings and livelihoods in the tail end are at much lower levels than at the head end, and this is in fact much more serious than waterlogging and increased salinity impacts occasionally reported in the head end, arising out of poor drainage facilities and over irrigation of fields.

2.5.8 Water reallocation

Bello (1987) studied the effects of differential availability of water on rice yields and farm practices in Vaca creek irrigation system. The study observed that average rice yield was lower in laterals located farther from the source of water compared to those situated near the water source.

Inequitable water distribution in a surface irrigation system (large scale canal system) is one of the major factors contributing to income inequality in irrigated agriculture. This is, however, still one of the unresolved issues in water distribution policies in irrigation commands. The problem is particularly severe in large-scale irrigation commands in developing countries with large numbers of smallholding farmers. Several studies have informed on water allocation between head and tail reaches that farmers at the tail end of the canal received a disproportionately small amount of irrigation water and sometimes no water at all. The head-end farmers, however, receive an unduly large share of canal water (Chambers, 1988; Shah, 1998).

Bhattarai et al. (2002) stated that the inequitable distribution of water across the head and tail ends of the canal system is clearly depicted through the farm-level actual water application data for these irrigation commands. The tail-end farmers unequivocally received a smaller share of water than the head-end and the middle-end farmers did. Within different reaches of the Rohera irrigation command in India, and the Khadir irrigation command in Pakistan, the tail-end farmers received, on average, only about 20 percent of the water than what head end farmers of the respective irrigation commands received for winter wheat in 2000-01. These farm-plot level water application data show the severity and gravity of the water allocation problem across the different reaches of the irrigation systems. Besides, receiving a smaller amount of water in absolute terms during any crop season, the tail-end farmers also face the high uncertainty level and fluctuation associated with water supply at the end reaches, inhibiting the adoption of improved agricultural technology and use of modern inputs (fertilizers and HYV) compared to their fellow farmers at the head reaches. Likewise, other irrigation water induced crises commonly seen at the tail-end reaches are less irrigation intensity, low level of agricultural intensification, widespread adoption of low yielding varieties (that can withstand water stress) and poverty-stricken livelihoods compared to the head end. The impact of the high variability in water allocation is one of the critical factors influencing poor performance of agriculture at the tail reaches in relation to the head reaches leading to the underperformance of the system as a whole.

Malashkhia (2003) said that water distribution is a problem as unequal distribution of water is another factor that is involved in emerging water stress conditions. It is result of water overuse at the head of the canal bringing less water toward its ends. So, the farmers at the tail of the canal and downstream suffer from water shortages and are forced to abandon cultivation of some part of their land in order to avoid yield losses, whereas at the head of the canal peasants enjoy the abundance of irrigation water.

Panda (1986) studied the use of water and its impact on cropping pattern at different locations of a canal system in Bamnal minor canal in Orissa. The study identified that due to availability of adequate water at the head reach and the middle reach, the farmers had devoted a considerable proportion of area to labour and capital-intensive crops like high yielding rice and potato. In contrast, because of inadequacy and uncertainty of water at the tail reach, the farmers had cultivated low duty crops like pulses and groundnut on a larger scale than their counterparts in the other two locations of the canal. The cultivation of vegetables occupied a higher percentage of area in the head reach (14.4%). In the mid reach, potato had higher percentage area (7.44%). Pulses (23.76%) and groundnut (11.88%) had higher percentage at the tail end.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Description of the Study Area

Sintgaing Township was purposively selected for the study. This Township represents as an area for river pumping irrigation. Sintgaing Township is located in Kyaukse District. It is situated between latitudes 21º 39′ North and 21º 51′ North and longitudes 95º 57′ East and 96º 16′ East. Total area is 173.18 square miles and it is 13 miles long from east to west and 15 miles from south to north. It is located in the central Myanmar. Dokehtawady river flows from east to west in Sintgaing Township and Panlaung river and Zawgyi river flow into Dokehtawady river from south to north (General Administration Department [GAD], 2018).

The land utilization of Sintgaing Township is shown in Table (3.1). The total land area of Sintgaing Township was 44872.88 hectares. The lowland was 16503.24 hectares, the upland was 10583.81 hectares, the orchard was 929.96 hectares of the total land of Sintgaing Township. The upland covered 23.59% of the total area. The lowland was 36.78%, orchard was 2.07%, fallow land (lowland and upland) was 0.37% reserved forests was 6.68%, uncultivated land was 30.52% of total area (DOA, 2017).

The types of land in study area were stated as upland land and orchard by Department of Agricultural Land Management and Statistics (Department of Agricultural Land Management and Statistics [DALMS], 2017). According to the water availability, soil type and location of the farm, farmers cultivated lowland crop such as rice. Therefore, land in the project area is grouped into three categories: Paddy-land, Ya-land (upland), and Orchard-land and orchards were grown on upland.

The project area has a tropical monsoon climate with three distinct seasons: a rainy season from mid-May to mid-October, a dry cool season from mid-October to mid-February, and a hot dry season from mid-February to mid-May. The annual precipitation of Sintgaing Township is about 1018.54 mm. An average temperature is 28.32ºC. The maximum rainfall was 224.54 mm in October and the minimum rainfall was 0.76 mm in February 2017. The average monthly temperature ranges from minimum of 18.35ºC to maximum 36.23ºC throughout a year. The weather data is shown in Appendix (1) (DOA, 2017).

Table 3.1. Land utilization of Sintgaing Township

Land Utilization	Hectare	Percentage
Lowland	16503.24	36.77%
Upland	10583.81	23.59%
Orchard	929.96	2.07%
Reserved forests	2996.76	6.68%
Uncultivated land	13694.33	30.52%
Fallow land (lowland and upland)	164.78	0.37%
Total	44872.88	100.00

Source: Department of Agriculture (DOA), 2017

3.2 Sampling Procedure and Data Collection

The data of secondary and primary sources were used in this study. Secondary data were gathered from various sources such as several books; public journals, thesis, government and non-government organizations and other related publications. The data on land utilization, studied village profile and information of Sintgaing Township were collected from Department of Agriculture (DOA). Information of the river pump stations such as starting year; service areas were collected from IWUMD.

The information needed for the study was collected by conducting a field survey. The survey was carried out in August 2018. A total of 160 farm households were interviewed by using structured questionnaire. For the survey, the sample respondents were drawn using stratified random sampling technique in head-end, the middle and the tail-end areas of pump irrigation. The respondents were grouped as Pump Station-1, Pump Station-2 and Pump Station-3 for Shwe Hlan Bo pump station (PS). Htee Taw Moe pump station delivered irrigated water from only one pump station. The respondents were selected from two villages to represent Htee Taw Moe pump station. Sample households which got water from Htee Taw Moe pump station added in head-end portion. Firstly, river water was pumped into the PS-1 and then delivered to PS-2 and PS-3. Therefore, it meant PS-1 as the head-end, PS-2 as the middle and PS-3 as the tail-end. Sample farm households selected from four villages from two village tracts. The head-end and the tail-end villages located in Meethwebote village tract, and the middle portion, Ywarbo located in Htaunggyigwae village tract. As shown in Appendix (2), Meethwebote and Kingtone were selected to represent the head-end, and Ywarbo and Nattyaekan were selected to represent the middle and the tail-end, respectively. A total of 105 sample respondents were selected from the head-end villages (Meethwebote village and Kingtone village) and 30 respondents from Ywarbo village were selected to represent the middle portion. For the tail-end portion, 25 respondents were selected and all sample respondents of three portions were randomly selected from the households which used river pumping water. Meethwebote village is located about 14 miles from Sintgaing Township while Kingtone, Ywarbo and Nattyaekan villages are far from Township about 11, 10 and 16 miles, respectively.

In this study, the data collected were demographic data (age, education, farm size, etc.), agricultural aspects (land type, irrigation scheme, cropping pattern and cropping intensity and crop yield), livelihood of the households (household income and their assets, housing conditions etc., infrastructure for education, health and transportation) and farmers' perception on environment (losses of the grazing pasture fields and tree, tree endangering and more greenness) to cover agricultural development, social and environmental changes.

In this study, cropping intensity and crop diversification were calculated to compare the agricultural conditions of the region before and after constructing river pumping stations. Cropping intensity is defined as a ratio between net sown area and gross cropped area. It is calculated by the following formula: -

$$\text{Cropping Intensity Index} = \frac{\text{Gross Cropped Area}}{\text{Net Sown Area}} \times 100$$

(Deshmukh & Tanaji, 2017)

The intensity of cropping, therefore, is computed by the number of crops raised from the same field during one agricultural year. If one crop is grown on a field in a year, the index of cropping is 100 percent, if two crops a year are produced, the intensity index will be 200 percent and so on.

Crop diversification index (CDI) was used to get the cropping diversification status of individual household.

Formula of Gibbs and Martin Index is:

$$\text{GM} = 1 - \sum(X^2)/\left(\sum X\right)^2$$

(Gibbs & Martin, 1962)

Where,

X = Percentage of total cropped area occupied by each crop or hectarage under individual crop.

The zero outcomes indicate for no crop diversification while the greater the resulted number, the more the crop diversification. The GMI value will be within 0 and 0.9.

3.3 Data Analysis

Some data were given numerical codes to continue data processing. These coding and responses were compiled into Microsoft excel program. Sets of primary data from the household survey were processed by using the Statistical Packages for Social Science (SPSS version 23) software. Descriptive statistics such as the mean, frequency counts, and percentage distributions were used to describe socioeconomic and agricultural conditions of sample farm households. Paired sample t-test and Pearson Chi-square test were used in order to compare the socioeconomic characteristics, agricultural production activities and other improvements before and after constructing pump stations.

CHAPTER IV
RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of the Respondents in Beneficial Area of Shwe Hlan Bo and Htee Taw Moe River Pumping Stations

4.1.1 Demographic characteristics of the respondents

The majority of the respondents were male accounting for about 93.13% of the sampled population, and only 6.87% were female. Their age was ranging from 26 to 92 years (Table 4.1). A total of 92.50% of respondents were from 37 to >66 years. The respondents with the age between 26 to 36 years were only 7.50%. Therefore, this study implies that majority of the respondents were from the middle ages to the old ages.

In this study, education level of the sample respondents was categorized into five groups: (1) monastery education, (2) primary school, (3) middle school, (4) high school, and (5) graduate. The respondents of 37.50% were with monastery education, 36.87% with primary school, 18.75% with middle school level and only 6.25% with high school. Among the respondents, only one is graduated representing 0.63% of the total respondents (Table 4.1).

