YANGON UNIVERSITY OF ECONOMICS
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A STUDY ON THE SURFACE WATER SUPPLY MANAGEMENT FOR FARMING IN MANDALAY REGION

(CASE STUDY IN PATHEINGYI TOWNSHIP)

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ABSTRACT

The surface water supply management for farming was studied to explore how the surface water resources are utilized for agriculture in selected area in Mandalay Region and to examine the efficiency on surface water supply management in the farming activities of Patheingyi Township. This study was based on descriptive method using both primary and secondary data. For primary data, a survey was conducted on interviewing to farmers of villages in both irrigated and non-irrigated area of Patheingyi with a semi-structured questionnaire. It was found that 60% of total are using irrigation method and remain 40% of total are using rain water for farming water. The 35 % of total respondents got water distribution in terms of adequacy, reliability, timeliness. And the 5 % of respondents from head area of Canal faced the challenges on getting heavy amount of water which made to damage their crops and 10 % of respondents faced same condition as heavy rain made damage their crops. And then 5% of respondents from tail side area of canal faced to the challenges for not getting required farm water in required time when the 2.5% of respondents from electric pump station area faced with the electricity and pump were broken and 2.5% of respondents from rain fed area faced same problems because of drought weather.

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LIST OF ABBREVIATIONS

ACC	Agriculture Coordinating Committee
ASEAN	Association of Southeast Asian Nations
DOA	Department of Agriculture
FAO	Food and Agriculture Organization
FCs	Frontline Centers
IWUMD	Irrigation and Water Utilization Management Department
Ha	Hectares
ID	Irrigation Department
MDGs	Millennium Development Goals
MDevS	Master of Development of Studies
MPA	Master of Public Administration
MOALI	Ministry of Agriculture, Livestocks and Irrigation
MWC	Myanmar Water Commission
MWRC	Myanmar Water Resources Management
NGOs	Non-Government Organizations
WUAs	Water User Associations
WUGs	Water User Groups

CHAPTER I

INTRODUCTION

Water resources have been historically regarded as essential for a good agricultural output and adequate food supply for the people. Water has unique characteristics that determine both its allocation and use as a resource by agriculture. Agricultural use of water for irrigation is itself contingent on land resources. Water resources for agriculture and food production are classified as either surface or underground water. In this chapter, introduction to the rationale of the study and objectives, scope and limitations and organizations of the study will be discussed.

1.1 Rationale of the Study

Water is of fundamental importance to human development, the environment and the economy. Access to water and water security is paramount to improving food security, incomes and livelihoods of rural communities.

The world needs to produce an estimated 60 percent more food by 2050 to ensure global food security, and it must do so while conserving and enhancing the natural resource base. Water is a major input in the provision of food from production in the field through all the steps in the value chain. Water is also required to meet personal and household needs, for energy and industrial production, and to maintain important water-dependent ecosystems and ecosystem services. With demand and competition for water on the rise, however, the planet's water resources are under increasing stress due to climate change, poor management and pollution.

Agriculture holds the key to successfully achieving the objectives and aspirations articulated in the Sustainable Development Goals and the Paris Agreement on climate change. It is also crucial to the livelihoods of hundreds of millions of smallholder farmers and rural communities worldwide.

Water resources have been historically regarded as essential for a good agricultural output and adequate food supply for the people. All ancient civilizations that have prospered developed successful water resources management schemes. Water has unique characteristics that determine both its allocation and use as a resource by agriculture. Agricultural use of water for irrigation is itself contingent on land resources. Water resources for agriculture and food production are classified as either surface or underground water. In humid climates surface water is the main source for irrigation systems. Under sub-humid and arid conditions, underground water is the major water resource for agriculture and food production.

Most of Myanmar's total water usage is the agricultural part, especially in irrigation, which takes up about 90% of the total and the rest of 10% accounts for domestic and industrial use. Surface water portion in agricultural usage, or irrigation, is around 95% whereas only 5% of it is from groundwater (FAO, 2011). Most of the groundwater are used in the domestic part and some of them are used in industrial part, taking up 22% of the total industrial withdrawal (R. Hasman, 2014).

In Myanmar, there have three main agro-ecological zones, namely the Delta, the Dry Zone and the hill areas where major agro-climatic zones. In contrast, central Myanmar, lying in the monsoon's rainfall shadow, is a dry region with population clusters along the main river valleys. The Central Dry Zone region, straddling large parts of Mandalay, Magawe and lower Sagaing region, along with Rakhine Region and Shan State is one of the most food insecure, water-stressed, climate sensitive and natural resource poor regions in Myanmar. This region has the second highest population density in Myanmar but remains one of the least developed. The main issue in this region is the availability of water. This is a problem for agriculture (irrigation), drinking and domestic water and energy need through (small scale) hydropower, all in the water-food-energy nexus. Deforestation, erosion and sedimentation add to the problems. Short heavy rainfall causes flash floods. Urbanization and industrialization are growing issues.

Access and availability of water resources are key determinants of rural poverty with livelihoods largely dependent on the southwest monsoon. Principal crops consist of oil seeds and legumes, chilies, and vegetables grown as rain fed, upland crops during the wet season. Rice cultivation depends on irrigation, even during the monsoon season. Seasonal water shortages caused by low and erratic annual rainfall patterns and sandy and fragile soils that are at high risk of water and wind erosion limit paddy rice cultivation, render rain fed agriculture a high risk endeavor, and contribute to low agricultural production. Under such uncertain climatic and rainfall conditions, the provision of functional canal irrigation systems is critical to safeguarding crops (ADB, 2013).

The main challenge confronting water management in agriculture is to improve water use efficiency and its sustainability. This can be achieved through (i) an increase in crop water productivity (an increased in marketable crop yield per unit of water transpired) through irrigation, (ii) a decrease in water losses through soil evaporation that could otherwise be used by plants for their growth, and (iii) an increase in soil water storage within the plant rooting zone through better soil and water management practices at farm and area-wide (catchment) scales.

Several ways of water supply for farming could be distinguished as (i) irrigation systems based on pumped water (electricity, diesel) from nearby rivers , (ii) spate irrigation systems to catch water from scarce-heavy-rainfall during short periods in the dry zone, (iii) irrigation systems with water storage in reservoirs all over the country, (iv) river water level setup though weirs for gravity irrigation possibly in combination with rain fed rice production, often in dyed polders and (v) groundwater irrigation using tube wells.

Therefore, this thesis would search the effectiveness surface water supply management including irrigation system for better performance in water distribution in terms of adequacy, reliability, timeliness and equality between head, middle and tail end area of Canal.

1.2 Objectives of the Study

The objectives of the study are (i) to identify how the surface water resources are utilized for Agriculture in Mandalay Region and (ii) to examine the efficiency of surface water supply management in the farming activities in selected area, Patheingyi Township.

1.3 Method of Study

This study was based on descriptive method using both primary and secondary data. For primary data, a survey is conducted on interviewing to farmers of villages in both irrigated and non-irrigated area of Patheingyi Township, Mandalay Region. A semi-structured questionnaire is used to obtain the required data for the analysis of the survey results. The secondary data is collected from Agriculture Department, Irrigation and Water Utilization Management Department, General Administration Department and libraries, articles etc.

1.4 Scope and Limitations of the Study

The study was focused on the surface water supply management for farming water in Patheingyi Township, Mandalay Region. The survey was conducted from December, 2017 to January 2018 in the irrigated and non-irrigated area were selected as survey area of this study. The random sample was 200 farmers of ten villages of study area in Patheingyi Township, Mandalay Region. This study is not be covered the water resource management in Mandalay Region and farming status of Mandalay Region.

1.5 Organization of the Study

This thesis is composed of five chapters. The first chapter is Introduction of the study and it has five subtitles; Rationale of the Study, Objective of the Study, Study Design and Method, Scope and Limitations and Organization of the Study. The second chapter outlines the Literature Review in which related international studies local research studies were reviewed for the importance of water resource for farming.. Chapter 3 presents about Surface Water Resource Management in Mandalay Region with agriculture production in Mandalay Region. Chapter four presents about A Case of the Efficiency of Surface Water Supply in Farming Groups in Selected Area and finally, Chapter five is the Conclusion with the Findings of survey analysis and presents the discussion and recommendation of the study.

CHAPTER II

LITERATURE REVIEW

2.1 Type of Climate Zones

There are six main climate zones in the world: tropical, dry, mild, continental, polar, and highland. The drylands could be defined according to the definition provided by the United Nations Convention to Combat Desertification (CCD). The CCD uses the ratio of mean annual precipitation to mean annual potential evapotranspiration to identify dry-lands of the world. Potential evapotranspiration is the amount of moisture that, if it were available, would be removed from a given land area by evaporation and transpiration.

Using the ratio of mean annual precipitation to mean annual potential evapotranspiration, the world is divided into six aridity zones. Drylands include arid, semi-arid, and dry sub-humid areas (other than polar and sub-polar regions) in which this ratio ranges from 0.05–0.65. Areas where the ratio is less than 0.05 are hyper-arid zones. And Areas where the ratio is greater than 0.65 are humid zones areas.

Of the approximately 135 million km^2 of terrestrial land area globally, the humid zone is the most extensive including about 46.5 million km^2 (or 34 percent of total land area). This zone covers most of Europe and Central America, and large portions of Southeast Asia, eastern North America, central South America, and central Africa. The hyper-arid zone is the least extensive, including approximately 11 million km^2 (or 8 percent of total land area), and is represented most predominantly by the Saharan Desert. Hyper-arid lands generally are unsuitable for growing crops. Dry lands cover almost 54 million km^2 of the globe. Semi-arid areas are most extensive followed by arid areas and then dry sub-humid lands.

Since the beginning of man, societies have been dependent on water. Their livelihood has always depended on the ability to manage and share this rare resource. This is today particularly true in some parts of Africa and in arid zones where surface water resources can be scarce and groundwater resources non-renewable. Water is at the foundation of sustainable development as it is the common denominator of all global challenges: energy, food, health, peace and security, and poverty eradication. (Robin P. White and Janet Nackoney, 1999)

People in arid areas are uniquely vulnerable not only to drought and other natural disasters, but also to economic and social changes. Achieving sustainable development has particularly significant implications for reducing poverty and hunger. Limited and unreliable access to water is a determining factor in agricultural productivity in many regions, a problem rooted in rainfall variability that is likely to increase with climate change. Today, under-performing irrigation systems and poor water management practices worsen the water shortages that already exist in many countries.

2.2 Nature of Farming in Dry Zone Area

In every region of the world it is necessary to find or develop appropriate techniques for agriculture. A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture. There are millions of people who live in such regions, and if current trends in population increase continue, there will soon be millions more. These people must eat, and the wisest course for them is to produce their own food. The techniques are so varied that only a very large volume would cover the entire subject.

Arid implies prolonged dryness, and is used with respect to the climate itself, and the land below it. In such regions the ability to produce agricultural crops is restricted. Usually on arid lands the potential evaporation of water from the land exceeds the rainfall. The land may be characterized according to the degree of aridity as dry forest, chaparral or brush land, grassland or savannah, or desert. The word, "arid" does not adequately characterize the soils, however, for they may vary in many ways. Often they are alkaline or saline.

Several degrees of dryness must be recognized. The first is where the dry climate is modified by seasonal rainy seasons. In such a region it might be possible to produce a wide range of annual crops during the short rainy season, enough to sustain animals and feed mankind, although few food or feed trees might be feasible without special techniques. The second situation is a year round aridity, sometimes modified by light or irregular rains, which might make production of crops impossible. The third situation is where water is brought in by wells, canals, or other means so that normal agriculture can exist, in spite of the aridity of the climate. This primer concerns the first two situations, but not the third. There are techniques suitable for all arid regions.

The arid regions of the world are often very extensive, but in the tropics it is common, even on a small island, to find arid regions not far from regions of abundant rainfall. Some of the larger arid regions are: North America Africa, Much of Western USA The Sahara Desert, The Sonora Desert The Sahel, The Kalahari Desert, Central America East Africa, The Pacific Coast, South America Asia, The Atacama Desert The Middle East, The Serrano of Brazil The Indian or Thar Desert, The Namub Desert , Australia The Karakum Desert, The Central Deserts The Gobi Desert. However, while the above mentioned regions may constitute the most arid regions, nevertheless, there are many more areas, large and small, where aridity is a problem (Randy Creswell and Dr. Franklin W. Martin, 1993).

2.3 Importance of Water Resources for Agriculture and Food Production

Water resources have been historically regarded as essential for a good agricultural output and adequate food supply for the people. All ancient civilizations that have prospered developed successful water resources management schemes. Water resources for agriculture and food production are classified as either surface or underground water. In humid climates surface water is the main source for irrigation systems. Under sub-humid and arid conditions, underground water is the major water resource for agriculture and food production.

Water in the form of rain and snow is made available by nature in the yearly hydrological cycle. Precipitation is even intercepted by the vegetation, infiltrated into the ground or runs off as runoff. From infiltrated amounts, a sizeable part goes to evapotranspiration for biomass generation. Another part percolates into the water table feeding natural aquifers. Surface runoff concentrates in channels that drain into larger channels making up a watershed drainage network that discharge into the sea or is stored in lakes or dams. Water is recycled continuously through transpiration, evaporation from land, river systems and oceans. A watershed or river basin is a natural entity that should be used as an integrating unit for water resources planning.

Precipitation, withdrawals and availability of water vary widely around the world. Per capital availability is highest in Latin America and lowest in North Africa and the Near East while withdrawals are highest in North America and lowest in Africa. Per capital water availability in Europe and North America is not expected to change greatly by 2000 while Asians, Africans and Latin Americans will face less per capital water availability as their populations continue to grow. The present global water use for agriculture and food production is about 70% of the total. As demands rise in all the various regions and countries to meet the requirement of 2025 is extremely varied.

It is estimated that while the population will grow from 6 billion to 8 billion in next 25 years, the present food production shall have to be doubled. Under this conditions, food needs will exceed projections of agricultural output. Large-scale farming could not provide food for the world's large populations without the irrigation of crop fields by water sources from rivers, lakes, reservoirs, and wells. Without irrigation, crops could never be grown in the Imperial Valley of California, the Irrigation Districts of Mexico or the deserts of Israel.