The average household size of the sample households in the study area was 5 (4.77) persons ranging from 1 to 10 persons. The average household member in farm was 2 (2.11) persons with a range of 1 to 7 persons. It indicated that two persons out of five family members were working in farming and the other three persons were engaging in other works such as housewife, the persons who work non-farm and off-farm activities, and dependent children and old people.

4.1.2 Total farming experience and irrigated farming experience

Farmers' working experiences play an important role in agricultural production. It is expected that if farmers' experience is higher in farming, the production capacity of the farmers will be better (Oo, 2018). In this study, the respondents can be classified into five groups according to their farming experience (Figure 4.1). Among the five groups, two groups of the respondents with 16 - 25 years and 26 - 35 years of farming experience were the same percentages (27%) of total respondents. The other three groups were the respondents with 36 - 45 years (23%), with >45 years (12%) and with 5 - 15 years (only 11%) of farming experience.

Table 4.1. Demographic characteristics of the respondents in the study area

Items		Households	
		Frequency	Percentage
Gender	Male	149	93.13
	Female	11	6.87
Total		160	100.00
Age group (year)	26 - 36	12	7.50
	37 - 46	40	25.00
	47 - 56	44	27.50
	57 - 66	38	23.75
	>66	26	16.25
Total		160	100.00
Educational Level	Monastery	60	37.50
	Primary School	59	36.87
	Middle School	30	18.75
	High School	10	6.25
	Graduate	1	0.63
Total		160	100.00
	Mean	Minimum	Maximum
Household Size	4.77	1	10
Household Members in Farm	2.11	1	7

N = 160

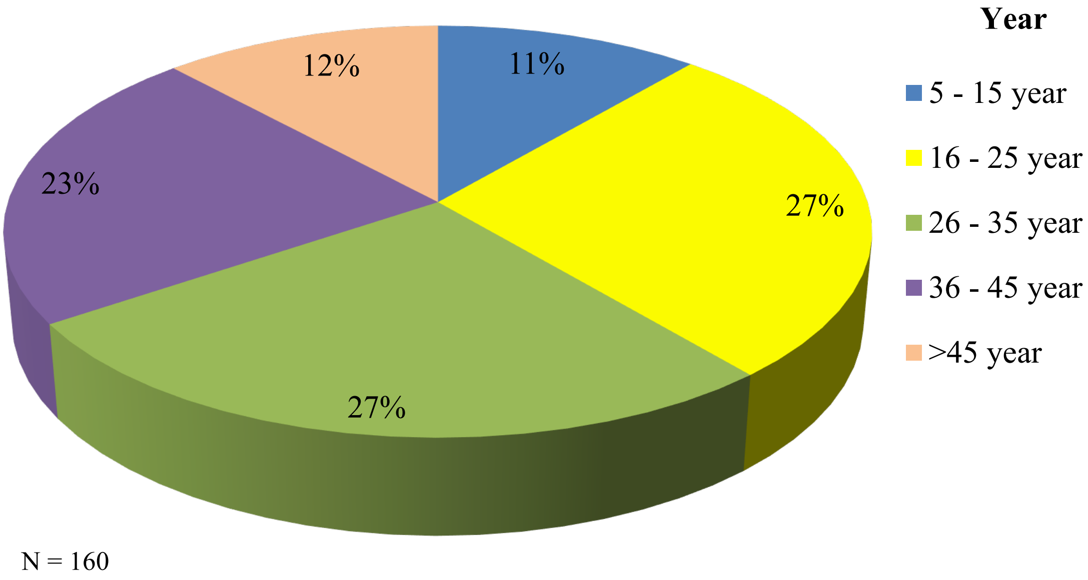

Figure 4.1. Proportion of the sample respondents having different farming experience

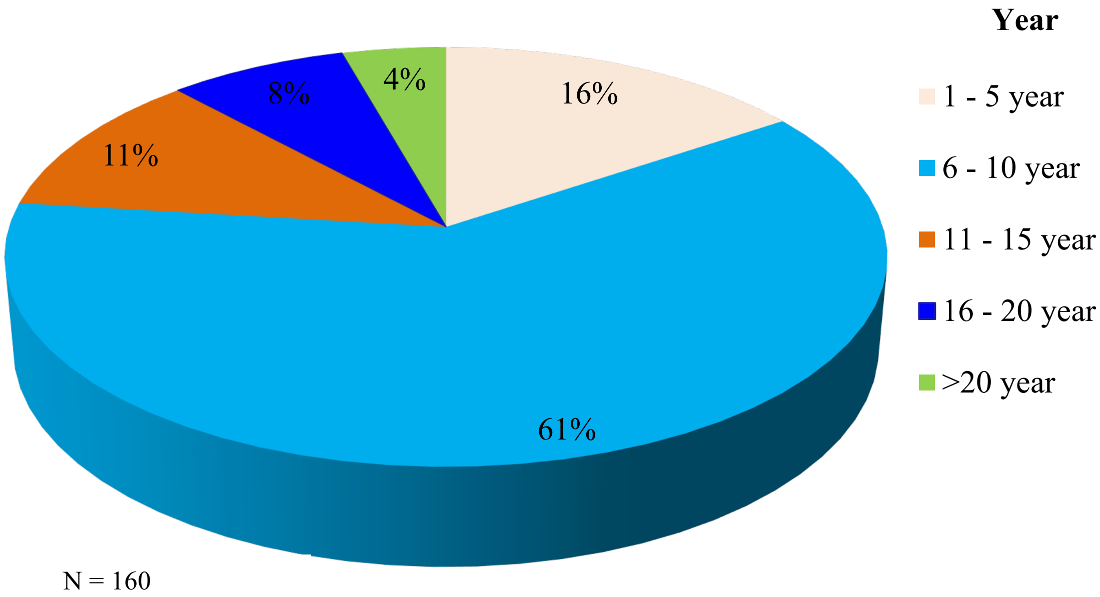

Figure 4.2. Proportion of the sample respondents having different irrigated farming experience

However, many of them started irrigated farming during a decade because a total of 77% of the respondents were found to have irrigated farming experience for less than 10 years. This situation was related with construction of river pumping stations established since after 2010 in this region. Most of the respondents could begin irrigated agriculture after construction river pumping stations. Irrigation for more than 20 years was practiced by only 4% of the respondents probably by self-irrigation schemes (Figure 4.2).

4.2 Types of Land Holding and Average Crop Area Cultivated with Different Sources of Water Before and After Constructing River Pumping Stations

4.2.1 Types of land holding

All crop sown areas of the study region were registered as upland and orchard by DALMS up to now. Most of the households cultivated upland crops before constructing river pumping stations. However, some households grew rice as rainfed crop for consumption. Now, rice growing areas were enumerated as lowland area in the study period. Although the sample households which did not grow rice before constructing river pumping stations were 76.24% (Table 4.2), it decreased to 54.37% after constructing river pumping stations. The households which did not possess lowland decreased from 76.24% before constructing river pumping stations to only 54.37% of the households after constructing river pumping stations. The majority of the households possessed lowland only <1 ha to 3 ha before and after constructing river pumping stations. However, the household percent which possessed 1 to 3 ha of lowland increased double after constructing river pumping stations. It indicated that lowland areas for rice growing significantly increased due to irrigation facility.

It was found that the households which possessed upland significantly decreased after constructing river pumping stations (Table 4.2). Although some households established orchard farm with self-irrigation schemes, some upland holders changed their land to orchards after constructing river pumping stations. Therefore, the households which did not possess upland increased from 21.24% to 43.76% after constructing river pumping stations. Although the households which possessed <1 ha of upland were only 6.87% before constructing river pumping stations, it increased to 10% after constructing river pumping stations. Among the households, the majority of the households (36.88%) and (19.38%) owned 1 to 3 ha and >3 to 5 ha of upland in both periods, and decreased to 25.61% and 11.25%, respectively. The households which possessed large area of upland >3 ha up to >9 ha also decreased from a total of 35.01% to a total of 20.63%.

Table 4.2. Proportion of households having different types of land holding before and after constructing river pumping stations

Types of land	Households (%)		χ^2
	Before projects	After projects	
Lowland (ha)			
0	76.24	54.37	17.90***
<1	10.63	16.88	
1 - 3	11.25	22.50	
>3	1.88	6.25	
Total	100.00	100.00	
Upland (ha)			
0	21.24	43.76	23.20***
<1	6.87	10.00	
1 - 3	36.88	25.61	
>3 - 5	19.38	11.25	
>5 - 7	10.00	6.88	
>7 - 9	3.75	1.25	
>9	1.88	1.25	
Total	100.00	100.00	
Orchard (ha)			
0	51.24	32.50	12.25**
<1	16.88	23.74	
1 - 3	18.75	28.75	
>3 - 5	11.88	13.13	
>5	1.25	1.88	
Total	100.00	100.00	
Total land (ha)			
<1	6.88	8.12	1.18^{ns}
1 - 4	53.13	56.88	
>4 - 7	28.13	24.38	
>7 - 10	6.88	6.25	
>10 - 13	3.75	3.75	
>13	1.24	0.62	
Total	100.00	100.00	

Note: *** = significant at 1% level, ** = significant at 5% level and ns = non-significant

N = 160

Before constructing river pumping stations, the households which did not grow orchard was 51.24% and it decreased to 32.50% after constructing river pumping stations implying that more orchards were established (Table 4.2). Among the orchard owners, the majority were the ones who possessed <1 ha (23.74%) and 1 to 3 ha (28.75%) after constructing river pumping stations. The households which possessed 3 ha to more than 5 ha of orchard farms also slightly increased. It showed that more farmers in this region engaged in small scale orchard farms and the farmers of the region got assured job opportunities from the orchard using water supply from the pump stations.

Total land holdings of the sample households were ranging from <1 ha to >13 ha and the majority of the households owned the total land of 1 to 4 ha before and after constructing river pumping stations. The households which owned <1 ha were slightly increased and the owners who had total land holdings >4 ha up to >13 ha tended to decreased reflected by the reduction of the owner with >4 to 7 ha and with >13 ha after irrigation projects. It may be due to irrigation canal across the farms, allocation to their progenies and land fragmentation. Sharma, Samyuktha and Deepa (2008) stated that land was cut into two uncultivable halves because of the canal at the tail-end of the Sagar canal in India. Jha, Nagarajan and Prasanna (2005); Tan (2005) noted that fragmentation also involves negative externalities such as reduced scope for irrigation, soil conservation investments and loss of land for boundaries and access routes. Traditionally, land used for agricultural purposes has over the years been fragmented as a regular phenomenon for various reasons (Shrestha, 2011).