According with the Food and Agriculture Organization of the United Nations, (FAO,1998), demands for water for growing more food will increase causing shortages in regions that up to know are self sufficient in water resources. The growth in shortage could be avoided only by developing the potential sources or by decreasing the withdrawals and simultaneously increasing water use efficiency. Countries with large populations are trying their best for maintaining self-sufficiency in food production. In this countries in case of droughts, the shortfalls will be too large to be covered by world trade due to financial constrains and food trade availability. Given these facts, it is clear that food security in the XXI century will is closely linked with water security and success in irrigation. FAO figures show that between 30 and 40 percent of the world's food comes from the irrigated 16 percent of the total cultivated land. Around one-fifth of the total value of fish production comes from freshwater aquaculture; and current global livestock drinking-water requirements are 60 billion liters per day. Forecasts estimate an increase of 0.4 billion liters of water per year for livestock consumption. (C.Him-Gomzalez, 2003)

The Second World Water Forum, (The Hague, October 2000), recognizes water as a scarce commodity. Its Vision Management Unit stated that supply and demand management has to go hand in hand for removing the mismatch between water resources and agriculture and food needs. To ensure a sustainable rural development "A holistic, systemic, participatory, innovative institutional mechanisms" is needed.

2.4 Surface Water Resource Management for Farming

Surface water resources used in agriculture and food production include water from rivers, lakes and ponds. Surface water is found in streams (rivers, creeks), or is stored in lakes and dams. Surface water systems are continuously interacting with underground and atmospheric water.

The American continent contains some of the world's largest rivers and many countries are considered "Water rich"; such as Canada, United States of America, Brazil and other countries of Central and South America. However, regional and temporal variations make even parts of these countries suffer from droughts, while on an annual basis, only 1% of the total volume of water is withdrawn in South America. The United States has some of the highly productive surface water from rivers in California and the Pacific Northwest. In Mexico, approximately 4.2 million (68%) hectares are irrigated with surface waters, and the remaining; some 2 million hectares are served by groundwater pumping. Presently, irrigation uses about 70% of waters withdrawn from global river systems, 60% of which gets used consumptively, the rest predominantly returning to the river systems enabling its reuse downstream.

Surface waters are stored in dams to provide a steady water supply for irrigation during the whole year. Dams are hydraulic structures artificially build to store water for irrigation, hydropower generation and flood control. Current estimates suggest that some 30–40% of irrigated land worldwide now relies on dams. Under most scenarios, there is a need for increasing freshwater storage. Increasing storage through a combination of large and small dams is critical to meeting the water demands of the twenty-first century especially in the regions under monsoonal climate, predominantly in Asia.

In Sub-Humid climatic conditions "Water Harvesting" is an additional useful technique for maximizing available precipitation amounts for orchards. The micro-topography of the area close to the trees is change and compacted creating a micro catchment area for storing precipitation close to the root system. The catchment area should be enough to provide moisture to the trees to survive until the next precipitation. In the Israeli experience, an arid zone with 200 mm winter rainfall requires approximately 40 m^2 of catchment area for each tree (WASAD, 1998). For the windbreaks in Niger and Nigeria, the basin area for each tree was set at 8 m^2. The technology involved in applying rainwater harvesting in the field is not complicated and can be adapted to the local environmental conditions of arid zones.

Surface water commonly is hydraulically connected to ground water, but the interactions are difficult to observe and measure and commonly have been ignored in water-management considerations and policies. As global concerns over water resources and the environment increase, the importance of considering ground water and surface water as a single resource has become increasingly evident. Issues related to water supply, water quality, and degradation of aquatic environments is increasingly important. The interaction of ground water and surface water has been shown to be a significant concern in many of these issues. For example, contaminated aquifers that discharge to streams can result in long-term contamination of surface water; conversely, streams can be a major source of contamination to aquifers. (C. Him-Gonzalez,2003)

As freshwater resources are declining in quantity and deteriorating in quality, water resource management is of greater importance than ever before, and it is widely agreed that integrated water resource management (IWRM) is the way forward. IWRM is the concept of managing water sectors subject to various objectives in an integrated manner, which considering social economic and environmental dimensions. Each country will have different ways of implementing the IWRM process and derive different benefits from it. Implementation modes will also depend on the geographic, social and economic context and, in particular, on the hydrology (Baris Yilmas and Nilgun B Harmancioglu, 2010).

In order to evaluate the management alternatives, nine criteria that are relevant to environmental, social and economic sustainability are developed as shown in Table (2.1).

Table (2.1) Evaluation Criteria of the efficiency of Water Resource Management

Criteria	Indicator	Description
Environmental	Agricultural Sustainability Index (ASI)	The temporal aggregation of supply/demand ratio time series (only for irritation) according to the performance measures where the satisfactory range is considered between 0.8 and 1.0
	Environmental Sustainability Index (ESI)	The temporal aggregation of supply/demand ratio time series (only for environmental needs) according to the performance measures where the satisfaction value is 1 (full coverage)
	Water Exploitation Rate (WER)	The percentage of surface water potential that is allocated for irrigation. (Annual average is used in the evaluations)
Social	Yield Reliability (YR)	Average yield reliability of main cultivated crops (the satisfactory range is considered between 0.75 and 1.00 for all crop)
	Irrigation Water Deficit (IWD) ($10^6 m^3$)	Represents annual unmet demand for irrigation (annual average is used in the evaluations)
	Domestic Supply Reliability (DSR)	The supply reliability of transmission link to required area from Dam)
Economic	Benefit/Cost Ratio	Total sum of benefit divided by total sum of costs of management alternatives for the simulation period
	Irrigation Water Use Efficiency (IWUE)	Production value (monetary) of agricultural practices per allocated water for irrigation (annual average is used in the evaluations)
	Total Production Value	Annual total production value of agricultural practice (annual average is used in the evaluations)

Source:IWRM,2010

2.5 Surface Water Resource Management in Asian Countries

For many Southern and Eastern Asia countries, the national institutions responsible for the management and planning of irrigation development are departments or divisions within the Ministry of Agriculture, In Bangladesh, minor irrigation schemes are under the jurisdiction of the Ministry of Agriculture and small scale surface irrigation under the Ministry of Local Government, Rural Development and Cooperatives, while large-scale irrigation schemes are under the Ministry of Water Resources. In Bhutan, irrigation management depends on the irrigation Agency, in Brunei Darussalam, on the Department of Agriculture of the Ministry of Industry and Primary Resources and in the Philippines, on the Department Agriculture of the National Irrigation Administration. In Nepal, there is a Ministry of Irrigation and in Thailand, irrigation is managed by the Royal Irrigation Department for public schemes, or by the Department of Water Resources.

Overall, the responsibility for water resource management, planning and development is shared by various government agencies and ministries, in some cases, there is little coordination between them.

In the Philippines, the National Water Resources Board is the overall government agency that is responsible for all water resources in the Philippines. In India, the federal states are primarily responsible for the planning, implementation, funding and management of water resources development, while the Ministry of Water Resources is responsible for laying down policy guidelines and programmers for the development and regulation of the country's water resources.

The management of the irrigation system is generally performed jointly by the State, as regards the primary infrastructure or public systems, and by user associations independent users for the secondary and tertiary infrastructure or private systems.

In most of the countries, surface water and ground water resources are state property. Water tariff is used in most countries of the region, although in different ways. China requires different charges to be collected according to the cost of water delivery. In India, there is no uniform set of principles in fixing the water rates. They vary from state, project to project and crop to crop. From the end of the 1960s, as Indonesia made large investments into land and water resources development to achieve food self-sufficiency. Since the beginning of the 1990s, however, as

Indonesia gained confidence in securing its national food supply, government investments in land and water resources gradually have been decreasing.

In Malaysia, it was estimated in 1999 that fees collected from farmers cover only 10-12 percent of the actual operational cost. In the Maldives, the domestic tariff is stepped to provide a minimum quantity of water per day at an affordable rate. Mongolia's law on water covers pricing policies intended to ensure cost recovery and the equitable allocation of water resources. In 2008, however, only about 65 percent of water costs were recovered through pricing, partly because of the country's present economic conditions.

In Myanmar, water tariff covering the Irrigation Department's gravity irrigation system is very low and does not recover the cost of maintenance work. The annual budget for the maintenance and repair of the facilities is mostly paid by the government.(FAO,2000)

In most countries of the region there has been financial assistance from international donors and foreign governments, such as the World Bank, International Bank for Reconstruction and Development, Japan International Cooperation Agency and Asian Development Bank, for major construction and projects directed at the agricultural and energy sectors.

A case study which would be studied is " Examining adaptations to water stress among farming households in Sri Lanka's dry zone studied by Nicholas E. Williams, Amanda Carrico(2007)". In Sri Lanka, climate change is increasing water scarcity. Whether these changes will undermine national- level food security depends upon the ability of the small- scale farmers that dominate rice production and the institutions that support them to overcome the challenges presented by changing water availability. Analyzing household survey data, this research identifies household, institutional, and agroecological factors that influence how water-stressed farmers are working to adapt to changing conditions and how the strategies they employ impact rice yields. Paralleling studies conducted elsewhere, there could be identified institutional factors as particularly relevant in farmer adaptation decisions. Notably, this research identified farmers' use of hybrid seed varietals as the only local climate adaptation strategy to positively correlate with farmers' rice yields. And these findings provided insight into additional factors pertinent to successful agricultural adaptation and offer encouraging evidence for policies that promote plant breeding and distribution in Sri Lanka as a means to buffer the food system to climate change-exacerbated drought.

2.6 Overview of Agriculture in Myanmar

As agriculture plays a crucial role in the economy of Myanmar, sustainable agriculture is a prerequisite for achieving sustainable development objectives. Sustainable agriculture requires the integration of environmental considerations with agricultural policy analysis and planning.

Myanmar is a favorable agrarian structure with high potential for development of small holder and large scale farming with average farm size of 2.5 ha accounting for the second largest in South East Asia after Thailand which is about 3.1 ha. Myanmar has a relatively high land/population ratio and half the arable land is still fallow. But development of the sector has been constrained by macroeconomic instability, infrastructure constraints, marketing and financial issues, and farmers' lack of access to quality research and extension support. Relatively weak agricultural performance has also impacted negatively on the overall development of the rural sector.

The country is highly diverse in terms of its agro-ecological zones and farming systems. It has three main agro-ecological zones, namely the Delta, the Dry Zone and the hill areas where major agro-climatic zones as shown in Table (2.2). The densely populated Delta in the south is home to about 22 million people who are mainly engaged in lowland rice cultivation, particularly during the monsoon season. In contrast, central Myanmar, lying in the monsoon's rainfall shadow, is a dry region with population clusters along the main river valleys. Dry Zone farmers cultivate a range of rain-fed crops. About 19 million people live in the Dry Zone.

The third largest agricultural zone is in the hill region, dominated by Shan State in the east, and inhabited by 6.5 million people. Hill farmers cultivate a wide range of rain-fed tree crops and horticulture products along with rice, maize and pulses.

Three different seasons enable farmers to cultivate crops at different times of the year. The main farming season for most of the country is the hot monsoon period from May to October. The ensuing dry period includes the cool, dry winter months from October to February, followed by the dry and hot summer season from February to April. The structure of crop, livestock and fish production varies considerably during Myanmar's three seasons as well as across its three principal agro-ecological zones. (Thanda Kyi, 2016).

Table (2.2) Major Agro-Climatic Zones in Myanmar

Name	Geographical description	Administrative unit	Main agricultural practice
Bago, Kachin Riverside land	Upper Delta, Kachin plain, flat plain along the Ayeyarwady and Sittaung, moderate rainfall (1 000-2500 mm).	Ayeyarwady Region, Kachin State, Sagaing, Mandalay and Bago Regions.	Rice, pulses, oilseeds, sugarcane, tobacco and Kaing/Kyun cultivation
Central Dry Zone	Flat plain, some uneven topography, less than 1 000 mm rain.	Magway, Mandalay and Sagaing Regions.	Upland crops, oilseeds, pulses, rice, cotton, irrigated agriculture and Kaing/Kyun cultivation
Delta and Coastal Lowland	Delta, lowland and mouth of rivers in coastal area, heavy rainfall (more than 2 500 mm).	Ayeyarwady, Yangon and Bago Regions, Mon and Kahyin States, Taninthayi Region and Rakhine State.	Rice, pulses, oilseeds and nipa palm
Kachin and Coastal Upland	Mountainous, sloping land, heavy rainfall (more than 2 500 mm).	Kachin and Rakhine States, Taninthayi Region, Mon, Kayin and Kayah States, Yangon and Bago Regions.	Orchards, plantation crops and upland agriculture
North, East and West Hills	Hilly, uneven topography, sloping land, moderate to heavy rainfall	Kachin, Chin and Shan States.	Upland crops, shifting cultivation and fruit trees
Upper, Lower Myanmar and Shan Plain	Plains, plateau, upper and lower parts outside central dry zone.	Sagaing Region, Kachin and Shan States, Bago, Magway, Mandalay and Yangon Regions.	Upland crops, oilseeds, pulses, vegetable and wheat

Source: FAO/WFP crop and food security assessment mission to Myanmar

Due to variations in agro-ecological conditions, more than 60 different crops are grown in Myanmar. They can be grouped into seven categories such as Cereals, Oil seeds, Food Legumes, Industrial Crops, Food Crops, Plantation Crops, and Miscellaneous Crops. Under the government policy which gives the right of tilling the land to the actual tiller, the number of farmers with large holding has substantially decreased while the number of farmers working on smaller holding has increased.

Recent Agricultural Developments in Myanmar are Introduction of Chemical Fertilizers, Pesticides, Quality Seeds, Selective Concentrative Strategy, Integrated Pest Management, Solid Conservation Practices, Organic Fertilizers, Biogas Plants and Organic Recycling, Green Manure Practices, Bio-fertilizers, and Improved Cropping Systems etc.

The major development objectives in the agricultural sector are (i) to attain self-sufficiency in food for the increasing population of the country, (ii) to produce sufficient raw material to meet the requirement of agro-allied industries at home and (iii) to maximize the foreign exchange earnings by expansion of our export potential for agricultural produce (Cho Cho Myint, 2000).