4.2.2 Crop area cultivated with different sources of water

Water is one of the most precious resources in agriculture. In the study area, average crop area cultivated with water from pumping stations was 2.23 ha (Table 4.3). Before the project time, their lands were mainly rainfed with the average of 2.73 ha and some area (1.06 ha) were irrigated by self-irrigation schemes. However, after irrigation projects, rainfed area and the area irrigated by self-irrigation schemes significantly decreased from 2.73 ha to 0.77 ha and 1.06 ha to 0.55 ha, respectively, because of available water from pumping stations. Water tax for irrigation was very low compared with fuel cost of own pumps. Water tax varied with crops, 6000 kyats per season for rice and 3000 kyats per one time (2 ac feet) for other crops. It is costing less and net income getting from crop may be more increased than before (Table 4.3).

Table 4.3. Crop area cultivated with different sources of water before and after constructing river pumping stations

Water sources for crops	Crop area (ha)		t-test
	Before projects	After projects	
Pumping Station	0.00	2.23	-21.01***
Rainfed	2.73	0.77	14.37***
Self-Irrigation Schemes	1.06	0.55	5.43***

Note: *** = significant at 1%

N = 160

4.2.3 Crop area cultivated with different sources of water in the head-end, the middle and the tail-end

Among the three portions, the average growing area with water from pumping station was the largest (2.34 ha) in the head-end and that of the middle and the tail-end portion were about 2.00 ha each (Table 4.4). After irrigation projects, average rainfed area of all three portions significantly declined and the rainfed area of the head-end portion was the smallest (0.55 ha). Accordingly, growing areas with self-irrigation schemes significantly decreased in the head-end and the middle portion but significant difference was not found in the tail-end portion. Although the middle and the tail-end areas involved in river pumping projects, water availability of these portions was not easy to compare with head-end area. Most of the farmers in the middle and the tail-end area pumped water from the canal to their farms with their own pumps. The farms of the middle and the tail-end areas were far from the water source and water canals were higher than their farms. The far the water source was, the less chance it received water sufficiently. Overall, it was found that the head-end users had got more benefit of river pumping projects than the middle and the tail-end users. Several studies on water allocation between the head and the tail reaches have reported that the farmers at the tail end of the canal received a disproportionately small amount of irrigation water and sometimes no water at all. However, an unduly large share of canal water was received by the head-end farmers (Chambers 1988; Shah 1998).

4.3 Cropping Patterns, Cropping Intensity, Average Crop Area, Crop Diversification, Crop Yields Before and After Constructing River Pumping Stations

4.3.1 Cropping patterns in lowland

The cropping pattern of a region has important implications for its agricultural growth in general and livelihood of farmers (Mandal & Bezbaruah, 2013). Availability of water is one of the important determining factors of changing cropping pattern. In the study area, lowland cropping patterns were changed after constructing river pumping stations (Table 4.5). Before constructing river pumping stations, 23.76% of the households cultivated rice as rainfed crop relying on the rain water and 5.63% of the households cultivated chickpea after rice. Most of the households (76.24%) did not grow rice before constructing river pumping stations. After constructing river pumping stations, the households which can grow rice increased to a total of 45.64% and the households which did not grow rice were 54.36% of the total households.

Table 4.4. Crop area cultivated with different sources of water in the head-end, the middle and the tail-end before and after constructing river pumping stations

Water sources for crops	Crop area (ha)					
	Head-end (N=105)		Middle (N=30)		Tail-end (N=25)	
	Before projects	After projects	Before projects	After projects	Before projects	After projects
Pumping stations	0.00	2.34	0.00	2.01	0.00	2.00
t-test	-16.43***		-10.03***		-10.38***	
Rainfed	2.34	0.55	3.28	1.34	3.36	1.00
t-test	13.90***		2.83***		7.73***	
Self-irrigation schemes	1.23	0.51	1.04	0.89	0.38	0.33
t-test	2.82***		9.71***		2.32^{ns}	

Note: *** = significant at 1% level and ns = non-significant

Table 4.5. Proportion of households practicing different cropping patterns in lowland before and after constructing river pumping stations

Cropping patterns	Households (%)	
	Before projects	After projects
Rice	18.13	2.50
Rice - Chickpea	5.63	0.63
Rice - Sesame	-	4.38
Rice - Green gram	-	23.75
Rice - Green gram, Sesame	-	3.13
Rice - Chickpea - Green gram	-	10.00
Rice - Chickpea - Green gram, Sesame	-	1.25
No lowland	76.24	54.36
Total	100.00	100.00

N = 160

Therefore, rice growing households significantly increased after constructing river pumping stations compared with before. Among the rice growing households, only 2.50% of the households could grow rice as monocrop per year. Some households could grow chickpea, green gram and sesame after rice as double and triple crops after constructing river pumping stations. About one-third of the households (31.89%) were practicing double cropping. Among them, the households of growing green gram after rice were 23.75% of the total households. It may be due to the facts that short duration and attractive price of that crop. Triple cropping was being practiced by 11.25% of the total households. Chickpea, sesame and green gram were grown in rice-based cropping patterns.

4.3.2 Cropping patterns in upland

In the study area, diverse upland cropping patterns were observed and mono cropping and double cropping were practiced in upland of the study area before and after constructing river pumping stations (Table 4.6). Chickpea, green gram, sesame, cotton, sunflower cowpea, wheat and pigeonpea were grown as mono crop by a total of 62.25% of households before constructing river pumping stations. However, this monocropping was decreased to 41.87% after constructing river pumping stations. Although there were some households which practiced double cropping before irrigation projects, it decreased from 16.25% to 14.39% of the households after constructing river pumping stations. The households which did not grow upland crops increased from 21.25% to 43.74% after constructing river pumping stations. It may be due to the reform of upland to lowland and orchard.

After starting irrigation projects, however, cowpea, wheat and pigeonpea were not grown by the households and the new crop, corn was cultivated in this area probably because of the market uncertainty and price of cowpea, wheat and pigeonpea. Corn was grown in mono cropping and double cropping as well. The attraction for growing corn may be market condition, price of the crop and supporting of seed companies such as seed, some credit for production costs.

4.3.3 Cropping intensity changes in the study area before and after constructing river pumping stations

Higher cropping intensity means that a higher proportion of the net sown area is being cropped more than once during one agricultural year. Soe (2011) stated that the development in irrigation facilities has not only led to expansion of area under cultivation but also increased cropping intensity. Cropping intensity of the study area significantly increased after irrigation projects (Table 4.7).

Table 4.6. Proportion of households practicing different cropping patterns in upland before and after constructing river pumping stations

Before projects		After projects	
Cropping patterns	Households (%)	Cropping patterns	Households (%)
Chickpea, Green gram, Sesame, Cotton, Sunflower, Cowpea, Wheat, Pigeonpea	62.25	Chickpea, Green gram, Sesame, Cotton, Sunflower, Corn	41.87
Green gram - Chickpea, Cotton, Sesame, Sunflower, Wheat	12.50	Green gram - Chickpea, Cotton, Sesame, Sunflower, Corn	10.63
Sesame - Chickpea, Cotton	1.25	Sesame - Chickpea	1.88
Sunflower - Chickpea	2.50	Sunflower - Chickpea, Corn	1.88
No upland	21.25	No upland	43.74
Total	100.00	Total	100.00

N = 160

Table 4.7. Cropping intensity changes in the study area before and after constructing river pumping stations

Types of land		Cropping Intensity (%)		t-test
		Before projects	After projects	
Lowland	Mean	121	217	-10.56***
	Maximum	200	300	
	Minimum	100	100	
Upland	Mean	115	120	-0.94^{ns}
	Maximum	200	200	
	Minimum	100	100	
Total	Mean	117	164	-7.78***
	Maximum	200	300	
	Minimum	100	100	

Note: *** = significant at 1% level and ns = non-significant

Before constructing river pumping stations, among the lowland growing households, the average cropping intensity was 121% and it increased to 217% after constructing river pumping stations. However, the average cropping intensity in upland was not significantly different between two periods. As a total, the average cropping intensity of the study area was noticeably increased from 117% to 164% after constructing river pumping stations because some households could grow up to triple cropping in lowland. Gayen and Zaman (2014) stated that about 62% of area under irrigation had achieved, the cropping intensity had already reached at 220% in Murshidabad, India. The cropping intensity has direct correlation with the extension of irrigation system created. Soe (2011) found that the availability of more water led to cropping intensity of 208.81% in irrigated area compared to 136.93% in rainfed area. This was because the farmers could cultivate two or three times in a year through the irrigation system.

4.3.4 Average crop area and crop diversification for overall area

It was found that the cultivated area of crops varied after getting irrigation facility. Before constructing river pumping stations, the largest cultivated area (1.33 ha) was occupied by chickpea representing 31.22% of the total cultivated area of a household followed by cotton (17.14%) and lime (12.52%) (Table 4.8). However, after constructing river pumping stations, the average chickpea growing area of a household decreased to 0.75 ha (16.39%). Land type changes (upland to lowland and orchard) and growing higher income crop such as corn were some of the reasons of decreasing chickpea growing area. After constructing river pumping stations, the average rice cultivated area was 0.76 ha (16.58% of total cultivated area) of a household which was two times increase than before. Three times increase in green gram cultivated area (0.78 ha with 17.08%) was found and it was the largest percentage among the crop areas after constructing river pumping stations. Short growth duration and higher price than other crops were the facts for increasing green gram growing areas. With regard to cotton area, it decreased from 17.14% to 5.73%. It may be due to the replacement of other crops for its high labour costs. Corn was the new crop only after constructing river pumping stations and its area was 0.40 ha occupying 8.83% of the total crop growing area. Orchard crops were lime, mango, plum and banana, and the growing areas of these crops did not much change after constructing river pumping stations. However, lime was grown in large area (0.74 ha) representing 16.13% of total cultivated area followed by mango area (0.26 ha) with 5.79%, banana area (0.17 ha) with 3.69% and plum area (0.11 ha) with 2.30% after constructing river pumping stations. The reason of lime growing area increase was due to high value crop in summer season and lime could be picked many times all year around depending on care and management.