Despite the country's richness in resources and having a strategic location, agriculture has underperformed in Myanmar over the past five decades especially in terms of productivity, inequality and high volatility. Low agricultural productivity translates into labor productivity and land productivity where both level of productivity are lower. Farm earnings per worker in Myanmar range between one-half and one-third of the levels in neighboring countries. The reasons for this vary across commodities but stem in large part from long-term chronic underinvestment in agricultural research, weak extension support and limited access to credit. Paddy yields are lower because of lower levels of input use, particularly improved seeds and fertilizers, inefficient weed and pest control, and uncertain water management (Denning and others 2013). Consequently, output gain has come mostly from increased area rather than increased yields. The slow agricultural productivity growth has resulted in stagnant farm incomes, while the share of agriculture in GDP has declined from about 57%in the early 2000s to 32%in 2015 due to rapid growth in natural gas production and related sectors.

The highly skewed distribution of land and other productive assets is a key reason for the high levels of rural inequality and poverty. The seasonality of agricultural employment, coupled with seasonal underemployment and low wages, limit annual rural incomes, with about one-fourth of the rural population under the poverty line (IHLCA 2011). With lower incomes and fewer assets to cushion against seasonal and episodic health and weather shocks, the average rural household has adequate food supplies for about 10 months a year. Landless households have food security for 9.6 months (LIFT 2012).

The high volatility of agricultural production and prices compounds risks for rural and agricultural households. Many farmers and traders talk explicitly about the increased unpredictability they face. The record flooding in 2008 was followed by both drought and floods. As a result, farmers are acutely aware of the increased risks to agricultural production. Most studies of climate change in Myanmar suggest that in the coming decades, average temperatures will increase along with aggregate rainfall although rains may become more sporadic, leading to higher volatility and increased flooding and drought (RIMES 2011, World Bank 2012).

Agricultural production volatility is linked to a number of factors. Increasingly irregular rainfall and poor water management, result in frequent floods and droughts. Unpredictable policies, particularly those related to trade, are also a concern for agribusiness. Unexpected export restrictions and, in some cases, land control measures have prevented exports of some crops over the past decade. A reliance on single export markets also contributes to price volatility in many commodities. Myanmar is exporting about 70%of its pulses production to India and 90%of its watermelon harvest to China. The onion production is mostly for domestic consumption and about 75%of onion exports are sent to Thailand. Dislocations in the Indian, Thai or Chinese markets can generate large swings in Myanmar’s pulses, onion and watermelon prices. In November 2012, sluggish Chinese demand for watermelons caused a noticeable price slump in Yangon and Mandalay as growers off-loaded production in local markets. The very low level of mobile phone connectivity in rural areas limits farmers’ access to regional price information (LIFT 2012). This is in sharp contrast to the rest of Southeast Asia where countrywide mobile phone connectivity is close to 100%. The marketing and logistics infrastructure, among the least efficient and with the highest costs in Southeast Asia (ADB 2012), also aggravates price swings (Thanda Kyi, 2016)

2.7 Reviews on Previous Studies

Regarding the study on water supply management for farming sector of Mandalay Region (Case study in Patheingyi Township), many scholars and researchers conducted in different areas. Among them, Kyawt May Aung (2007) studied on Framing Status in Irrigated Area of Nga-Moe-Yeik Dam (Hlegu Township, Yangon Region) . She found that the two key issues for farmers: (a) labor shortage and insufficient agricultural machinery and (b) price fluctuation. In the study area, most of the farmers sowed monsoon paddy and groundnut before constructing Nga Moe Yeik Dam. After getting irrigation from Nga Moe Yeik Dam, monsoon paddy and summer paddy are sowed. Only the farms which cannot get the irrigated water cultivate groundnut because the farm soil is in the high region.

May Khine Win (2016) studied the Effectiveness of River Water Pumping Irrigation System in Mandalay Region (Case Study: Shwe Hlan Bo Project, Sinkaing Township, Kyaukse District). She found that three villages show to improve their life style appeared after implementing the water pump irrigation project. Local people used more water, increase yields of paddy, improve health and education.

Soe Sint Win (2009) studied Socio-economic Impact of Zaungtu Multipurpose Dam Project in Eastern Bago Yoma. She found that the completion of Zaungtu Multipurpose Dam, local people faced with the good chances of the increasing of the income from the agricultural production.

CHAPTER III

SURFACE WATER RESOURCE MANAGEMENT IN MANDALAY REGION

3.1 Topography of Dry Zone

Surface water is water on the surface of the planet such as in a river, lake, wetland, or ocean. It can be contrasted with groundwater and atmospheric water. Myanmar is endowed with abundant water resources. Therefore the north-south direction of Myanmar's mountain ranges is reflected in the flow of its major rivers, of which two are international. There are many river basins such as the Ayeyarwady (Irrawaddy)-Chindwin river basin, the Sittaung river basin, the Thanlwin river basin, Rakhine coastal basin and the Tanintharyi coastal basin respectively.

The country is highly diverse in terms of its agro-ecologyical zones and farming systems. It has three main agro-ecological zones, namely the Delta, the Dry Zone and the hill areas where major agro-climatic zones. The densely populated Delta in the south is home to about 22 million people who are mainly engaged in lowland rice cultivation, particularly during the monsoon season. In contrast, central Myanmar, lying in the monsoon's rainfall shadow, is a dry region with population clusters along the main river valleys. Dry Zone farmers cultivate a range of rain-fed crops. About 19 million people live in the Dry Zone. The third largest agricultural zone is in the hill region, dominated by Shan State in the east, and inhabited by 6.5 million people. Hill farmers cultivate a wide range of rain fed tree crops and horticulture products along with rice, maize and pulses.

The Dry Zone of Myanmar lies in the central portion of the country, astride the mighty Ayeyarwady River, between latitudes 19° 20" to 22° 50"and longitudes 93° 40" to 96° 30". Incorporating 57 townships in 13 districts in Sagaing, Mandalay and Magway Region, the Dry Zone covers a total area of 33,680 sq miles accounting for approximately 17 % of national territory as shown in Map (3.1) in Appendix I.

The Dry Zone is part of the central plain of Myanmar, sandwiched by the mountainous zone on the west, and the highlands on the east. It spreads across three Regions - Sagaing (Sagaing, Shwebo and Monywa districts), Mandalay (Kyaukse, Myingyan, Meikhtila, Yamethin and Nyang U districts) and Magwe (Pakokku, Magwe, Minbu and Thayet districts). The Dry Zone is mostly flat, with the Irrawaddy flowing through it from north to south. A range of hills (Bago Hills) runs parallel to the river in the southern part of the Dry Zone, gaining altitude towards the north and ending in southeast Mandalay. Fertile alluvial soil is found mostly along the banks of the Irrawaddy, with Sagaing Region having the largest area under alluvial soil, and Magwe Region the lowest. The Bago hills are composed of sandstone, with less fertile sandy soil.

The climate of the Dry Zone can be divided into two periods—the wet season and the dry season. The wet season coincides with the southwest monsoon and lasts from May to October. The dry season is divided into “winter” (November to February) and “summer” (March to April). Mean annual rainfall in the Dry Zone is lower than in the rest of the country, ranging from 500 to 1000 mm . The Dry Zone also typically experiences a brief dry spell during the wet season in June/July.

The zone is strongly influenced by its climate: although average annual rainfall levels (960 mm) are lower than in other areas of the country, they are nevertheless moderate. However, they are concentrated largely in the period May-October, with an intermediate dry period often occurring during June or July. The lengthy period without precipitation, relatively high average temperatures and generally light shallow soils, result in semi-arid conditions restricting agricultural potential in the absence of irrigation. Even where ground water is available, salinity levels may restrict its utilization.

It is widely reported that precipitation levels in recent years have become increasingly erratic, with significant declines in total amounts and, equally importantly, in its distribution during the rainy season. These changes have significantly increased the perceived risks associated with agricultural production in the zone as well as increasing the difficulty of ensuring year-round water supplies for human and animal consumption.

3.2 Geographical Background of Mandalay Region

Mandalay Region of Upper Burma, lies between 21° 42′ and 22° 46′ N. and between 95° 54′ and 96° 46′ E. with an area of 2,131 square miles. It is bounded on the north by the Mogôk Subdivision of the Katha District; on the east by the Hsipaw State of the Northern Shan States; on the south by the Lawksawk State of the Southern Shan States, by the Kyauksè District, and by the Tada-u Township of the Sagaing District; and on the west by the Sagaing and Shwebo Districts. Of the gross area of the district, 427 square miles are occupied for cultivation and 669 square miles are Reserved Forest; of the balance 203 square miles are classed as culturable waste, and 832 square miles as not available for cultivation as shown in Map(3.2) of Appendix II.

The main feature of the district is a wide plain, about 700 square miles in extent (of which about 400 square miles are occupied for cultivation),spreading from the Irrawaddy eastwards to the foot of the Shan Plateau, and gradually increasing in width from north to south. This wedge-shaped plain slopes both southward and westward, and with the except ion of the portions that are flooded by the Irrawaddy during the rains, or are irrigated from canals and tanks, is liable to drought owing to the uncertainty of the rainfall. To the north and east of the plain are the hills which form the western edge of the Shan Plateau, running, for the most part in broken parallels north and south. Those in the north, however, taking off from the Mogôk group, end abruptly in the Sagyin Hill, and cover about one half of the Singu Township. The highest points in this system are from 2,000 to 3,600 feet above sea level.

3.2.1 Rivers

Besides the Irrawaddy which skirts the district for 75 miles on its western boundary, the main rivers of the district are the Chaungmagyi and the Myitngè. Where the Irrawaddy enters the district at its northern end it is only half a mile wide and where it leaves it at its confluence with the Myitngè it is only three quarters of a mile wide. Between these two points it widens out considerably to two or three miles in the dry weather and sometimes as much as eight in the rains. It is studded with rich alluvial islands and is navigable all the year round by the largest river steamers. The Chaungmagyi, known also as the Madaya River and to the Shuns as the Nam Pai, enters the district at its north-east corner and flowing south forms the boundary between it and the Shun States as far as the Maymyo Subdivision. A few miles south of this, it turns to the west at right angles and debouches from the hills at Sèdaw, where the head works of the Mandalay canal are situated. It then flows westwards across the plain to join a branch of the Irrawaddy close to the Sagyin Hills. The old mouth of the Shwetachaung canal takes off from its southern bank midway between Sèdaw and the Irrawaddy. It is navigable in the rains for country boats as far up as Sagabin:, a few miles west of Sèdaw; before the Mandalay canal was built it was navigable all the year round as far as this. The Myitngè or Doktawaddy, known in the Shan States as the Namtu, forms the southern boundary of the district flowing in a deep gorge through the hills; its bed is full of rapids and falls. It leaves the hills in a north westerly direction near Kywetnapa at the foot of a 2000 feet bluff of the Myaleittaung in the Kyauksè District and flows across the plain in a series of loops to join the Irrawaddy immediately north of Ava. Its channel in the plains is comparatively narrow and well defined by high banks, with no islands or sandbanks. It is navigable in the rains by country boats and small launches up to the point where it leaves the hills and in the dry weather as far as Gwebin though large dugouts are employed on the whole of its course through the plains all the year round.

3.2.2 Climate and Rainfall

Mandalay draws on average 36 inches of rainfall per year, or 3 inches per month. On average there are 51 days per year with more than 0.004 inches of rainfall (precipitation) or 4.4 days with a quantity of rain, sleet, snow etc. per month. The driest weather is in March when an average of 1 mm (0 in) of rainfall (precipitation) occurs. The wettest weather is in October when an average of 185 mm (7.3 in) of rainfall (precipitation) occurs. The amount of rainfall and temperature in Mandalay for consequence of last four years are as shown in Table (3.1).

Table (3.1) Rainfall and Temperature in Mandalay Region

No.	Year	Rainfall per year (inches)		Temperature (C)	
		No. of Raining Day	Total rainfall	Highest	Lowest
1	2014	55	27	44.7	13.5
2	2015	62	32	42.2	16.3
3	2016	81	36	43.7	11.0
4	2017	61	26	38.5	10.3

Source: Department of Agriculture, Mandalay Region

3.3 Surface Water Supply Projects in Mandalay Region

Water of a optional availability and quality of water are scared to satisfy the demand for different uses, decisions and plans have to be made on how it will be shared between different locations and competing users, one of the practice of water allocation. In simple term, it is the mechanism for determining who can take water, how much they can take, from which location and for what purposes. Nowadays, water shortage is one of the real challenges facing many countries in the world. In Myanmar, the process of population growth, urbanization and industrialization occur at an ever increasing phase at every year. These processes show that demands for water usage are increasing in the sector of domestic water supply, industry, and agriculture and hydropower generation. Thus, the water allocation plan and water resources development projects are undertaken to address these requirements. And water allocation plans need to balance the water supplies with demands, particularly to manage the natural water availability to avoid frequent or unexpected water shortfalls. According to report from Asian Development Bank, total water withdrawal from available water resources in Myanmar are around 89% for agriculture, 10% is for municipalities and 1% is for industries. Approximately 91% of the total water withdrawal comes from surface water and 9% from groundwater. Groundwater is mostly used for domestic purpose. As the difference between water resources and demand is ever increasing, the government is facing with the increasingly difficult task of allocating the available water resources among the competing demands.

In Mandalay Region, the various irrigation projects have been implemented. Dam, Canals, Tanks, Wells, Weirs, and pumps are some of the different types of irrigation. There are 99 projects under these types of water supply systems for irrigation which are administrated by Irrigation and Water Utilization Management Department (IWUMD), Ministry of Agriculture, Livestock and Irrigation (MOALI) as shown in Tables in Appendix III.

Around Mandalay area, most of the water supply is controlled by the Sedawgyi Multipurpose Dam and used for irrigation, hydropower and domestic purposes. Almost of irrigated areas are downstream of the Sedawgyi Dam. The Sedawgyi dam is constructed across the flow of Chaungmagyi river and is divided into three separated river and canals. These are Yenatha Canal, Mandalay Main Canal and the Chaungmagyi River which continues to flow towards the Ayeyarwaddy River. The Yenatha Canal is the man-made canal that flows into the northern irrigation network distributaries. And the Mandalay Main Canal is also a man-made canal which flows southward to Mandalay and is used as water supply canal for both irrigation and domestic use of Mandalay city. Sedawgyi dam water supply covers all irrigated areas of Mandalay city, Mattaya, Patheingyi and Amarapura townships. In selected area, Sedawlay weir is located across Nadaung Kya Chaung in Patheingyi township. This weir can supply for Patheingyi and Amarapura irrigated areas with canals.

The Sedawgyi Irrigation Area is one of the largest rice production area in Mandalay Division. The Irrigation Systems of Sedawgyi Dam and location of the study area is shown in Map (3.3) of Appendix IV.

Sedawgyi hydropower plant is an integral part of the irrigation and domestic supply utilizing the surface water of the Chaungmagyi River by construction of a storage dam and related facilities. The design capacity of the hydropower station is 12.5 MW x 2 Units of Kaplan turbines. Yearly targeted power generation fluctuates around 134 GWh. This fluctuation of generation was caused by irrigation demand side requirements since irrigation supply is main purpose of the reservoir. The outflow from hydropower plant is used for irrigation and domestic purposes by Mandalay.

3.4 Agricultural Production in Mandalay Region

The land types of Myanmar used by the Settlements and Land Records Department(SLRD) are: Le-land (Paddy land); Ya-land (Dry land); Kaing (Alluvial land); Garden land (planted with perennial trees); Dhani (a land along the mouth of the river within reach of salt water); Rubber (land stable for rubber trees); and Other land types. The classification is based on the utilization of land by cultivation of a specific crop on it. In Mandalay Division, the totally nearly 34 million Acres could be divided by utilization as shown in Table(3.2).

Table(3.2) Utilization of Land in Mandalay Division

No.	Type of Land	Total amount (Acres)
1.	Le-Land (Paddy Land)	914494
2.	Ya-Land (Dry Land)	2210923
3.	Kaing/Kyun	165948
4.	Garden land	28450
5.	Other (Taung-ya Land)	726

Source: Department of Agriculture, Mandalay Region

In Mandalay Region, water sources of agricultural are irrigation water from irrigation project, rain water. Therefore, agricultural area are divided into four region such as (i) region irrigated by means of Government Main Cannel, (ii) region irrigated by means of electric pump station, (iii)rainfed region and (iv)alluvial.

3.4.1 Crops Pattern Culvitated in Mandalay Region

Due to variations in agro ecological conditions, more than 60 different crops are grown in Myanmar. They can be grouped into seven categories are as shown in Table (3.3).

Table(3.3) Categories of Crops

No	Type	Name of crops
1	Cereals	Rice, wheat, maize, and millets.
2	Oil Seeds	Groundnut, sesame, sunflower and mustard
3	Food Legumes	Black mungbean, green mungbean, butter bean, red bean, pigeonpea, cowpea, chickpea and soybean
4	Industrial Crops	Cotton, jute, sugarcane, rubber and tobacco
5	Food Crops	Potato, onion, chilies, vegetables, and spices
6	Plantation Crops	Tea, coffee, coconut, cocoa, oil palm, toddy palm, banana and other fruits
7.	Miscellaneous Crops	Other crops which are not listed in above groups

Source: Department of Agriculture, Mandalay Region

The Mandalay District may be described as an extensive plain covered with rice fields, which are intersected by hedgerows and dotted with trees Rice, to the cultivation of which an area of about 30 million acres is now annually devoted, occupies most of the arable land and is, consequently, the principal crop. Nearly the whole of this vast area is irrigated by means of Government Canals, water to grow the crop on the rest being raised by water lifts, such as kyat-set, from streams, ins, backwaters and wells.

The only other crops of any importance which are produced on the Ya Lands of the Mandalay plain are pyaung, khan, beans and vegetables. The beans more usually grown on the Ya Lands are pe'gyi, pegya, pebyugale, gram (kalape), peyin and pindaung myepe.

The noteworthy, though not peculiar, feature in the agricultural practice of this district is the dry cultivation of mixed crops in the kyuns, and sandy spits which are exposed in the bed of Irrawaddy when the river runs low. This 'Kaing' cultivation supplies a good deal of the food and money crops of the people. The land is stocked with a variety of crops, such as maize, beans, tobacco, vegetables, melons, gourds, cucumber and sun-hemp. Gardens are planted at the end of the rains about October, it is usual to bring silt with which to start the garden. The young plants are obtained from existing gardens by setting a length of vine as a runner is the ground and taking the shoots that spring from it. The cultivated Area, yield and production in terms of cropping are shown in Table (3.4), Table (3.5) and Table (3.6). These data were collected from Department of Agriculture, Region.

Table (3.4) Cultivated Area (Thousand Acre) in Terms of Cropping (Yearly)

Year	Monsoon Paddy	Summer Paddy	Wheat	Maize	Bean	Oilseed crops
2003-2004	610	190	30	20	120	160
2004-2005	680	190	30	19	120	160
2005-2006	840	180	30	19	120	160
2006-2007	1000	240	30	21	140	180
2007-2008	990	220	30	12	150	190
2008-2009	920	220	30	13	150	200
2009-2010	750	180	30	15	170	200
2010-2011	600	190	30	14	160	180
2011-2012	620	170	20	14	150	170
2012-2013	550	160	20	13	140	160
2013-2014	530	150	20	14	150	170
2014-2015	510	100	20	15	140	160
2015-2016	460	80	20	15	150	170
2016-2017	540	110	10	15	150	170

Source: Department of Agriculture, Mandalay Region

According data of Cultivated Area in terms of crops, it can be seen that the cultivated areas for monsoon paddy are sharply increase in the period of year (2005-2006) and year (2006-2007) as by government pilot plan to raise cultivated area in three region of Central Dry Zone, Mandalay Region, Magwe Region and Sigaing Region. This pilot plan was to promote cultivated area for paddy in Mandalay Rregion and Magwe Region up to 100 thousand Acres and in Sigaing Region up to 200 thousand Acre. The pilot project was started as three year project plan from year (2004-2005) to year (2006-2007). To fulfill the target, monsoon paddy was sown in all area of irrigated region and rain-fed region. Therefore, the cultivated area for Monsoon is sharply increased in year (2006-2007). As increase in Monsoon Paddy cultivated, the other crop cultivated areas are also increase respectively. After that duration, the monsoon paddy cultivated area decreased gradually because one of the agriculture policy issued that statement was farmers can change crop type as their desire. Therefore, farmers cultivated exported crops instead of paddy. And then, there also can be seen in cultivated area of summer paddy is sharply decreased to 34% in year (2014-2015) than year (2013-2014) because of Al-Nino weather effect.

Table (3.5) Yield (Thousand Basket) per Acre in Terms of Cropping (Yearly)

Year	Monsoon Paddy	Summer Paddy	Wheat	Maize	Bean	Oilseed crops
2003-2004	690	870	200	90	100	160
2004-2005	690	880	200	90	100	160
2005-2006	750	880	200	90	100	160
2006-2007	800	910	210	100	110	160
2007-2008	820	1000	220	100	120	160
2008-2009	860	1020	230	110	120	170
2009-2010	840	960	240	110	120	170
2010-2011	830	970	250	120	130	170
2011-2012	780	950	250	120	120	130
2012-2013	760	970	260	110	120	160

Table(3.5) Yield (Thousand Basket) per Acre in Terms of Cropping (Yearly) (Contd.)

Year	Monsoon Paddy	Summer Paddy	Wheat	Maize	Bean	Oilseed crops
2013-2014	780	1000	260	110	120	160
2014-2015	800	1010	260	120	120	180
2015-2016	910	1000	260	110	120	180
2016-2017	810	990	240	120	130	180

Source: Department of Agriculture, Mandalay Region

In Table (3.5), it can be seen that the yield rate of monsoon paddy was increased by 15 % of the adjacent year of (2005-2006) although the cultivated area were increased by 23%. After this year, the yield of monsoon paddy was nearly same rate.

Table (3.6) Production Rate (Thousand Basket) in terms of Cropping (Yearly)

Year	Monsoon Paddy	Summer Paddy	Wheat	Maize	Bean	Oilseed crops
2003-2004	4100	1670	55	190	1200	2500
2004-2005	4600	1720	58	180	1280	2480
2005-2006	6400	1600	59	180	1270	2560
2006-2007	7800	2190	62	210	1630	2910
2007-2008	8100	2240	61	130	1740	3060
2008-2009	7900	2250	65	150	1890	3290
2009-2010	6320	1690	67	170	2040	3310
2010-2011	5010	1800	71	160	1990	3070
2011-2012	4840	1620	58	160	1810	2720
2012-2013	4160	1530	57	140	1610	2480

Table (3.6) Production Rate (Thousand Basket) in terms of Cropping (Yearly)

Year	Monsoon Paddy	Summer Paddy	Wheat	Maize	Bean	Oilseed crops
2014-2015	4020	1000	55	180	1770	2870
2015-2016	3750	820	53	170	1860	2880
2016-2017	4310	1100	30	180	1840	3040
2017-2018	4550	1830	17	170	1830	3120

Source: Department of Agriculture, Mandalay Region

The consequences of increase in cultivated area, the production rate of monsoon paddy are also increased by 38% in the year (2006-2007) as seen in Table (3.6).

3.4.2 Method of Cultivating Paddy

There are two methods for planting rice, Transplanting and direct Seeding .The cultivation of Monsoon paddy is carried on during the eight months June to January. There is usually irrigational water available by the month of May, occasionally even in the latter half of April. To moisten the soil properly for the first ploughing five inches each have to be lied in. Seed is sown or seedlings are transplanted according to circumstances. On low lying and favorably situated land seedlings are planted, on high land and land remoter from the water source seed is broadcasted, as on these lands the session of growth is shortened by the later arrival of the water supply. The seedling nurseries are prepared about forty days before the date when ploughing ordinarily commences, and the young plants are removed and planted out when they have attained a height of 15 to 18 inches. They are dibbled into the paddy fields which have been plastered by frequent ploughing and watering.

3.4.3 Crop Pattern

The rainfall of the Mandalay Division is altogether insufficient in volume and untimely in distribution for habitual paddy cultivation. Therefore the crops which required less water and short life crops are cultivated depend on the weather changes, thus in every related township of Mandalay division planned to cultivate by depending on type of supplements of farming water. The crop patterns cultivation in different location on different type of land and different management for farming water are shown in Table (3.7).

The income of farmer is also difference on cultivated crop pattern of the year. The difference ratio of cost and income depend on cultivated crop pattern on Type of farming water are as shown in Tables of Appendix V.

Table(3.7) Crop Pattern in Mandalay Division

Type of Farming Water	Land Type	Monsoon Paddy	Monsoon Crop	Winter crop	Summer paddy	
					Other paddy	Muyin Paddy
Main Cannel	La-Land	✓	✘	✓	✓	✘
	Ya-Land	✘	✘	✘	✘	✓
Pump Station	La-Land	✓	✘	✓	✓	✘
Rain-fed	Ya-Land	✘	✓	✓	✘	✘
Alluvial/Rivering land	Kaing/Kyun	✘	✘	✓	✘	✘

Source: Department of Agriculture, Mandalay Region

3.5 Organizational Structure in Surface Water Management

Ministry of Agriculture, Livestock and Irrigation (MOALI) is responsible for agriculture and irrigation with organized by 11 Departments. Under the structure of MOALI, the 17 regional maintenance divisions of Irrigation and Water Utilization Management Department , IWUMD are responsible for operation and maintenance of completed irrigation schemes at regional and district level, although this responsibility is coordinated with regional, district and township administration and other department at this level.

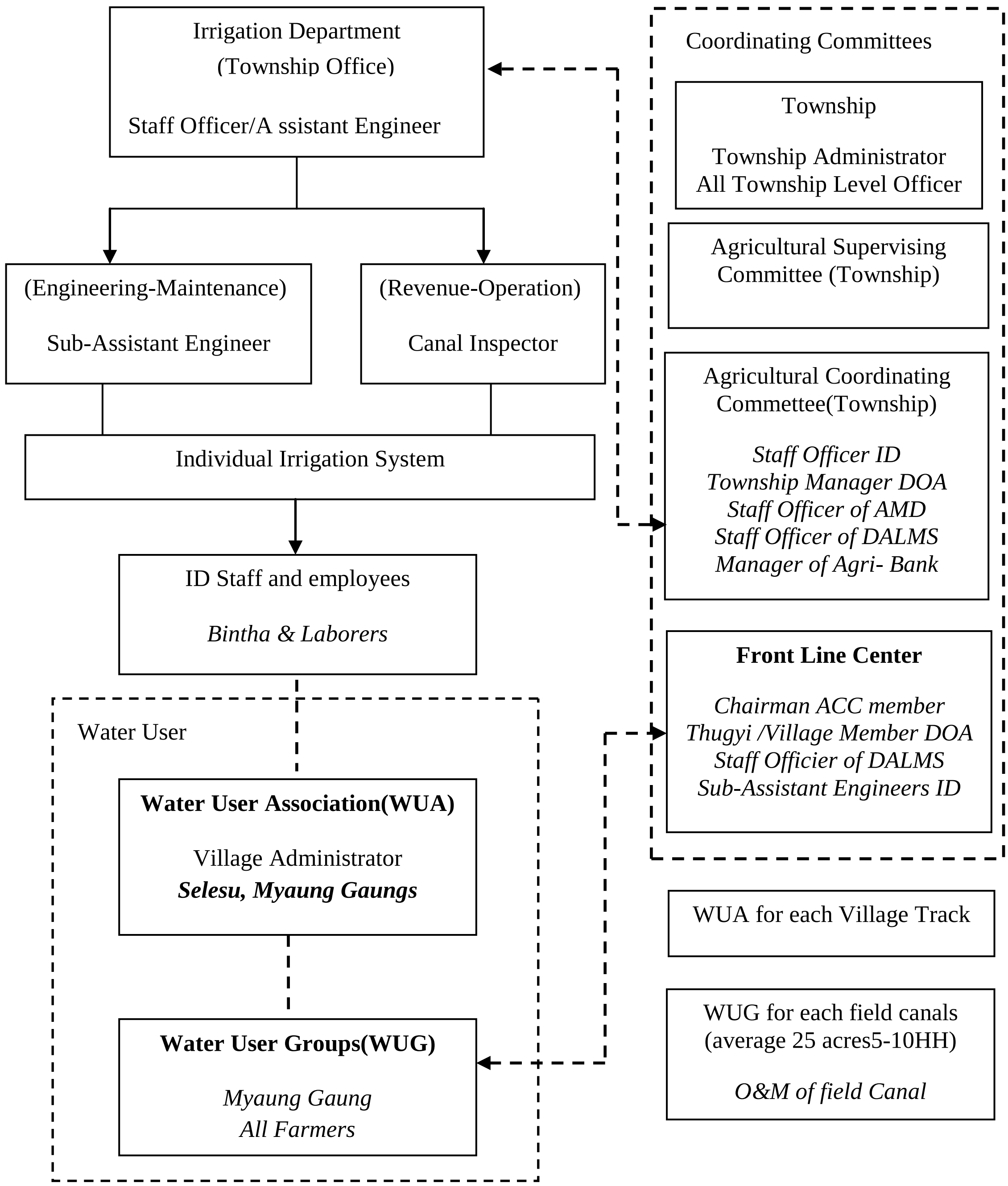
Irrigation is largely managed IWUMD at township level, but there is an elaborate structure of committees to enable coordination with DOA and others, and representation by farmers in the process of management. Most systems fall within a single township but large systems which cross township boundaries will be coordinated by the IWUMD at district level.