Crop diversification index (CDI) was not much different before the projects but it tended to decrease to 0.87 from 0.89 (Table 4.8). It may be due to the feasibility of growing specific crops in large area with irrigation facility, instead of diverse crops in small area. Another factor may be substituting marketable crops in the place of non-marketable and labour intensive crops. Sharma, Samyuktha and Deepa (2008) found that villagers grow crops such as red gram, maize, sajjar, jowar and black gram, which are all rain-fed crops before the canal was commissioned in Velatoor and Kondrepol, India. However, with the commencement of canal irrigation, paddy cultivation became the common work in the region and in the entire Sagar command. Therefore, it was hardly any or little crop diversification.

4.3.5 Average crop area and crop diversification in the head-end, the middle and the tail-end area

In the head-end area, chickpea occupied the largest cultivated area (1.09 ha) with 28.05% of the total cultivated area by individual household, followed by lime area (0.72 ha) with average crop area percent of 18.57 before constructing river pumping stations (Table 4.9). After constructing river pumping stations, rice cultivated area became 1.13 ha with 24.50% of the total cultivated area and it was two times increase. Chickpea cultivated area decreased from 28.05% to 12.10% and wheat, pigeonpea and cowpea were not cultivated after constructing river pumping stations. After constructing river pumping stations, corn was to be grown in small area (0.02 ha) with percentage 0.46%. In the orchard crops, lime was grown in more increased area (0.94 ha) with 20.39% of cultivated area after constructing river pumping stations.

Among the three portions of river pumping stations, chickpea was grown in the middle part with the largest sown area, 2.73 ha and the greatest crop area percentage (48.55%) before constructing river pumping stations and 1.78 ha with 36.16% of cultivated area after constructing river pumping stations. Rice could be grown in very small area, 0.08 ha with 1.64% of cultivated area even after constructing river pumping stations. Wheat and pigeonpea cultivated area were not found after constructing river pumping stations and cotton growing area decreased half after constructing river pumping stations. Corn was grown in 21.92% of the crop growing area which was the second largest area (1.08 ha) in middle portion after constructing river pumping stations. In orchards, lime growing area increased double (0.62 ha) with 12.60% of the cultivated area and there was some acreage of mango, plum and banana areas.

Table 4.8. Average crop area and crop diversification for overall area before and after constructing river pumping stations

Types of Crop	Cultivated Area (ha)			
	Before projects		After projects	
Rice	0.34	(7.92)	0.76	(16.58)
Chickpea	1.33	(31.22)	0.75	(16.39)
Green gram	0.22	(5.06)	0.78	(17.08)
Sesame	0.36	(8.56)	0.27	(5.87)
Cotton	0.73	(17.14)	0.26	(5.73)
Sunflower	0.09	(2.20)	0.07	(1.61)
Corn	-		0.40	(8.83)
Wheat	0.15	(3.50)	-	
Cowpea	0.05	(1.28)	-	
Pigeonpea	0.01	(0.30)	-	
Mango	0.25	(5.96)	0.26	(5.79)
Lime	0.53	(12.52)	0.74	(16.13)
Plum	0.09	(2.20)	0.11	(2.30)
Banana	0.09	(2.14)	0.17	(3.69)
Total	4.24	(100.00)	4.57	(100.00)
Crop Diversity Index (CDI)	0.89		0.87	

Note: The value in the bracket = percentage

N = 160

Table 4.9. Average crop area and crop diversification in the head-end, the middle and the tail-end area before and after constructing river pumping stations

Types of Crop	Head-end (N=105)		Middle (N=30)		Tail-end (N=25)	
	Cultivated Area (ha)		Cultivated Area (ha)		Cultivated Area (ha)	
	Before projects	After projects	Before projects	After projects	Before projects	After projects
Rice	0.49 (12.60)	1.13 (24.50)	0.08 (1.44)	0.08 (1.64)	-	-
Chickpea	1.09 (28.05)	0.56 (12.10)	2.73 (48.55)	1.78 (36.16)	0.65 (15.62)	0.31 (7.81)
Green gram	0.16 (4.12)	0.94 (20.27)	0.33 (5.88)	0.43 (8.63)	0.31 (7.42)	0.55 (14.10)
Sesame	0.39 (10.00)	0.32 (6.85)	0.22 (3.84)	0.19 (3.84)	0.44 (10.55)	0.16 (4.12)
Cotton	0.38 (9.83)	0.03 (0.67)	0.67 (11.99)	0.27 (5.48)	2.26 (54.50)	1.22 (31.06)
Sunflower	0.01 (0.15)	-	0.45 (8.03)	0.34 (6.99)	0.03 (0.78)	0.06 (1.44)
Corn	-	0.02 (0.46)	-	1.08 (21.92)	-	1.19 (30.35)
Wheat	0.03 (0.64)	-	0.65 (11.63)	-	0.06 (1.56)	-
Cowpea	0.06 (1.43)	-	0.09 (1.68)	-	-	-
Pigeonpea	0.02 0.49)	-	-	-	-	-
Mango	0.36 (9.18)	0.37 (8.11)	0.03 (0.48)	0.03 (0.55)	0.09 (2.15)	0.09 (2.27)
Lime	0.72 (18.57)	0.94 (20.39)	0.31 (5.52)	0.62 (12.60)	-	0.02 (0.41)
Plum	0.05 (1.38)	0.06 (1.34)	0.05 (0.96)	0.07 (1.37)	0.31 (7.42)	0.33 (8.44)
Banana	0.14 (3.56)	0.24 (5.31)	-	0.04 (0.82)	-	-
Total	3.90 (100.00)	4.60 (100.00)	5.63 (100.00)	4.93 (100.00)	4.15 (100.00)	3.94 (100.00)
Crop Diversity Index (CDI)	0.84	0.83	0.72	0.79	0.66	0.78

Note: The value in the bracket = percentage

In the tail-end area, rice growing area was not observed before and after constructing river pumping stations. Water demand of rice is more than other upland crops and water availability and adequacy for the tail-end users are insufficient. Therefore, they could grow only less water-consuming crops, upland crops. Cotton was the main crop in the tail-end area of the canal before and after constructing river pumping stations. Although cotton was grown in more than half of the area (54.50%) before constructing river pumping stations, it decreased to 31.06% of the area after constructing river pumping stations. It may be due to the fact that this area was cotton special zone before constructing river pumping stations. At present year, cotton growing area declined all over the region, and lower price and higher labour cost may be the reasons for decreasing cotton areas. Corn was the second highest growing area with 30.35% of cultivated area after cotton, although it was not grown in the past. Green gram area increased double from 7.42% to 14.10%. In orchard crops, it was observed that lime was found to be grown in small area with less than 1% of the total cultivated area, and some acreage of plum and mango growing areas were observed without much changes before and after constructing river pumping stations.

Overall, as rice requires the largest amount of water, it could be grown in the head-end area and small percent in middle portion of the river pumping stations. It was found that rice could not be grown in the tail-end area due to water insufficiency. Upland crops could be grown in the middle and the tail-end area. It was observed that rice growing area contributed the highest crop area percentage of the total cultivated area owned by individual households in the head-end area. After constructing river pumping stations, chickpea and cotton contributed to the highest area percentage in the middle and the tail-end area, respectively.

Crop diversification index in the head-end area decreased with small changes after constructing river pumping stations. It may be due to growing higher income crops in large area instead of diverse crops in small areas. Crop diversification index of middle area slightly increased from 0.72 to 0.79. Higher crop diversification index (0.66 to 0.78) was found in tail-end area and its change was higher than that of other two portions. It may be because of growing new crops such as corn and lime after constructing river pumping station. Water sufficiency and easy access of water may be also related to the crop diversification.

4.3.6 Crop yields

It was found that the yield of some crops significantly increased after constructing river pumping stations (Table 4.10). Before constructing river pumping stations, most crops including rice were grown relying on the rain water. Rice required more water than non-rice crops over a season. After constructing river pumping stations, rice was cultivated with sufficient irrigated water from pumping stations, and rice yield significantly increased from 2.87 t ha^{-1} to 4 t ha^{-1} after constructing river pumping stations. Rice yield may depend not only on irrigated water but also on other factors such as improved varieties and cultural practices. In this study, however, yield increase in rice was probably contributed by the assured irrigation water and scheme. In addition to yield, the number of rice growing households obviously increased from 38 to 73. However, the number of chickpea and cotton growing households decreased from 91 and 50 to 67 and 25, respectively. Although the number of chickpea growing households decreased, the average yield increased from 1.04 t ha^{-1} to 1.16 t ha^{-1}. The average yield of green gram increased from 0.92 t ha^{-1} to 1.09 t ha^{-1} after constructing river pumping stations. In green gram, not only yield but also the number of growing households evidently increased (22 to 83). Green gram was grown with irrigation water in pre monsoon season. The yield increase of green gram may be due to not only irrigation water but also using improved varieties. Hussain and Hanjra (2004); Lipton, Litchfield and Faurès (2003) stated that crop yields everywhere in the developing world are consistently higher in irrigated areas than in rainfed areas. Yields of sesame, cotton and sunflower were not significantly different as compared with before time although the yield tended to decrease. Corn was grown only after constructing river pumping stations. The number of corn growing households was 36 and the average yield of corn was 4.66 t ha^{-1}. Although wheat, cowpea and pigeonpea were cultivated giving the yield of 2.28 t ha^{-1}, 1.17 t ha^{-1} and 0.82 t ha^{-1}, respectively, in the past, these crops were not cultivated after constructing river pumping stations.

4.3.7 Crop yields in the head-end, the middle and the tail-end

Yields of some cultivated crops in three portions significantly increased after constructing river pumping stations (Table 4.11). Farmers in the head-end and the middle area could grow rice, and there were no rice growers in the tail-end area even after constructing river pumping stations. The rice yield in the head-end area significantly increased from 2.91 t ha^{-1} to 4.03 t ha^{-1} and the number of rice growing households increased double (35 to 70) after constructing river pumping stations. In the middle portion of the canal, rice yield was numerically increased from 2.51 t ha^{-1} to 3.20 t ha^{-1} and the number of rice growing households was the same as before.