The Agricultural Coordinating Committee (ACC) and Frontline Centers (FCs) are important for irrigation planning and provide forums for identification and resolution of problems. The IWUMD, which is represented on the ACC and FCs, is then responsible for delivery of water in accordance with the plans, and for maintenance of the main systems. Farmer representative organizations are responsible fro management within tertiary units. The current typical actual local arrangements for irrigation management are as shown in Figure (3.1). There are some differences between regions, but these are mainly of detail rather than substance.

The ACC is a township level committee drawing on all departments related to agriculture and the township administrator. The FCs are lower lelvel committees, at sub-township level, with a similar core membership but with the difference that farmers and farmer representatives are invited to attend. These are informal meetings but provide a valuable forum and mechanism for coordination. The findings of the FC are presented to the ACC doe approval and if necessary to the township administration for ratification.

At farmer level, canal leaders (myaunggaungs) are responsible for irrigation management at tertiary level, and in some places ‘ leader farmers’ (selesu, representing 10 farm households) have also been identified. The water user associations (WUAs) were established in 2014 at village tract level, comprising the village tract leader as chairman and all selesu and myaunggaungs as members but their rold has not been well-defined and this arrangement has not be sustained. The Village Tract leader and myaunggaungs often attend FC meetings and this is seen as a forum which could be used to agree the rold for WUAs. WUAs and WUGs may sometimes be reported to exist elsewhere, but they remain largely theoretical.

Figure(3.1) Existing Management Structure for Irrigation Projects



Resource: IWUMD , Mandalay Region

3.6 Water Tax and Embankment Tax

Staring from the 2007-2008 financial year, the government of the Union of Myanmar enacted the water tax and embankment tax law. The legible rates according to the enactment are as follows:

(A) For the beneficiary areas of irrigation system constructed and maintained by the State, water tax is as follows.

(1) If fully irrigated from land preparation to heading stage at the paddy cultivation areas, the water tax is 1950 Kyats per acre.

(2) For any other crops except paddy, the water tax for use of irrigation water for crop cultivation is 900 Kyats per acre.

(3) At the paddy cultivation areas, if irrigated only for land preparation (or) transplanting (or) seedling (or) reproduction (or) heading (or) partial irrigation, the water tax is same as the other crops at the rate of 900 Kyats per acre.

(B) For the beneficiary areas protected from flood with the embankments and drainages constructed and maintained by the State, the water tax us 5 Kyats per acre.

(C) If any cultivated land is inclusive both for items (A) and (B), the water tax is the same rate as in item (A).

The annual budget for the maintenance and repair of the facilities is mostly paid by the government.

However, the water tax in the river pumping system of the Water Resource Utilization Department is higher than that of the dam projects which is 9,000 Kyats per acre afor rice crop and 6,000 Kyats per acre for other crops(Amy Soe and Thanda Kyi,2016).

CHAPTER IV

A CASE OF THE EFFICIENCY OF SURFACE WATER SUPPLY IN FARMING GROUPS IN SELECTED AREA

4.1 Profile of the Study Area

Patheingyi Township is located in the eastern part of Mandalay. Incorporated into the Mandalay city's limits, Patheingyi represents the eastward march of Mandalay's urban sprawl. Patheingyi is still largely made up of rice paddy fields but in the past two decades has become home to a number of universities.

Patheingyi Township is in 5miles northeast of Mandalay. It is a rural township within Mandalay Region. It is situated between North Latitude 21 degree 51 minutes to 22 degree 19 minutes and East Longitude 96 degree 01 minutes to 96 degree 22 minutes. The township area is 231.55 square miles and total lengths are east to west 20 miles and south to north 24 miles. This township is 250 feet above sea level. The climate of Patheingyi Township is tropical wet and dry season with the maximum temperature at 36.9° C and the minimum temperature at 29° C. The average annual rainfall is 51.21 inches in 2016-2017.

According to the Patheingyi Township General Administration Department report, the population of township is 0.2 million people, the large 93%of population are living in rural area and remaining 07% are in the urban. This township is comprised on 140 villages, and 58 village tracts and 1wards. Like all townships in Myanmar the local township administration unit is overseen and managed by the Township Administrator who is an appointee of the General Administration Department, Ministry of Home Affairs.

In Patheingyi Township, the totally nearly fifteen hundred thousand Acres could be divided by utilization condition as shown in Table (4.1).

Table (4.1) Type of Land Utilization in Patheingyi Township

No.	Type of Land	Total amount (Acres)
1.	Le-Land (Paddy Land)	27667
2.	Ya-Land (Dry Land)	26338
3.	Kaing/Kyun	4851
4.	Garden land	2802
5.	Other (Taung-ya Land)	48041
6.	Forest Area	35179
Total		148192

Source: Patheingyi Township General Administration Department

In generally, these lands are situated in two regions, irrigated region and non-irrigated region. In Patheingyi Township, the cultivated areas are divided into five area by Department of Agriculture. The numbers of cultivated land with different type of farm water in each dividend area are as shown in Appendix VI.

4.2 Survey Design

The survey was conducted from December, 2017 to January, 2018 in irrigated region and non-irrigated region of Patheingyi Township, Mandalay District. The random sample was 200 farmers of ten villages in these two regions. The required data was collected from the selected villages through face-to-face interviews, using the structure questionnaire. It includes multiple choice questions which the respondents were asked to select one or more of the alternatives of the respondents.

4.3 Data Analysis

4.3.1 Characteristics of Respondents

Regarding the household heads or respondents, the study made an assessment through sample respondents of 200 farmers from selected regions. Table (4.3) represents the characteristics of respondents of the survey.

Table (4.2) Characteristics of Respondents

Gender	**Frequency**	**Percentage**
Male	180	90%
Female	20	10%
Age Level		
40 to 45	120	60%
46 to 50	70	35%
50 to 60	8	4%
Over 60	2	1%
Educational Qualification		
Literate	30	15%
Primary School	60	30%
Middle School	80	40%
High School	30	15%
Race		
Bamar	190	95%
Other	10	5%
Religion		
Buddhist	190	95%
Others	10	5%

Table (4.2) Characteristics of Respondents (Contd.,)

Number of Household Members		
Less Than 5	80	40%
More than 5	120	60%
House Ownership		
Self-owned	190	95%
Rental	10	5%
Type of House		
Brick Noggin	20	10%
Wooden	180	90%

Source : Survey Data

From the Table (4.2), the majority, 180 respondents or 90.0% of the total respondents are males and the remaining 20 respondents or 10% are females. And most of respondents are those who are still in the working age level as the majority's age ranges from 40 years to 50 years and this is somehow a factor that they may have the capacity to hold on to the livelihood activities they are engaged in. This shows why the villagers or respondents are relying largely on agriculture for their livelihood. The majority of the total respondents' main income earning activity is agriculture.

The education level of the respondents is seen as majority 80 respondents or 40% have an education of middle school level. This level of education can improve technology absorption in farming practice and that can achieve agricultural development.

More than 90% of the total respondents of the study area have their own house and only a few are staying in rental houses. For the type of houses, the majority of the respondents, 120 respondents or 60% of the total respondents own brick noggin and followed by wooden house, 80 respondents or 40% of the total.

For the number of household members, 40 % of respondents have less than 5 members and 60% have more than 5 members.

4.3.2 Land Utilization and cropping Pattern

(a) Land Holdings

According to survey data, all respondents in the survey area own Le- Land and Ya- Land and other type such as Kyun. There is no one who doing business on borrow land and no one who hire the cultivated land. The status of ownership of cultivated lands are as shown in Table (4.3).

Table (4.3) The Ownership of Cultivated Land

Size of Farm			Frequency	Percentage
Le-Land	Ya-Land	Other		
Less than 5 acres	0	0	79	39.5%
More than 5 acres	Less Than 5 acre	0	86	43%
More than 10 acres	Less than 5 acre	0	35	17.5%
Total			200	100%

Source: Survey Data

From the data, it can be seen that 79 respondents or 39.5% of total have less than 5 acres of Le- Land only, 86 respondents or 43% of total have more than 5 acres of Le- Land and less than 5 acre of Ya-Land and 35 respondents or 17.5% of total have more than 10 acres of Le- Land and less than 5 acres of Ya-land , doing cultivation in the study area.

(b) Cropping Pattern

There are different kinds of paddy and seasonal crops which were cultivated in the survey area and the crop pattern depends on the market price and designated crops by agriculture policy.

The paddy crops such as Sinthukha, Ayarmin, Shwethwalyin, Day (90), Mayin and Magyantaw have been cultivated as Monsoon Paddy and the Sinthukha, Manawthukha, Palethwe and Shwethwelyin have been cultivated as Summer Paddy. The crops such as Groundnut, Sesame, Sunflower, Sugarcane, Maize and kitchen crops such as onion, garlic, tomato and variety of vegetables and Fodder crops have been cultivated as seasonal crops in summer, raining and winter season. For the farmers, it is very rare to get highly-yielding varieties and rice as the inputs for planting in their farms. The majority of the farmers plants short life paddy (Shwethweyin, D(30)) and middle life paddy. There are long life paddies (Ayarmin, Manawthukha) which are planted by minority. Table (4.4) shows that the cultivated crop pattern getting in terms of their cultivated land used in survey area.

Table (4.4) Land Usage In Terms of Cultivated Crop Pattern

Crops Pattern					Frequency	Percentage
Summer Paddy	Monsoon Paddy	Seasonal Crops	Cultivated Area (Acre)			
			Le-Land	Ya-Land		
Shwethweyin	Ayarmin	Grams	< 5	0	68	34%
Shwethweyin	Ayarmin	Maize	> 10	< 5	24	12%
D(90)/ Manawthukha	Ayarmin	Vegetable	< 5	0	11	5.5%
-	Ayarmin	Grams	> 5	< 5	43	21.5%
-	Shwethweyin	Vegetable	> 5	< 5	43	21.5%
-	Mayin Paddy	Vegetbale	> 10	< 5	11	5.5%
Total					200	100%

Source: Survey Data

According to survey data, 34% of respondents cultivated 3 crops per year on less than 5 acres , they cultivated summer paddy, shwethweyin, seasonal crops, Grams, and monsoon paddy, Ayarmin when another 5.5 % of respondents cultivated summer paddy, D(90) or Manawthukha, seasonal crops, vegetable and monsoon paddy, Ayarmin. And then 12% of respondents cultivated on more than 10 acres of Le- land and more than 5 acres of Ya-Land such as summer paddy, shwethweyin, seasonal crops, Maize and monsoon paddy, Ayarmin.

And then, 21.5% of respondents cultivated 2 crops per year on more than 5 acre of Le-Land and less than 5 acres of Ya-Land monsoon paddy, Ayarmin and seasonal crop, Grams, when another 21.5% of respondents cultivated Shwethweyin in raining season and vegetables in winter. And other 5.5% of respondents cultivated on more than 10 acres of Le-Land and less than 5 acres of Ya-land Mayin paddy in the end of rainy season and vegetables in winter.

4.3.3 Agricultural equipments and labor requirement

(a) Agricultural Equipment

The use of appropriate agricultural equipment and tools for small-scale intensive crop production contributes to the viability of the farm by enhancing production efficiency. Equipment and tools are necessary for plant propagation, soil preparation, planting, pest and weed control, irrigation, harvesting, postharvest handling, storage, and distribution. Sustainable agriculture can be a labor-intensive business and by selecting the appropriate tool for the task at hand, farmers can increase profits by increasing crop yields, improving crop quality, and reducing expenses. Factors to consider when choosing appropriate agricultural equipment and tools include the location and growing conditions of the farm, the type of crops being grown, the production practices being used, and how the crops are marketed. Table(4.5) shows the ownership of agricultural material in the survey area.

Table (4.5) Ownership of Agricultural Equipment

Material Name	Number of Items	Type of ownership	Frequency	Percentage
Cultivator	1	Owner	29	14.5%
Farm Tractor	1	Owner	17	8.5%
Combine Harvester	1	owner	15	7.5%
Rice Transplanter	1	owner	11	5.5%
Seeding Machine	1	owner	10	5%
Pump	1	owner	35	17.5%
Cows	2	owner	38	19%
Non of above		borrower	45	22.5%
Total			200	100%

Source: Survey Data

In Table(4.5), there can be seen that 22.5% of respondents who have no agricultural equipments for small farm and thus these respondents have to hire these equipments in required time for doing cultivation. It can also be seen that the 14.5% of respondents own 1 cultivator, 8.5 own 1 farm tractor, 7.5% of them own 1 combine harvester, 5.5% of them own 1 rice transplanter, 5% of them own seeding Machine, 17.5% of them own 1 pump and 19% of them have 2 cows. The respondents own one type of agriculture equipment only and other needed equipment are hired by each other. If they have no other tools, they have to hire when they need.

(b) Labor Requirement

The number of labor required depends on the planting methodology. In cultivation of paddy, the transplanting method requires more labor than direct seeding method. The requirement of labor per Acre in terms of crops in a year is as shown in Table (4.6).

Table (4.6) Labor Requirement per Acre in Terms of Crop in A Year

Crop establishment method	Labor cost	Labor requirement (man-day = 8 hours of work)
Paddy (Direct seeding)	Land Preparation	7
	Seeding	1
	Plant Treating	2
Paddy (Transplanting)	Planting Land Preparation	6
	Cultivation Land Preparation	12
	Transplanting Time	14
	Plant Treating	14
Maize	Planting	10
	Harvesting	10
Grams	Planting	20
	Harvesting	20
Vegetable	Planting	5
	Harvesting	5

Source: Survey Data

From the respondents' saying that, for paddy cultivating by direct seeding method, the labor requirement are 7 persons for land preparation, 1 person for seeding and 2 persons for treating plant time. In transplanting method, the labor requirement are 6 persons for land preparation, the 12 persons for cultivated land preparation, 14 persons for transplanting and 14 persons for treating plant time. Land preparation, transplanting and harvesting, unlike in a traditional farming system, need to be finished in a short period of time so that the cropping seasons allow year-round cultivation. Thus the farmers are faced with labor shortages, especially for these periods and have no time to rest. Some farmers utilize tractors for land preparation. In harvesting period, the farmers usually hire the machines to harvest their crops instead of hiring labors.

For Maize and Grams cultivating, the requirement for labor is, 20 person for planting and 20 persons for harvesting. For vegetable cultivating, the requirement for labor is 5 persons for planting and harvesting.

4.3.4 Sources of Water Supply and Changes in Cropping Pattern

(a) Sources of Water Supply

From the respondents' saying that, there are no water resources in the farm, they started irrigation method in the (1987) after dam construction by using farm water from Sedawgyi dam through Mandalay Main Canal. Table (4.7) represents about the status of using farming method in survey area.

Table (4.7) Status of Farming Method

Farming Method	Frequency	Percent	Remarks
Irrigation	120	60%	No water resource in the farm
Non-irrigation	80	40%	Rain water and river water could be used for farming

Source: Survey Data

As shown in Table (4.7), 120 respondents or 60% of total are using irrigation method because there are no water resources in the farm. And remain 40% of total, who staying in rain-fed area and alluvial , are using rain water for farming water.

From the survey data, the cultivated land area were classified into 4 groups in terms of farm water as shown in Table (4.8). There can be seen that 30% of respondents are using water from Main Cannel of Sedawgyi Dam, 30% of them are using water through Electric Pump Station of weir, 30% are using rain water and only 10% are using river water.

Table (4.8) Classification of Group in Terms of Farm Water

No	Group	Farm water	Frequency of respondent	Percentage of respondents
1.	Group I	Mandalay Main Cannel and its Weir	60	30%
2.	Group II	Electric Pump Station	60	30%
3.	Group III	Rain-fed	60	30%
4.	Group IV	Alluvial area	20	10%
Total			200	100%

Source: Survey Data

(b) Changes in Cropping Pattern

According to the respondents of irrigated area saying that, they cultivated two crops per year such as monsoon paddy and winter seasonal crops before the construction of Sedawgyi Dam or getting irrigation water. After construction of Sedawgyi Dam, the respondents used irrigated method cultivated 3 crops per year such as summer paddy, monsoon paddy and seasonal crops. The cultivated crop pattern in each group as classified in above section in terms of farm water is as shown in Table (4.9).

Table (4.9) Cultivated Crop Pattern in Each Groups in Terms of Farm Water.

No.	Crop Pattern	Group I	Group II	Group III	Group IV
1.	Monsoon Paddy-Winter Seasonal Crops-Summer Paddy	✓	✓	✘	✘
2.	Monsoon Paddy- Winter Seasonal Crops	✓	✓	✓	✘
3.	Summer and Winter Seasonal Crops	✘	✘	✘	✓

Source: Survey Data

According to respondents' saying that by using irrigation method, they have got more effects on using fertilizer. And to get a good yield, the paddy fields required more fertilizer had to be used because of the continuous irrigation for double or triple cropping became less fertile. And the yield rate per acre of summer paddy was also increased by using irrigation water.

4.3.5 Efficiency of Water Supply System in Farming

The efficiency of water supply system in farming was measured by getting water distribution in terms of adequacy, reliability, timeliness. Especially in transplanting method, if they cannot get required water to prepare a nursery stage and the seed sowing to uprooted to transplant, yield will be decreased. A consistently adequate supply of water to farmers is the most important factor. Table (4.10) will show the efficiency of water supply system in Farming of survey area.

Table (4.10) Efficiency of Water Supply System in Farming

Measurements	Frequency	Percentage	Location
Can get enough required water in time	45	22.5%	Adjacent to Canal
	30	15.0%	Electric Pump Station
	15	7.5%	Rain fed area
Can get in time but not enough required water	25	12.5%	Middle area from Canal
	18	9.0%	Electric Pump Station
	17	8.5%	Rain fed area
Can get in time but heavy amount of water to cause defect the crop	10	5.0%	Adjacent to Canal
	20	10.0%	Rain fed area
Cannot get required water in time	10	5.0%	Tail side area of Canal
	5	2.5%	Electric Pump Station
	5	2.5%	Rain fed area
Can get low quality to use for farm	0	0%	

Source: Survey Data

As shown in Table (4.10) , 22.5 % of respondents from head side area of Canal , 15% of respondents from electric pump station areas and 7.5% of respondents from rain fed area and got water distribution in terms of adequacy, reliability, timeliness .

The 12.5% of respondents from middle area of Canal faced the challenges on getting inadequate water in timeliness if the farmers from head side area closed the gate of watercourses to their region. Also 9.0% of respondents from electric pump station area had to face on getting inadequate water in timeliness when the electrical voltage was low to run electric water pump when the 8.5% of respondents in rain fed area faced same condition as less raining.

And the 5.0 % of respondents from head area of Canal faced the challenges on getting heavy amount of water which made to damage their crops and when 10.0 % of respondents faced same condition as heavy rain made damage their crops.

And then 5.0% of respondents from tail side area of canal faced to the challenges for not getting required farm water in required time as the far distance from canal and when the 2.5% of respondents from electric pump station area faced too because the electricity and pump were broken. Also 2.5% of respondents from rain fed area faced same problems because of drought weather.

The water tariff in the gravity dam irrigation systems of the Irrigation Department is very cheap for irrigation and it does not recover the cost for the maintenance work. However, the water tariff in the electric pumping system of the Water Resources Utilization Department is higher than the dam system. The water price for dam systems are less than those of the electric and diesel types of pumping system respectively. The respondents from Group II will have to burden more water tariff than Group I, III and Group IV.

And also the respondents from middle and tail side area from canal had to burden for extra cost to improve the terminals units such as watercourses and field ditches. And the maintenance works are performed differently even in the same area. Therefore these respondents will cost charges for making ditches to their farms and to repair and maintain that portion of the watercourse connected to their area.

The downstream irrigation facilities in the existing projects have to be developed to promote agriculture production and efficient water uses. The main canals should be rehabilitated for sufficient water supply in these specific periods when it is required. Off-farm facilities such as watercourses, field ditches, land consolidation and a proper irrigation and drainage network for farm productivity should also be developed.

4.3.6 Other Challenges and Opportunities in Farming

According to the survey data, there can be seen that some barriers for agriculture in survey area such as insecticides, labor shortage, less yield rate, seasonal price fluctuation, far from market, market uncertainty, inadequate agricultural tools, and less capital budget but not in very serious condition.

And sometimes, the respondents had to face natural disaster effects such as unexpected flooding events and drought condition and abnormal weather condition such as Al-Niño.

The respondents of survey area got some supports from Department of Agriculture and non-government organizations such as training for land preparation, reduce labor requirement method, effective transplanting methods, systematically use of water resources to get more effectiveness, and workshop training on methods which technically solve for weather changes and seminar on sharing farming status to each other.

CHAPTER V

CONCLUSION

5.1 Findings

Myanmar has abundant water resources which can be used to meet the demand for water of the agriculture and other sectors. Agriculture is a major economic sector of Myanmar and irrigation systems, especially rice-based irrigation systems, have been developed to promote agricultural production. These irrigation systems allow crop production throughout the year as they make available water stored in the

Myanmar is basically an agricultural country, endowed with a wealth of resources, including fertile land, water resources, forests and remarkably -young population. The development of agricultural sector is crucial to the Government of the Republic of Myanmar for its role in achieving food security and nutrition for the country as well as being a significant contributor to the economic output, export earnings and employment in Myanmar. Given the importance of the sector, the current agricultural policy of the Ministry of Agriculture, Livestock and Irrigation (MOALI) focuses on improving production and productivity, promoting sustainable and climate-smart agriculture, encouraging transition from conventional to mechanized agriculture and extension of irrigated area.

Irrigation works are concentrated in the central dry zone area with the largest benefited area 600 million acre, which is around 50 % of the total benefited area of the three irrigation systems in the whole country. The number of pump irrigation stations in that area is more than 50 % of total number in the whole country. More than 75% of the total irrigated area is sown to rice, but vegetables, pulses and sesame are also grown under irrigation.

The Central Dry Zone of Myanmar lies in the central portion of the country, Incorporating 57 townships in 13 districts in Sagaing, Mandalay and Magway Region.

In Mandalay Region, the various irrigation projects have been implemented. Dam, Canals, Tanks, Wells, Weirs, and pumps are some of the different types of irrigation.

Around Mandalay area, most of the water supply is controlled by the Sedawgyi Multipurpose Dam and used for irrigation, hydropower and domestic purposes. Almost of irrigated areas are downstream of the Sedawgyi Dam. The Sedawgyi dam is constructed across the flow of Chaungmagyi river and is divided into three separated river and canals. These are Yenatha Canal, Mandalay Main Canal and the Chaungmagyi River which continues to flow towards the Ayeyarwaddy River. The Yenatha Canal is the man-made canal that flows into the northern irrigation network distributaries. And the Mandalay Main Canal is also a man-made canal which flows southward to Mandalay and is used as water supply canal for both irrigation and domestic use of Mandalay city. Sedawgyi dam water supply covers all irrigated areas of Mandalay city, Mattaya, Patheingyi and Amarapura townships. In selected area, Sedawlay weir is located across Nadaung Kya Chaung in Patheingyi township. This weir can supply for Patheingyi and Amarapura irrigated areas with canals.

Patheingyi township is located in the eastern part of Mandalay. Incorporated into the Mandalay city's limits, Patheingyi represents the eastward march of Mandalay's urban sprawl. Patheingyi is still largely made up of rice paddy fields but in the past two decades has become home to a number of universities. The climate of Patheingyi Township is tropical wet and dry season with the maximum temperature at 36.9° C and the minimum temperature at 29° C. The average annual rainfall is 51.21 inches in 2016-2017.

Analyses the socio-demographic characteristics of the study participants showed that out of 200 respondents, 90.0% of the total respondents are males and the remaining 10% are females. And most of respondents are those who are still in the working age level as the majority’s age ranges from 40 years to 50 years and this is somehow a factor that they may have the capacity to hold on to the livelihood activities they are engaged in. This shows why the villagers or respondents are relying largely on agriculture for their livelihood. The majority of the total respondents’ main income earning activity is agriculture.

The education level of the respondents is seen as majority 80 respondents or 40% have an education of middle school level. This level of education can improve technology absorption in farming practice and that can achieve agricultural development.

More than 90% of the total respondents of the study area have their own house and only a few are staying in rental houses. For the type of houses, the majority of the respondents, 120 respondents or 60% of the total respondents own brick noggin and followed by wooden house, 80 respondents or 40% of the total.

For the number of household members, 40 % of respondents have less than 5 members and 60% have more than 5 members.

According to survey data, all respondents in the survey area own Le- Land and Ya- Land and other type such as Kyun. There is no one who doing business on borrow land and no one who hire the cultivated land.

From the data, the 79 respondents or 39.5% of total have less than 5 acres of Le- Land only, 86 respondents or 43% of total have more than 5 acres of Le- Land and less than 5 acre of Ya-Land and 35 respondents or 17.5% of total have more than 10 acres of Le- Land and less than 5 acres of Ya-land , doing cultivation in the study area.

It was found that, the respondents in this survey area were cultivating paddy in both rainy season and summer season. In the summer season, they cultivated paddy by irrigation water supply from Sedawgyi Dam. And also the farmers grew two different types of crops such a paddy in the rainy season and seasonal crops in the summer season. And there were also different kinds of paddy and seasonal crops which were cultivated in the survey area and the crop pattern depended on their desire and designated crops by agriculture policy. The paddy crops such as Sinthukha, Ayarmin, Shwethwalyin, Day (90), Mayin and Magyantaw have been cultivated as Monsoon Paddy and the Sinthukha, Manawthukha, Palethwe and Shwethwelyin have been cultivated as Summer Paddy. The crops such as Groundnut, Sesame, Sunflower, Sugarcane, Maize and kitchen crops such as onion, garlic, tomato and variety of vegetables and Fodder crops have been cultivated as seasonal crops in summer, raining and winter season. For the farmers, it is very rare to get highly-yielding varieties and rice as the inputs for planting in their farms. The majority of the farmers plants short life paddy (Shwethweyin, D(30)) and middle life paddy. There are long life paddies (Ayarmin, Manawthukha) which are planted by minority.

With regard to the cropping pattern, the 34% of respondents cultivated 3 crops per year on less than 5 acres , they cultivated summer paddy, shwethweyin, seasonal crops, Grams, and monsoon paddy, Ayarmin when another 5.5 % of respondents cultivated summer paddy, D(90) or Manawthukha, seasonal crops, vegetable and monsoon paddy, Ayarmin. And then 12% of respondents cultivated on more than 10 acres of Le- land and more than 5 acres of Ya-Land such as summer paddy, shwethweyin, seasonal crops, Maize and monsoon paddy, Ayarmin.

And then, 21.5% of respondents cultivated 2 crops per year on more than 5 acre of Le-Land and less than 5 acres of Ya-Land monsoon paddy, Ayarmin and seasonal crop, Grams, when another 21.5% of respondents cultivated Shwethweyin in raining season and vegetables in winter. And other 5.5% of respondents cultivated on more than 10 acres of Le-Land and less than 5 acres of Ya-land Mayin paddy in the end of rainy season and vegetables in winter.