Table 4.10. Crop yields before and after constructing river pumping stations

Crops	Before projects		After projects		t-test
	HH no.	Yield (t ha^{-1})	HH no.	Yield (t ha^{-1})	
Rice	38	2.87	73	4.00	-7.64***
Chickpea	91	1.04	67	1.16	-2.50**
Green gram	22	0.92	83	1.09	-2.45**
Sesame	40	0.44	36	0.40	1.29^{ns}
Cotton	50	1.40	25	1.39	0.16^{ns}
Sunflower	11	0.46	11	0.45	0.03^{ns}
Corn	-	-	36	4.66	
Wheat	10	2.28	-	-	
Cowpea	5	1.17	-	-	
Pigeonpea	2	0.82	-	-	

Note: *** = significant at 1% level, ** = significant at 5% level and ns= non-significant

HH= household

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Table 4.11. Crop yields in the head-end, the middle and the tail-end before and after constructing river pumping stations

Crops	Head-end					Middle					Tail-end				
	Before Projects		After Projects		t-test	Before Projects		After Projects		t-test	Before Projects		After Projects		t-test
	HH no.	Yield (t ha^{-1})	HH no.	Yield (t ha^{-1})		HH no.	Yield (t ha^{-1})	HH no.	Yield (t ha^{-1})		HH no.	Yield (t ha^{-1})	HH no.	Yield (t ha^{-1})	
Rice	35	2.91	70	4.03	-7.86***	3	2.51	3	3.20	-0.59^{ns}	-	-	-	-	
Chickpea	53	1.07	35	1.16	-1.48^{ns}	26	1.05	26	1.18	-2.07**	12	0.97	6	1.04	-0.87^{ns}
Green gram	11	0.83	60	1.07	-2.85**	6	1.22	11	1.21	0.05^{ns}	5	0.82	12	1.13	-2.54**
Sesame	27	0.40	28	0.40	0.36^{ns}	3	0.54	3	0.49	0.45^{ns}	10	0.51	5	0.34	1.84^{ns}
Cotton	18	1.28	1	1.41		9	1.34	7	1.38	-0.21^{ns}	23	1.45	17	1.36	0.60^{ns}
Sunflower	1	0.56	-	-		9	0.46	9	0.44	0.22^{ns}	1	0.37	2	0.46	
Corn	-	-	2	5.45		-	-	17	4.77		-	-	17	4.45	
Wheat	7	2.45	-	-		2	2.27	-	-		1	2.04	-	-	
Cowpea	4	1.06	-	-		1	1.63	-	-		-	-	-	-	
Pigeonpea	2	0.82	-	-		-	-	-	-		-	-	-	-	

Note: *** = significant at 1% level, ** = significant at 5% level and ns = non-significant

HH = household

The significant increased yield of chickpea was found only in the middle portion. In the head-end and the tail-end area, chickpea growing households decreased from 53 to 35 and from 12 to 6, respectively, and no change in the number of chickpea growing households was found in the middle portion. The number of green gram growing households increased in all three portions (11 to 60, 6 to 11 and 5 to 12). The yield of green gram increased from 0.83 t ha^{-1} to 1.07 t ha^{-1} and from 0.82 t ha^{-1} to 1.13 t ha^{-1} in the head-end and the tail-end, respectively. In contrast to green gram, cotton growing households decreased in all three portions, and obvious decrease was found in head-end area explained by the only one household number decreased from 18 households. It may be due to changing from upland crops to lowland crops and orchards. No significant yield changes of sesame, cotton and sunflower were observed in all three portions. Sunflower was not grown at all by the head-end users after constructing river pumping stations. Corn was grown only after constructing river pumping stations and the number of corn growing households were mostly found in the middle and the tail-end area. The yield of corn was 5.45 t ha^{-1} in the head-end, 4.77 t ha^{-1} in the middle and 4.45 t ha^{-1} in the tail-end area. Corn is heavy feeders, needing lots of nitrogen and other nutrients. Therefore, yield may depend on not only getting irrigation water but also other care and management. Wheat, cowpea and pigeonpea were not grown at all in these regions after constructing river pumping stations. Malashkhia (2003) observed that the farmers at the tail of the canal and downstream suffer from water shortages and are forced to abandon cultivation of some part of their land in order to avoid yield losses, whereas at the head of the canal peasants enjoy the abundance of irrigation water. Chambers (1988) showed that the yield level of crops in field plots, away from the water courses, sharply declined across the gradients of the irrigation outlet, i.e., yield declines when moving from the head towards the middle and the tail-end locations, respectively.

4.4 Different Household Income, Sources of Income and Sources of Credit Availability Before and After Constructing River Pumping Stations

4.4.1 Household income

Two types of income such as main income and other income were found in the sample households (Table 4.12). Main income means the majority of the total income of a household. It may be not only from farming but also from other sources in some small holder farmers. Other income means the additional income for surplus in the households. In this study, as crop yields increased, income of the households increased after constructing river pumping stations. Before constructing river pumping stations, about half of the households (46.87%) got less than 1.5 million kyats as main income, but number of the household significantly decreased to 18.12% after constructing river pumping stations. After getting irrigation facility, the household percentages were increasing in every main income level. Particularly, the households which got over 7.5 million kyats increased to 13.13%. from 3.13%. Between 1.5 and 4.5 million kyats were earned by 49.99% of the households after constructing river pumping stations. Peprah, Amoah and Achana (2015) observed that irrigation had direct effects on output and income of farmers in Sankana, Ghana.

Before constructing river pumping stations, about three-fourths of the households (76.87%) did not get extra income whereas 23.13% of the households obtained extra income <1.5 million kyats. After constructing river pumping stations, although there were households (74.37%) which did not obtain extra income, 10% of the households were able to earn other income between 1.5 and 3 million kyats. Generally, it was found that household incomes improved after constructing river pumping stations in the study area.

4.4.2 Household income in the head-end, the middle and the tail-end

Before constructing river pumping stations, in all three portions, half of the households got <1.5 million kyats which was the lowest income level. However, the proportion of the household with this income was decreased in the head-end area and the tail-end portions after getting irrigation facility. Before constructing river pumping stations, the highest income levels were different in all three portions. The households of the head-end area could earn >7.5 million kyats and the households of the middle and the tail-end area got >4.5 - 6 million kyats and >3 - 4.5 million kyats, respectively. However, after getting irrigation facility, it was found that the household percent with more income level increased. In the head-end area, households with the income level of >3 - 4.5 million kyats and >7.5 million kyats significantly increased. In the middle and the tail-end area, there were some households which can earn from 4.5 million kyats to >7.5 million kyats after constructing river pumping station. Although the household with other income were not significantly different in the middle and the tail-end area, significant increase in household percent (13.34%) which could earn 1.5 - 3 million kyats was observed in the head-end area after constructing river pumping stations. Overall in three portions, it was observed that income of the head-end area was more than that of the middle and the tail-end area. Chambers (1988) observed that the income of head reach farmers was more than six times higher than that of tail-reach farmers in a minor.

Table 4.12. Proportion of households with different income levels before and after constructing river pumping stations

Levels of income (Million Kyats $Year^{-1}$)	Households (%) Before projects	After projects	χ^2
Main income			
<1.5	46.87	18.12	37.87***
1.5 - 3	26.87	28.74	
>3 - 4.5	13.13	21.25	
>4.5 - 6	6.25	13.13	
>6 - 7.5	3.75	5.63	
>7.5	3.13	13.13	
Total	100.00	100.00	
Other income			
0	76.87	74.37	18.39***
<1.5	23.13	15.63	
1.5 - 3	0.00	10.00	
Total	100.00	100.00	

Note: *** = significant at 1% level

N = 160

Table 4.13. Proportion of households with different income levels in the head-end, the middle and the tail-end before and after constructing river pumping stations

Levels of income (Million Kyats Year^{-1})	Households (%)								
	Head-end (N=105)			Middle (N=30)			Tail-end (N=25)		
	Before projects	After projects	χ^2	Before projects	After projects	χ^2	Before projects	After projects	χ^2
Main income									
<1.5	44.77	14.28	32.70***	46.67	23.33	7.76^{ns}	56.00	28.00	10.41*
1.5 - 3	27.62	27.62		23.33	36.67		28.00	24.00	
>3 - 4.5	9.52	23.81		23.33	16.67		16.00	16.00	
>4.5 - 6	7.62	12.38		6.67	10.00		0.00	20.00	
>6 - 7.5	5.71	3.81		0.00	10.00		0.00	8.00	
>7.5	4.76	18.10		0.00	3.33		0.00	4.00	
Total	100.00	100.00		100.00	100.00		100.00	100.00	
Other income									
0	76.19	69.52	15.46***	73.33	83.33	0.88^{ns}	84.00	84.00	2.67^{ns}
<1.5	23.81	17.14		26.67	16.67		16.00	8.00	
1.5 - 3	0.00	13.34		0.00	0.00		0.00	8.00	
Total	100.00	100.00		100.00	100.00		100.00	100.00	

Note: *** = significant at 1% level, * = significant at 10% level and ns = non-significant

4.4.3 Sources of income

All sample households in the study area mainly relied on agriculture for their main household income. Income sources of the households in the study area were not significantly changed before and after constructing river pumping stations (Table 4.14). Before constructing river pumping stations, the main income sources were farming, broker, motor-bike repairer and mason. Farming was single most contributing source of income before and after constructing river pumping stations. A total of about 25% of households earned some other incomes from farming, government staff, home shop, broker, farm labour, motor-bike repairer, mason and car driver, and there were about 75% of the households without other income before and after projects.

4.4.4 Sources of credit availability

Credit is necessary for farm households to increase crop production (Win, 2018). In the study area, before constructing river pumping stations, 45% of the households did not borrow credit and 55% were credit borrowers (Table 4.15). They received credit mostly from Myanmar Agricultural Development Bank (MADB) and it was the formal credit source, and only 0.63% received from other. After constructing river pumping stations, 64.38% of the households borrowed credit and there were various sources of credit. The majority of the credit borrowers (52.50%) got credit from MADB and a few percentages of households received from cooperative in village, Mya Sein Yaung, cooperative, Minglabar and others. The sample households used credit mainly for crop production and also for household expenditures. Availability of finance is important for sustaining the production of agricultural commodities (Ahangar, Ganie & Padder, 2013; De Castro & Teixeira, 2012). Khan (2014) stated that the microfinance positively affects the household income level, consumption level and agriculture sector.