Related to the use of appropriate agricultural equipment and tools for small-scale, the 22.5% of respondents who have no agricultural tools for small farm and thus these respondents have to hire these tools in required time for doing cultivation. It can also be seen that the 14.5% of respondents own 1 cultivator, 8.5 own 1 farm tractor, 7.5% of them own 1 combine harvester, 5.5% of them own 1 rice transplanter, 5% of them own seeding Machine, 17.5% of them own 1 pump and 19% of them have 2 cows. The respondents would use their own agriculture tool but they had to hire the agriculture tool which they didn’t have.

The number of labor required depends on the planting methodology. In cultivation of paddy, the transplanting method requires more labor than direct seeding method. From the respondents’ saying that, for paddy cultivating by direct seeding method, the labor requirement are 7 persons for land preparation, 1 person for seeding and 2 persons for treating plant time. In transplanting method, the labor requirement are 6 persons for land preparation, the 12 persons for cultivated land preparation, 14 persons for transplanting and 14 persons for treating plant time. Land preparation, transplanting and harvesting, unlike in a traditional farming system, need to be finished in a short period of time so that the cropping seasons allow year-round cultivation. Thus the farmers are faced with labor shortages, especially for these periods and have no time to rest. Some farmers utilize tractors for land preparation. In harvesting period, the farmers usually hire the machines to harvest their crops instead of hiring labors.

There were no water resources in the farm, therefore they started irrigation method in the (1987) after dam construction by using farm water from Sedawgyi dam through Mandalay Main Canal. It can be found that 120 respondents or 60% of total are using irrigation method because there are no water resources in the farm. And remain 40% of total, who staying in rain-fed area and alluvial, are using rain water for farming water.

Therefore, the cultivated land areas of study area were classified into 4 groups in terms of farm water. It showed that that 30% of respondents are using water from Main Cannel of Sedawgyi Dam, 30% of them are using water through Electric Pump Station of weir, 30% are using rain water and only 10% are using river water.

According to the respondents of irrigated area saying that, they cultivated two crops per year such as monsoon paddy and winter seasonal crops before the construction of Sedawgyi Dam or getting irrigation water. After construction of Sedawgyi Dam, the respondents used irrigated method cultivated 3 crops per year such as summer paddy, monsoon paddy and seasonal crops. And they have got more effects on using fertilizer. And to get a good yield, the paddy fields required more fertilizer had to be used because of the continuous irrigation for double or triple cropping became less fertile. And from the respondents' saying that, the yield rate per acre of summer paddy was increased by using irrigation water.

The efficiency of water supply system in farming was measured by getting water distribution in terms of adequacy, reliability, timeliness. Especially in transplanting method, if they cannot get required water to prepare a nursery stage and the seed sowing to uprooted to transplant, yield will be decreased. A consistently adequate supply of water to farmers is the most important factor.

This study showed that, the 22.5 % of respondents from head side area of Canal, 15% of respondents from electric pump station areas and 7.5% of respondents from rain fed area and got water distribution in terms of adequacy, reliability, timeliness.

The 12.5% of respondents from middle area of Canal faced the challenges on getting inadequate water in timeliness if the farmers from head side area closed the gate of watercourses to their region. Also 9.0% of respondents from electric pump station area had to face on getting inadequate water in timeliness when the electrical voltage was low to run electric water pump when the 8.5% of respondents in rain fed area faced same condition as less raining.

And the 5.0 % of respondents from head area of Canal faced the challenges on getting heavy amount of water which made to damage their crops and when 10.0 % of respondents faced same condition as heavy rain made damage their crops.

And then 5.0% of respondents from tail side area of canal faced to the challenges for not getting required farm water in required time as the far distance from canal and when the 2.5% of respondents from electric pump station area faced too because the electricity and pump were broken. Also 2.5% of respondents from rain fed area faced same problems because of drought weather.

With regard to the water tariff in the gravity dam irrigation systems of the Irrigation Department is very cheap for irrigation and it does not recover the cost for the maintenance work. However, the water tariff in the electric pumping system of the Water Resources Utilization Department is higher than the dam system. The water price for dam systems are less than those of the electric and diesel types of pumping system respectively. The respondents from Group II will have to burden more water tariff than Group I, III and Group IV.

And also the respondents from middle and tail side area from canal had to burden for extra cost to improve the terminals units such as watercourses and field ditches. And the maintenance works are performed differently even in the same area. Therefore these respondents will cost charges for making ditches to their farms and to repair and maintain that portion of the watercourse connected to their area.

The downstream irrigation facilities in the existing projects have to be developed to promote agriculture production and efficient water uses. The main canals should be rehabilitated for sufficient water supply in these specific periods when it is required. Off-farm facilities such as watercourses, field ditches, land consolidation and a proper irrigation and drainage network for farm productivity should also be developed.

There can be seen that some barriers for agriculture in survey area such as insecticides, labor shortage, less yield rate, seasonal price fluctuation, far from market, market uncertainty, inadequate agricultural tools, and less capital budget but not in very serious condition.

And sometimes, the respondents had to face natural disaster effects such as unexpected flooding events and drought condition and abnormal weather condition such as Al-Niño.

The respondents of survey area got some supports from Department of Agriculture and non-government organizations such as training for land preparation, reduce labor requirement method, effective transplanting methods, systematically use of water resources to get more effectiveness, and workshop training on methods which technically solve for weather changes and seminar on sharing farming status to each other.

5.2 Recommendations

Agriculture's use and impact on water resources involves complex trade-offs between economic, social and environmental demands under a wide range of institutional structures. Irrigated farming accounts for a major and growing share of farm production and rural employment but overuse of often scarce water resources is an increasing concern. Agriculture is a major source of water pollution but also contributes to ecosystem services. Agricultural production and input subsidies, especially for water and energy, continue to misalign farmer incentives and aggravate overuse and pollution of water across most OECD countries.

The major challenge is to ensure that water resources used by agriculture are best allocated among competing demands to efficiently produce food and fiber, minimize pollution and support ecosystems, while meeting social aspirations under different property right arrangements and institutional systems and structures. Policies and actions are beginning to shift toward more sustainable agricultural water management as policy makers are giving higher priority to water issues in agriculture.

There is a widespread recognition of the need for greater use of market based instruments, such as better pricing structures and tradable permits, accompanied by government regulations, as well as cooperative efforts among water users. But the adoption of these measures should take into account the frequent regional imbalances of water resources within countries and the negative and positive environmental externalities arising from agriculture's use of water. A growing concern is the impact of agricultural policy on opportunities to mitigate or adapt to climate change and climate variability as they affect the water sector.

There are a number of issues that could be addressed by policy decision makers ranging from decision makers at the watershed through to national levels, including (i) using an appropriate mix of instruments and tools aimed at addressing agriculture resource management issues to ensure the achievement of coherent agricultural, environmental and water policy goals as well as cost effective implementation such as integrated policy treatment of water and energy input use by agriculture, including coordinated policy responsibilities and structures at different levels from the watershed to national level, (ii) integrating and expanding current scientific research and data collection capacity to underpin improved policy making, including better water accounts, (iii) identifying property rights attached to water withdrawals, water discharges and ecosystem provision, (iv) establishing clear lines of responsibility in the institutional framework to manage water – who does what, who pays for what, who monitors and evaluates – underpinned by a long term commitment from governments to resource the necessary actions, especially with the growing concerns related to climate change and climate variability, (v) strengthening water policy reforms to provide a robust regulatory framework to allow, for example, for water pricing and trading, and water service competition or benchmarking performance where competition is limited, and nutrient trading for pollution abatement, and (vi) raising the capacity for stakeholders (farmers, industry and community groups) to participate in the design and delivery of policy responses for integrated water management.

It is urgently necessary to adopt more appropriate ways for generating complex water resources projects in Myanmar to meet the requirement in all sectors.

Both technical and institutional measure are required to be developed to replace traditional and conventional practices, but this should be carried out on the basis of the careful consideration of previous experience, making adjustments where necessary.

A reasonable and functional system of water users groups (WUGs) should be newly established or modified in conjunction with the local characteristics of the farming communities, including their economy, culture and the social background of the respective regions in which they are to be found. They can support the adoption of new measures for better water resources management. A reasonable water pricing system also should be implemented to lessen the government's burden and to promote the farmers' participation in irrigation. A suitable marketing and trading system for crops and farm products is necessary for the farmers' convenience and to bring them sufficient benefits.

The efficiency of water supply system in farming was measured by getting water distribution in terms of adequacy, reliability, timeliness. A consistently adequate supply of water to farmers is the most important factor. It is difficult to quantify and attribute the change in performance occurring with participatory management, but the schedules prepared by farmer organizations are well planned and more effectively implemented. According to irrigation officials, conflicts over water and control structures by farmers were also common problems thus with increased farmer participation in irrigation management, the incidence of water related conflicts and purposive damage to structures by farmers had decreased. The availability of water has also increased due to improved maintenance performance and increased operation performance of irrigation systems. The success of irrigation an irrigation project depends largely on the active participation and co-operation of individual farmers. Irrigation technician cannot satisfactorily operate and maintain the system.

Thus, under the leadership of the Myanmar Water Resources Committee, the irrigation systems can contribute to development of multifunctional roles and the sustainable development of the rural environment.

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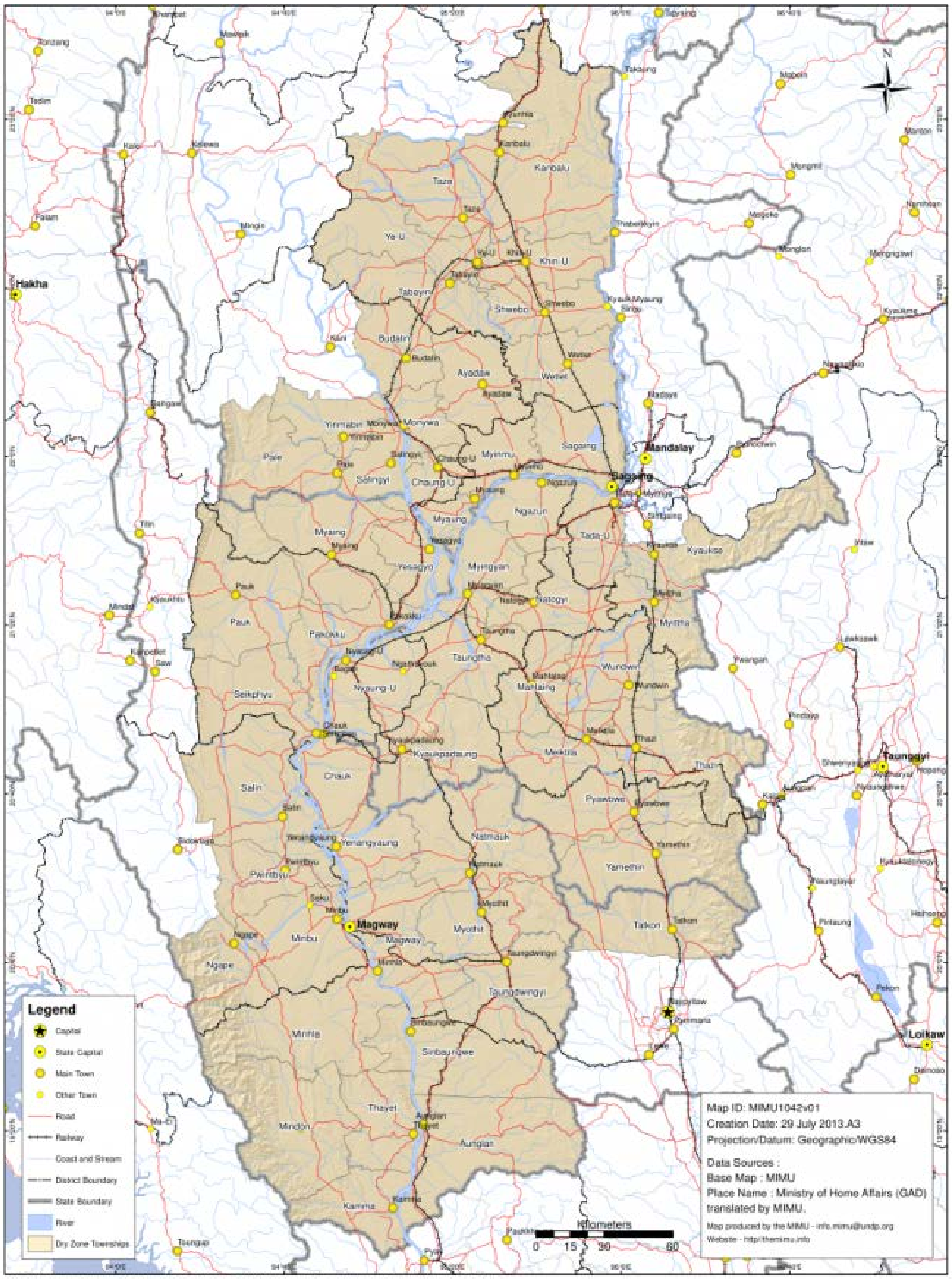
APPENDIX I