Table 4.14. Proportion of households with different sources of income before and after constructing river pumping stations

Different sources of income	(Household %)					
	Main income		χ^2	Other income		χ^2
	Before projects	After projects		Before projects	After projects	
Farming	94.37	96.24	2.51^{ns}	5.63	3.71	3.66^{ns}
Government staff	0.00	0.00		1.22	1.89	
Home shop	0.00	0.00		5.00	5.63	
Broker	2.50	1.87		4.38	5.63	
Farm labour	1.25	0.63		3.13	1.88	
Motor-bike repairer	0.00	0.63		0.00	0.63	
Mason	1.88	0.63		1.88	2.50	
Car driver	0.00	0.00		3.13	3.75	
None	0.00	0.00		75.63	74.38	
Total	100.00	100.00		100.00	100.00	

Note: ns = non-significant

N = 160

Table 4.15. Sources of credit availability of the sample households before and after constructing river pumping stations

Credit Sources	Households (%)		χ^2
	Before projects	After projects	
MADB	54.37	52.50	0.11^{ns}
Cooperative in viillage	0.00	1.25	2.01^{ns}
Mya Sein Yaung	0.00	1.88	3.03*
Cooperative	0.00	3.75	6.12**
Minglabar	0.00	1.25	2.01^{ns}
Other	0.63	3.75	3.35*
(No credit)	45.00	35.62	

Note: ** = significant at 5% level, * = significant at 10% level and ns = non-significant

N = 160

4.5 Housing Conditions, Farm Assets, Livestock Assets, Home Assets, Sources of Water for Households, Electricity and Toilet Facility of the Sample Households Before and After Constructing River Pumping Stations

4.5.1 Housing conditions

Housing is a major element of people's material living standards and income is an essential driver of housing conditions. The housing conditions of the household in the study area significantly changed after constructing river pumping stations as compared with before time (Table 4.16). The housing conditions were sorted as four kinds depending on roof and wall. They were corrugated iron sheet + brick wall, corrugated iron sheet + wood wall, corrugated iron sheet + bamboo wall and thatch roof + bamboo wall. The household percent with corrugated iron sheet + brick wall households increased double from 29.38% to 61.25% while the household with thatch roof + bamboo wall houses significantly decreased from 31.25% to 3.13% after constructing river pumping stations. The household with corrugated iron sheet + wood wall and corrugated iron sheet + bamboo wall houses were not significantly different. The improved housing conditions of the households may be due to their increased income (Table 4.12).

4.5.2 Total farm assets, livestock assets and home assets

Significantly changes of farm assets in the study area were observed comparing before and after constructing river pumping stations (Table 4.17). In other words, the more machines the respondents owned, the less animal and animal drawn tools they had. The number of power tillers increased from 43 to 85 which was double increase after constructing river pumping stations. The number of water pumps also increased from 73 to 91, and sprayer numbers used by households slightly increased from 158 to 167 after constructing river pumping stations. Over three times increase (5 to 18) was found in the number of trailers (htawlargyi). In contrast with machine, it was found that the number of animal drawn tools significantly decreased. After constructing river pumping stations, the number of animal drawn ploughs and harrows decreased half from 122 to 75 and 119 to 76, respectively. It may be due to changes of traditional agriculture to mechanize farming.

The sample households used cattle for crop production activities while pig and chicken were also raised for extra income and meat consumption. However, cattle numbers significantly decreased from 438 to 256 after constructing river pumping stations. It may be due to the fact that the farmers used machines instead of draught animals to be easy and quick in land preparation and transportation. Not significant difference in pig numbers and chicken numbers was observed for the two periods of before and after constructing river pumping stations.

Table 4.16. Proportion of households with different housing conditions before and after constructing river pumping stations

Items	Households		χ^2
	Before projects	After projects	
	Percentage	Percentage	
Corrugated iron sheet + brick wall	29.38	61.25	32.80***
Corrugated iron sheet + wood wall	3.75	2.50	0.41^{ns}
Corrugated iron sheet + bamboo wall	35.62	33.12	0.22^{ns}
Thatch roof + bamboo wall	31.25	3.13	44.46***
Total	100.00	100.00	

Note: *** = significant at 1% level and ns = non-significant

N = 160

Table 4.17. Total farm assets and livestock assets in the sample households before and after constructing river pumping stations

Items	Before projects	After projects	t-test
Farm Assets (no.)			
Power tiller	43	85	-7.29***
Water pump	73	91	-4.23***
Sprayer	158	167	-2.09^{ns}
Trailer (Htawlargyi)	5	18	-3.75***
Bullock cart	112	76	6.56***
Animal drawn plough	122	75	7.30***
Animal drawn harrow	119	76	6.83***
Livestock Assets (no.)			
Cattle	438	256	3.51***
Pig	25	11	0.68^{ns}
Chicken	160	187	-0.80^{ns}

Note: *** = significant at 1% level and ns = non-significant

N = 160

As household income increased, the use of home assets except bicycle was significantly improved after constructing river pumping stations (Table 4.18). The number of motor-cars increased from 2 to 10 and it was five times increase after constructing river pumping stations. The remarkable increase was found in the possession of motor-bike (113 to 213) after constructing river pumping stations. However, the number of bicycles decreased from 44 to 33. Audio visual equipment (TV, EVD, sky net, set-top box, radio and mobile phone) were dramatically upgraded time by time. The number of mobile phones increased from 26 to 257 after constructing river pumping stations. It may be related to improvement of Myanmar's telecommunications sector and the increased income of the households. Although other luxury assets as refrigerator and fan were not owned by the households before, there were 26 refrigerator and 42 fan numbers after constructing river pumping stations. It may be also related to the access of electricity in their region and their increased income. The number of sewing machines increased double (8 to 15). There were some households which cannot afford to get electric public lighting and they used solar cells and generators. Thus, the remarkable increased number in solar cells (19 to 45) and slight increase in the number of generators were observed in the region. It clearly pointed out the increased income of rural people related to the improvement of their living standard. In this region, the increase income from farm (Table.4.12) may be the benefit from the cultivation with irrigation water. Setboonsarng (2008) reported that change in wealth status can be based on change in ownership of household assets (TVs, radios, refrigerators, and electric fans).

4.5.3 Basic needs for households

Access to safe drinking-water is essential to health. In the study area, it was found that the use of drinking water of the sample households significantly improved after constructing river pumping stations (Table 4.19). In the study area, the majority (69.38%) of the sample households acquired drinking water from river before constructing river pumping stations. However, this condition decreased to 16.88% after constructing river pumping stations. The reasons for drinking river water were such as not far from the river and preference on river water taste. The household drinking water from tube well water obviously increased from 19.37% before constructing river pumping stations to 71.24% after constructing river pumping stations. There was some percentage (8.75%) of the sample households who used purified water for drinking indicating that rural people in the area got the awareness in the importance of water quality in their life and health, and it may be also related to their increased income (Table 4.12).

Table 4.18. Total home assets in the sample households before and after constructing river pumping stations

Items	Before projects	After projects	t-test
Home assets (no.)			
Motor-car	2	10	-2.57***
Motor-bike	113	213	-9.71***
Bicycle	44	33	3.43***
TV	76	120	-7.53***
EVD	12	38	-5.32***
Sky net	0	4	-2.02**
Set-top box	0	28	-5.81***
Radio	32	38	-1.91*
Mobile-phone	26	257	15.76***
Refrigerator	0	26	-5.55***
Fan	0	42	-5.86***
Sewing machine	8	15	-2.37***
Solar cell	19	45	-3.83***
Generator	15	19	-2.37^{ns}

Note: *** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level and ns = non-significant

N = 160

Table 4.19. Proportion of households with different sources of water for household, electricity and different toilet facility before and after constructing river pumping stations

Items	Households (%)		χ^2
	Before projects	After projects	
Drinking water			119.99***
Tube well	19.37	71.24	
Pond	11.25	3.13	
River water	69.38	16.88	
Purified water	0.00	8.75	
Total	100.00	100.00	
Household used water			127.35***
Tube well	25.75	86.25	
Pond	11.25	3.75	
River water	65.00	10.00	
Total	100.00	100.00	
Electricity			186.48***
Public light	0.00	55.61	
Private generator	4.38	3.13	
Village generator	31.25	9.38	
Solar-cell	11.88	28.13	
Battery	48.11	3.75	
Oil lamp	4.38	0.00	
Total	100.00	100.00	
Toilet facility			35.41***
Opened pit	2.50	0.00	
Enclosed pit	91.87	70.00	
Enclosed pour flush	5.63	30.00	
Total	100.00	100.00	

Note: *** = significant at 1%

N = 160

Daily access to clean water is necessary to satisfy basic needs of cooking, washing, and bathing. In the study area, before constructing river pumping stations, as a source of common household used water (domestic water), most of the households (65%) used river water, and 11.25% and 25.75% of the households used water from pond and tube well, respectively. After constructing river pumping stations, the households which used water from tube well as domestic water significantly increased to 86.25% and the ones who used of pond and river water decreased from 11.25% and 65% to 3.75% and 10%. Therefore, it was found that the status of water used by the households was improved compared with before constructing river pumping stations.

Many sources of electricity were observed for lightening in the households of the study area. Before constructing river pumping stations, there was no access to electric public lighting. About half (48.11%) of the households used battery for lighting and some households (31.25%) which used village generator were second largest group at that time. However, over half (55.61%) of the households had access to electric public lighting and 28.13% of the households used solar cell after constructing river pumping stations. There were still a few households which used private generator, village generator and battery but there was no household which used oil lamp after constructing river pumping stations. It was found that use of electric public lighting was significantly improved after constructing river pumping stations. Income may be closely related with development and overall social well-being of a region. The development of a region may be due to government supporting and self-help of the people in this region as well.

In toilet facility, three types such as opened pit, enclosed pit and enclosed pour flush were found before constructing river pumping stations. The majority (91.87%) of the households used enclosed pit at that time. There was no household at all that used opened pit after constructing river pumping stations. In addition, the households that used enclosed pit decreased to 70% and the households that used enclosed pour flush increased five times (30%) after constructing river pumping stations. It showed one of the improvements in the livelihood status in the studied area.

4.6 Donation and Improving Residential Halls After Constructing River Pumping Stations

Buddhist religious buildings reflect the piousness, generosity, richness and dignity of the people. It was found that 65% of the sample households could donate more than before whereas 35% of the sample households could not donate in the study area.

Most (79.80%) of the households could donate at least one time and some households could donate two times (10.58%) and three times (9.62%) after constructing river pumping stations. There were some households (26.90%) which could build and maintain residential halls more than before (Figure 4.3). It may depend on their enthusiasm for donation and associate with their increase income.

4.7 Infrastructure for Education, Health and Transportation Before and After Constructing River Pumping Stations

In a region, as their economy improved, their health, education and transportation become developed. Among the villages which are benefited from Shwe Hlan Bo and Htee Taw Moe river pumping stations, the improvement of the school and road was obvious. The schools of Meethwebote and Nattyaekan villages improved from primary school to middle school whereas the improvement of middle school to high school was observed in Ywarbo and no improvement of primary school was found in Kingtone. The road infrastructure of all these four villages became from earthen road to gravel road. However, it was still the same condition as before in their health infrastructure (Table 4.20).

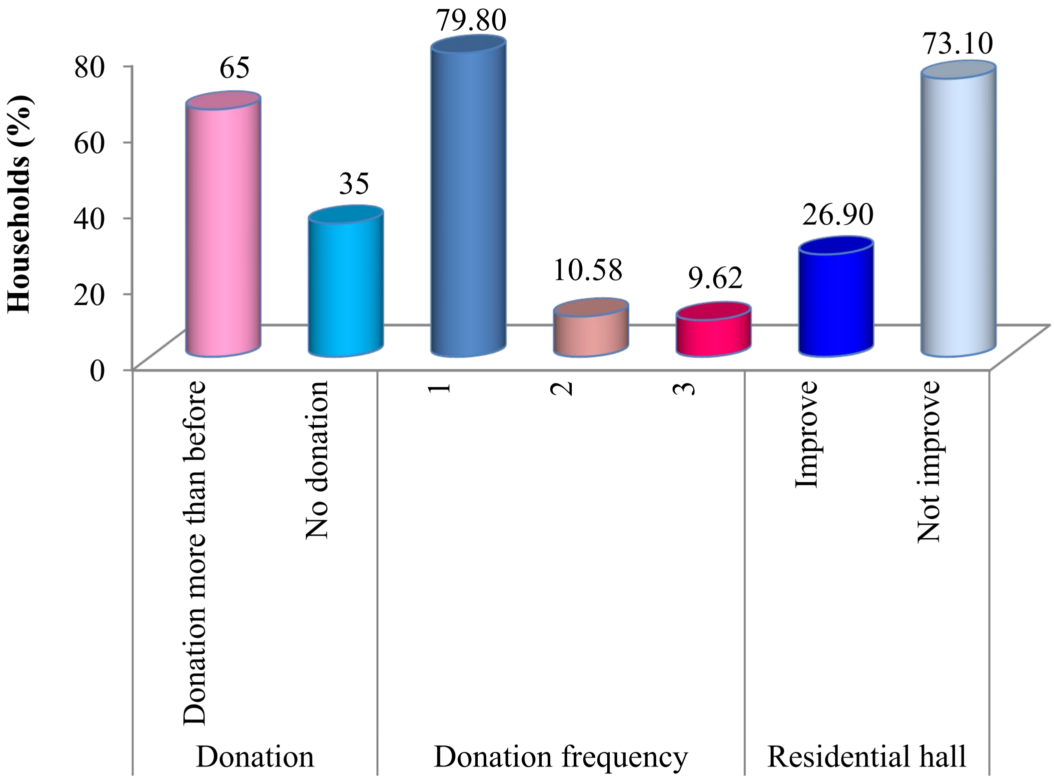
4.8 The Availability of Water, Difficulties and Satisfaction on the Pump Stations

In this study, 71% of the respondents answered that they got enough water and 29% of the respondents said that they did not get enough irrigation water (Figure 4.4).

A few respondents (2%) said that they suffered from water logging due to drainage difficulty and 38% of the respondents answered that they got insufficient water because the farms were far from water source. and the farmers pumped water again from the canal to their plots. Thus, costs of fuel, hiring labour and machine were burdens for farmers who did not own water pump. The farmers from the middle and the tail-end area of the pump station may experience these difficulties.

When the respondents were interviewed about the satisfaction on pumping station, the majority (87%) of the respondents satisfied on constructing pump stations in their region and impact of it. Only a few percentages answered no satisfaction on pump stations. It may be related to not enough water for their crops and other difficulties.

Overall, the majority of the respondents got easy access and enough irrigation water, and satisfied on pump constructing stations.



N = 160

Figure 4.3. Proportion of households regarding donation and improving residential halls after constructing river pumping stations

Table 4.20. Comparison of infrastructure for education, health and transportation of villages before and after constructing river pumping stations

Sample Villages	School		Health service		Road	
	Before Projects	After Projects	Before Projects	After Projects	Before Projects	After Projects
Meethwebote	Primary	Middle	Nurse	Nurse	Earthen	Gravel
Ywarbo	Middle	High	Clinic	Clinic	Earthen	Gravel
Nattyaekan	Primary	Middle	Clinic	Clinic	Earthen	Gravel
Kingtone	Primary	Primary	None	None	Earthen	Gravel

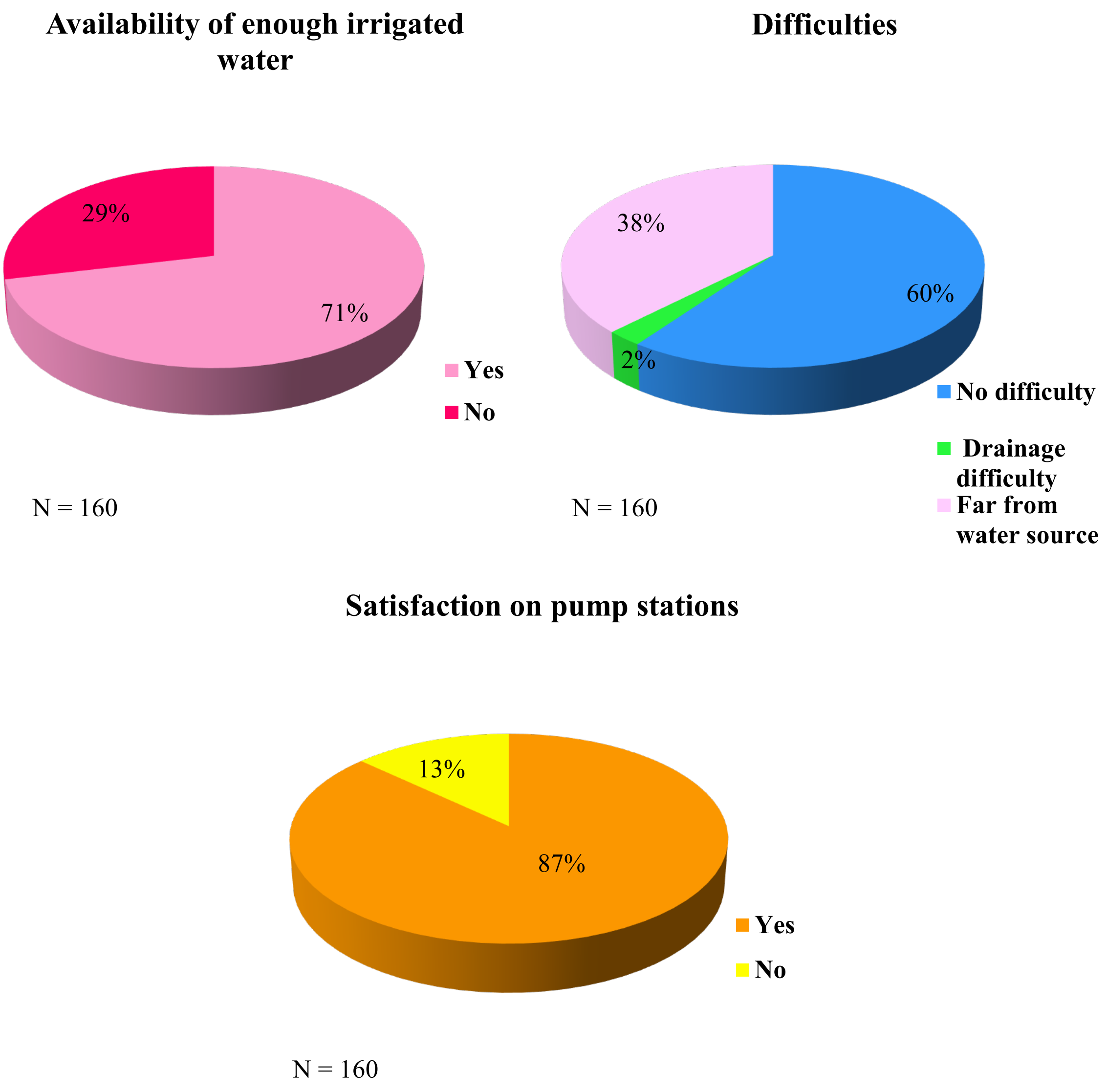


Figure 4.4. Proportion of households regarding the availability of water, difficulties and satisfaction on the pump stations

4.9 Environmental Changes After Constructing River Pumping Stations

There may be positive and negative impact in irrigation projects. However, in this study, when the respondents were interviewed for their notice on environmental impact, a total of 55% of the respondents answered that there was loss of grazing pasture fields and 45% of the respondents said that no loss in pasture fields were found. Although land types of the households changed from upland to lowland and orchard, the total cultivated area of the households were not significantly different before and after constructing river pumping stations (Table 4.2). Nowadays, as population growth is increasing all over the world, the number of households in the study area may be increased although land ownership of the individual households did not change. It may be one of the reasons of loss of grazing pasture fields. In the past, animals were grazed at field after harvest and common grazing land of the study area. However, after getting irrigation facility, mono crop growing households became double crop, triple crop and orchard growing households, and increased cropping intensity makes decreased grazing time or no grazing time in the field. This fact may lead to loss of grazing fields. Although there were a few percent (6% and 2%) of the respondents who said that tree loss and endangering tree were found, almost all of the respondents noticed on no changes of both issues. It may be due to no changes in tree loss and endangering tree and/or the need of the respondents' awareness on environment. There was no change in greenness in accordance with the answer of 14.4% of the respondents whereas 86% of the respondents perceived as more greenness in the environment (Figure 4.5).

According to perception of the respondents, it can be generally considered that there was not much negative impact presently on the environment due to river pumping stations. However, the respondents may need more awareness on the environment.

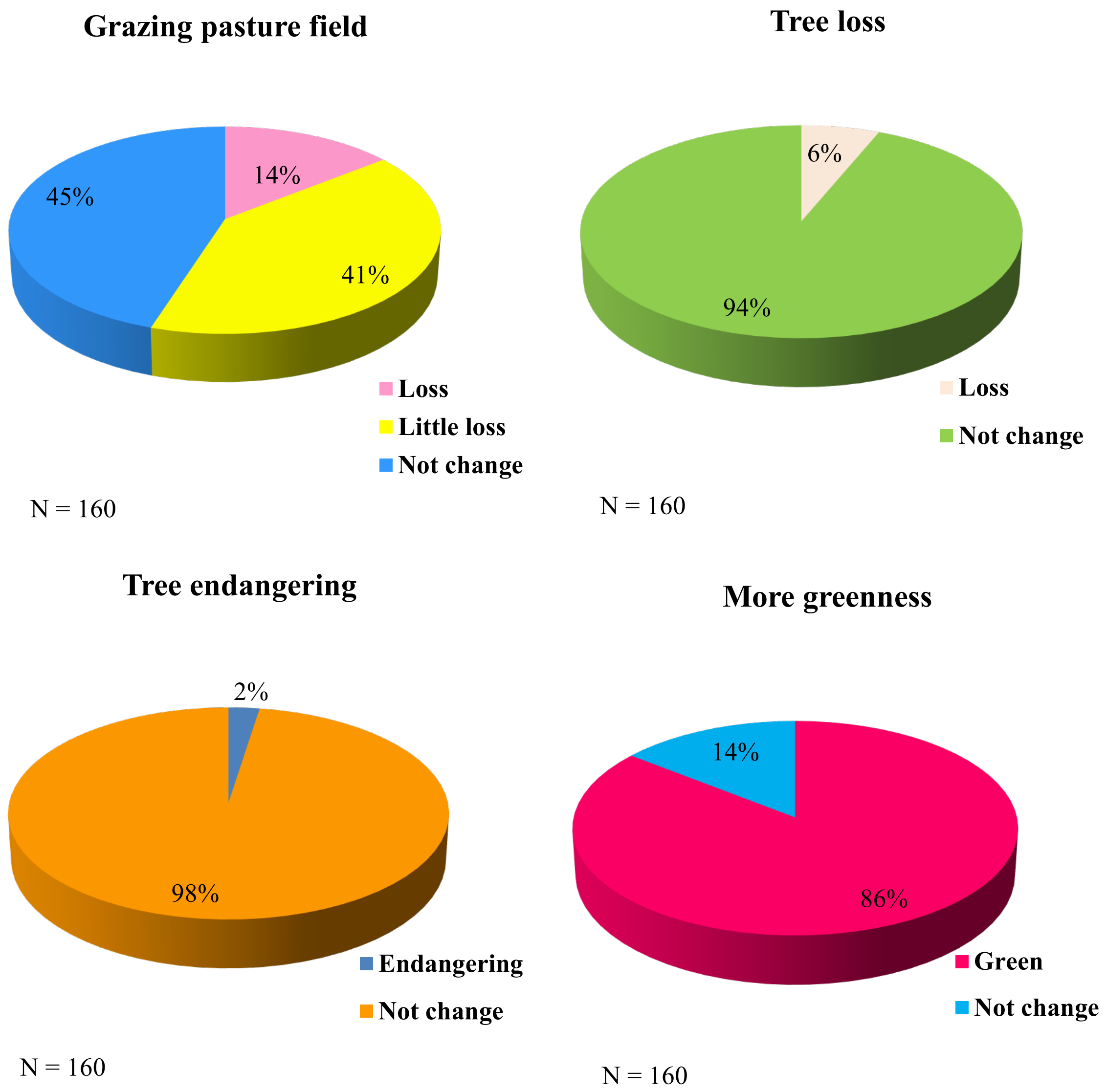


Figure 4.5. Proportion of Respondents who perceived on environmental changes after constructing river pumping stations

CHAPTER V
CONCLUSION

The types of land holding of the households significantly changed from upland to lowland and orchard after constructing river pumping stations. Rainfed areas and the cultivated areas with self-irrigation schemes significantly decreased after constructing river pumping stations. Although rice was grown by a few households before constructing river pumping stations, rice growing households increased double and chickpea, green gram, and sesame were grown after rice in lowland after getting irrigation facility. In upland cropping patterns, mono cropping also decreased after irrigation projects. The average cropping intensity increased in the study area because some households cultivated two or three cropping a year after constructing river pumping stations. Chickpea, cotton, and lime occupied the highest percentage of the cultivated area before irrigation projects whereas rice, chickpea, green gram, corn and lime areas were higher than other crop areas after constructing river pumping stations. Changes of cultivated crops were found in project area. Rice, green gram and lime cultivated areas increased obviously after constructing river pumping stations. Corn was grown instead of wheat, pigeonpea and cowpea. Crop diversification index (CDI) was not much different between before and after constructing river pumping stations because of the feasibility of growing specific crops in a large area with irrigation facility. The yield of rice, chickpea and green gram significantly increased after constructing river pumping stations. In the study area, the main income of the households relied on farming and the significant increased farm income was observed after constructing river pumping stations. Accordingly, the livelihood status of the households in the study area improved and infrastructure for community development also partially improved after getting irrigation facility. During a period of time from irrigation projects starting year to now, there was not much negative impact on the environment according to the perception of respondents.

Generally, the study area benefited from these two river pumping projects. However, if pump irrigation water could be evenly distributed among the head-end, the middle and the tail-end areas, cultivated areas of the middle and the tail-end portions can be increased, and crop yields and farm incomes of the households can be accordingly increased.

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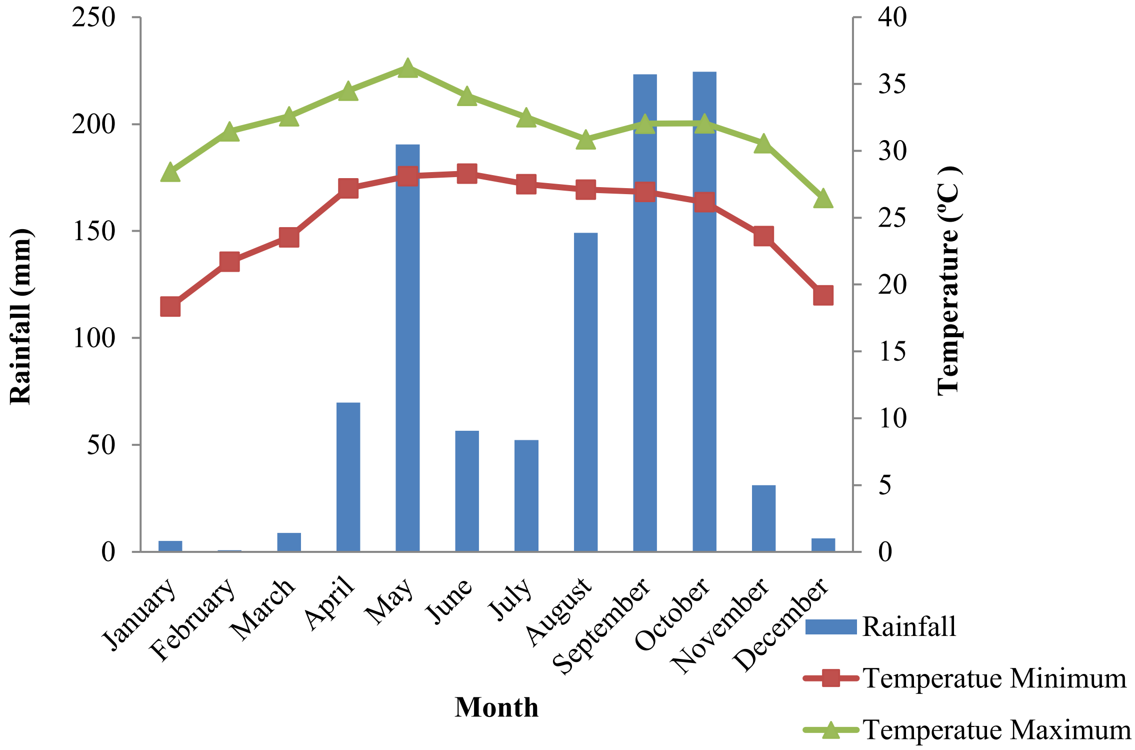
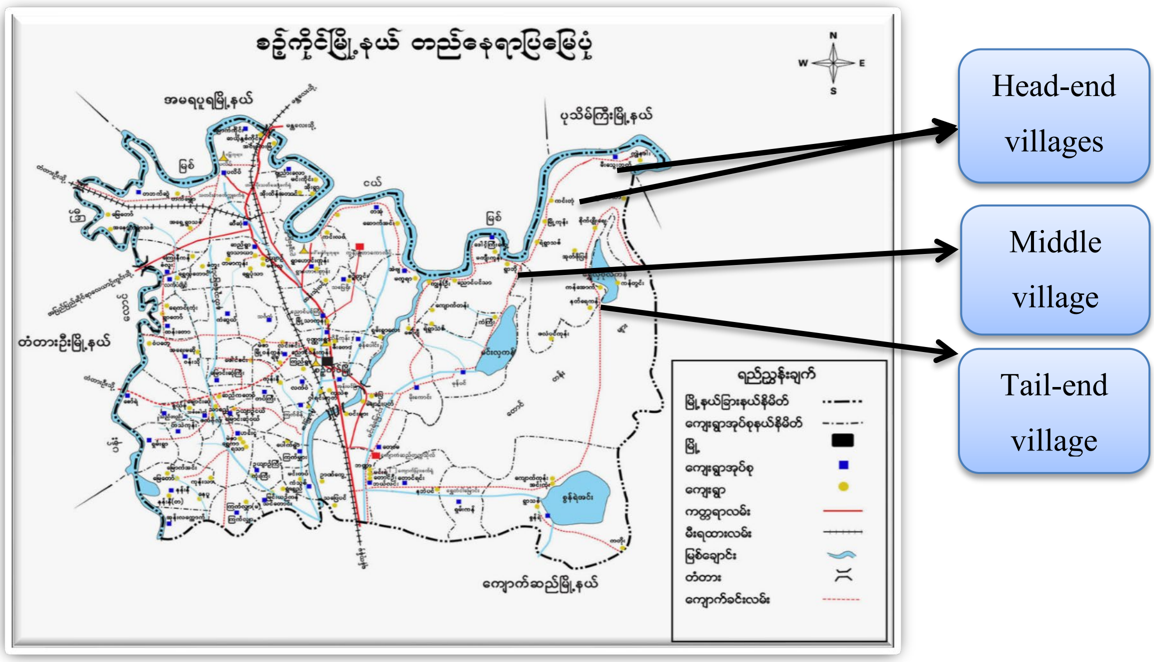
APPENDICES



Appendix 1. Monthly average rainfall and minimum and maximum temperature in Sintgaing Township (DOA, 2017)



Appendix 2. Map of sampling villages (DOA, 2017)