Map 3.1 Central Dry Zone Map, Myanmar

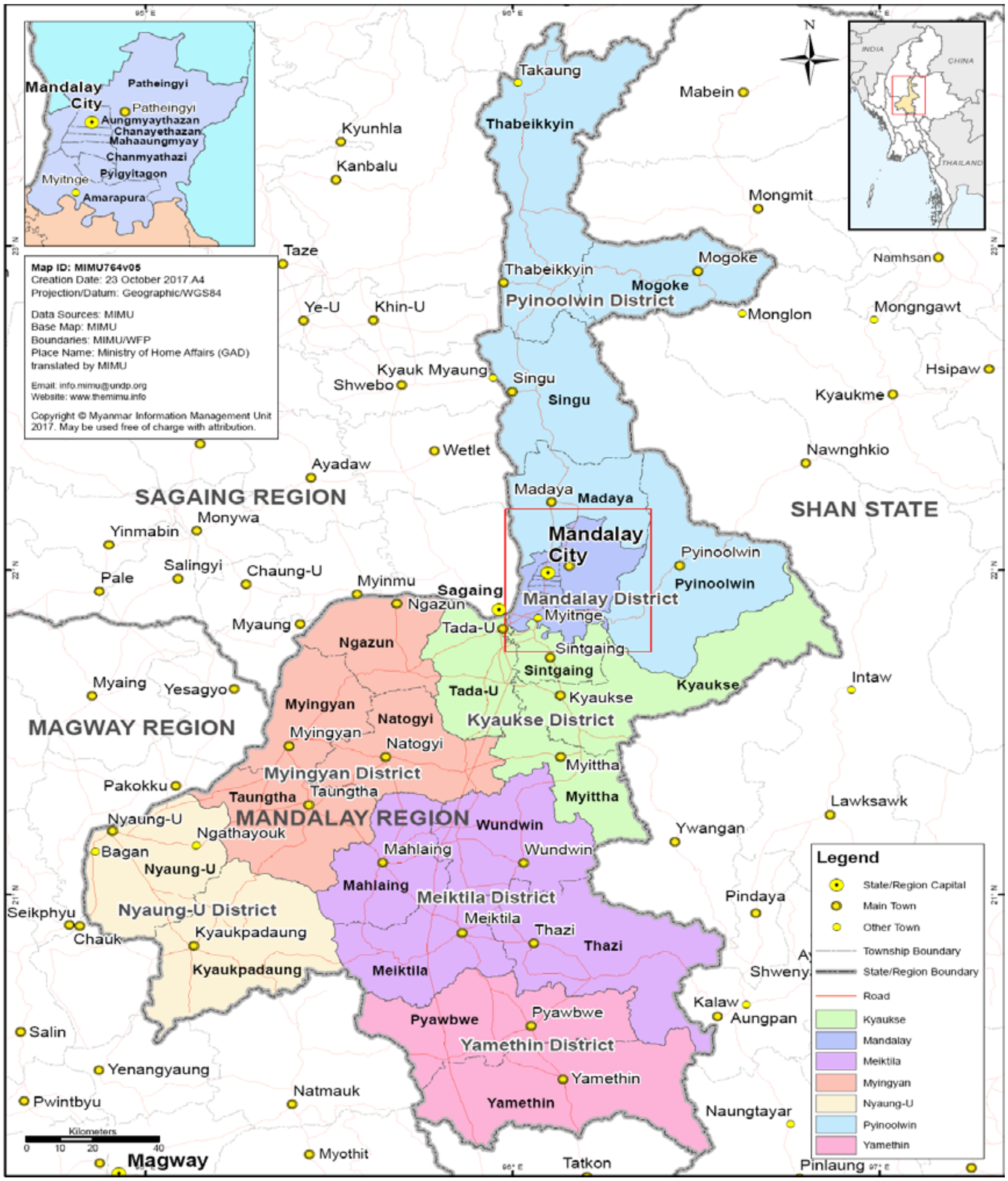


Disclaimer: The names shown and the boundaries used on this map do not imply official endorsement or acceptance by the United Nations.

Source: Myanmar Information Management Unit

APPENDIX II

Map (3.2) Map of Mandalay District Region



Source: Myanmar Information Management Unit

APPENDIX III

SURFACE WATER SUPPLY MANAGEMENT PROJECT IN MANDALAY REGION

Table (I) Dams In Mandalay Region

No.	Name of Dam	Name of District
1	Doe Kwin	Pyin Oo Lwin
2	Si Thar	Pyin Oo Lwin
3	Sin Lan	Pyin Oo Lwin
4	Si Thar Supplement	Pyin Oo Lwin
5	Malae Nat Taung	Sint kuu
6	Kintar	Myit Thar
7	Sedawgyi	Medaya
8	Mone Tine	Meiktila
9	Naung Tone	Meiktila
10	Lat Khote Pin	Meiktila
11	Lon Ngin	Meiktila
12	Shan Ma Nge	Meiktila
13	Naungyan	Meiktila
14	Thet Taw (1)	Meiktila
15	Thet Taw (2)	Meiktila
16	Sa Mone	Meiktila
17	Taung Pu Lu	Meiktila
18	Tha Pyay Yoe	Meiktila
19	Ahlaung Sithu	Meiktila
20	Zeetaw	Meiktila

Table (I) Dams In Mandalay Region (Contd.)

No.	Name of Dam	Name of District
21	Thin Pone	Meiktila
22	Poe Ma Kyee	Meiktila
23	Kone Tae	Meiktila
24	Kyin Thar	Meiktila
25	Chaung Sone	Meiktila
26	Don Lon	Myingyan
27	Taung Pin Lal	Myingyan
28	Myount Pin Lal	Myingyan
29	Pyaung Pyar	Myingyan
30	Khat Lan	Myingyan
31	Taung Thar	Myingyan
32	Kyaut Ta lone	Myingyan
33	Wae Laung	Myingyan
34	Kyaut Ta Lone Supplement	Myingyan
35	Sin Tae Wa	Myingyan
36	Phaung kataw	Myingyan
37	Nat Thar Taw	Myingyan
38	Myot Thar	Myingyan
39	Chaung Ma Gyi	Myingyan
40	Tha Phan Chaung	Yemaethin

Table (I) Dams In Mandalay Region (Contd.)

No.	Name of Dam	Name of District
41	Chaung Kaut	Yemaethin
42	Nat kar	Yemaethin
43	Yoe Gyi	Yemaethin
44	Thit Sone	Yemaethin
45	Kyee Ni	Yemaethin
46	Kutin	Yemaethin
47	Thar Tit	Yemaethin
48	Lal Phyu	Yemaethin
49	Ngar Tha Yaut	Nyaung Oo
50	Kyat Maunt Taung	Kyautpadaung
51	Pin Chaung	Kyautpadaung
52	Taung Yay	Kyautpadaung
53	Mar Gyi	Kyautpadaung

Source: IWUMD, Mandalay Region

Table (II) Weirs in Mandalay Region

No.	Name of Dam	Name of District
1	Sedawlay	Patheingyi
2	Kyautselay	Pyin Oo Lwin
3	Thit Tat Kone	Myit Thar
4	Nga Pyaung	Kyaut Se
5	Myin Ye	Kyaut Se
6	Thin Twe	Kyaut Se
7	Zee Taw	Kyaut Se
8	Naung Khan	Kyaut Se
9	Myot Kyi	Kyaut Se
10	Naung Pin Hla	Meiktila
11	Woon Twin	Meiktila
12	Kyii Pin	Meiktila
13	Khin Gyi	Meiktila
14	Mya Kan	Meiktila
15	Inn Yin	Meiktila
16	Chaung Kaut	Yamaethin
17	Thit Sone	Yamaethin

Source: IWUMD, Mandalay Region

Table (III) Lakes In Mandalay Region

No.	Name of Dam	Location
1	Pyu Kan	Tadar OO
2	Tha Nga Taw	Tadar OO
3	Chaung Ma Nat	Tadar OO
4	Min Hla	Tadar OO
5	Han Zar	Tadar OO
6	Yaut Yoe	Tadar OO
7	Bwet Char	Tadar OO
8	Sae Gyi	Tadar OO
9	Ta Kon Taing	Meiktila
10	Htii Hlaing	Meiktila
11	Nwar Nan	Meiktila
12	Phoe Paw Nweni	Meiktila
13	Kan Yar	Meiktila
14	Ote Foe	Meiktila
15	Naung Pin Thar	Meiktila
16	Pyoe	Meiktila
17	Myaing Thar	Meiktila
18	Kan Nar	Meiktila
19	Yin Taw	Meiktila
20	Kayutse	Meiktila

Source: IWUMD, Mandalay Region

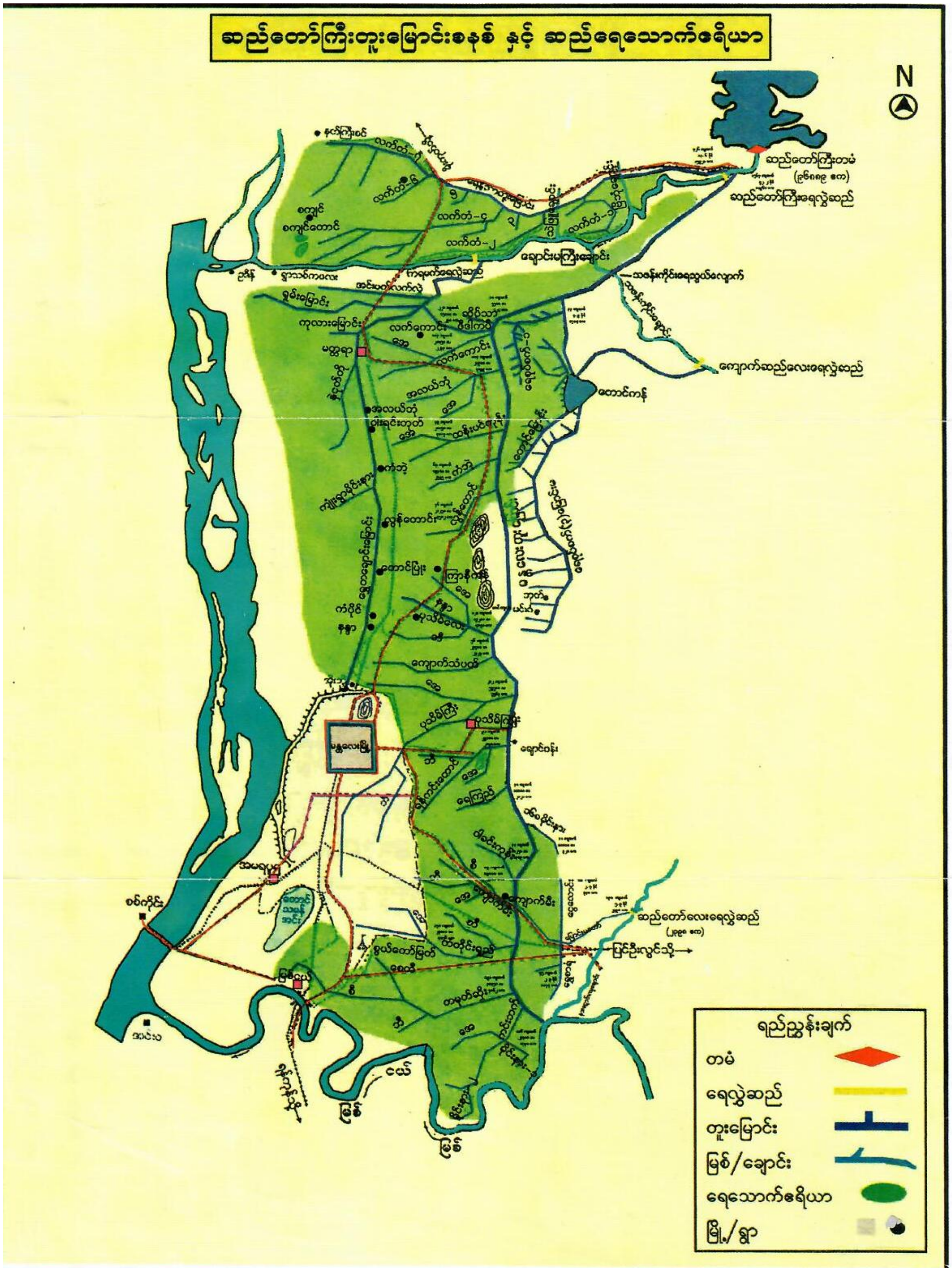
Table (III) Lakes In Mandalay Region (Contd.)

No.	Name of Dam	Location
21	Ngint Zinn	Meiktila
22	Min Thar Gyi	Meiktila
23	Yan Aung	Meiktila
24	Sar Kyin	Meiktila
25	Nwar Htoe	Meiktila
26	Gway Htaut	Meiktila
27	Kan Kyi Kone	Nyaung Oo
28	Yatanar Boneme	Nyaung Oo
29	Htii pu Kan	Nyaung Oo

Source: IWUMD, Mandalay Region

APPENDIX IV

Map (3.3) Location Map of Irrigated Area of Sedawgyi Dam



Source: IWURD, Mandalay Region

APPENDIX V

THE INCOME OF FARMER IN TERMS OF CROP PATTERN

The income of farmer is also difference on cultivated crop pattern of the year. The difference ratio of cost and income depend on cultivated crop pattern on Type of farming water are as shown in Table (I). (II), (III), (IV).

Table (I) The ratio of Cost and income per acre in terms of cultivated crop pattern in La-Land irrigate by MC and Pump Station.

No.	Cultivated Crop Pattern of year	Ratio of Income
1	Monsoon Paddy-Onion	1 : 4.02
2	Monsoon Paddy-Grams/sunflower-Summer sesame	1 : 2.88
3	Monsoon Paddy- Grams/Sunflower-Summer Paddy	1 : 2.73
4	Monsoon Paddy- Winter Groundnut	1 : 2.73
5	Monsoon Paddy-Patisane/sunflower- Summer sesame	1 : 2.36
6	Monsoon Paddy- Summer sesame	1 : 2.33
7	Monsoon Paddy-Summer Paddy	1 : 2.17
8	Monsoon Paddy- Gram	1 : 1.97

Source: Department of Agriculture, Mandalay Region

Table (II) The ratio of Cost and income per acre in terms of cultivated crop pattern in Le-Land in Rain-fed region.

No.	Cultivated Crop Pattern of year	Ratio of Income
1	Monsoon Paddy-Onion	1 : 3.96
2	Monsoon Paddy- Sunflower	1 : 2.04
3	Monsoon Paddy-Sesame	1 : 1.93
4	Monsoon Paddy- Monsoon Patesane	1 : 1.89
5	Monsoon Paddy- Grams	1 : 1.197

Source: Department of Agriculture, Mandalay Region

Table (III) The ratio of Cost and income per acre in terms of cultivated crop pattern in Ya-Land of Rain-fed region.

No.	Cultivated Crop Pattern of year	Ratio of Income
1	Monsoon Sesame – Onion	1 : 4.24
2	Monsoon sesame – Grams	1 : 3.36
3	Monsoon Pate'sane - Corn	1 : 2.3
4	Monsoon sesame - Sunflower/Groundnut	1 : 1.81
5	Monsoon Sesame – Maize	1 : 1.54

Source: Department of Agriculture, Mandalay Region

Table (IV) The ratio of Cost and income per acre in terms of cultivated crop pattern in Kaing/Kyun of Rain-fed region.

No.	Cultivated Crop Pattern of year	Ratio of Income
1	Winter groundnut - Corn	1 : 2.51
2	Winter groundnut – Summer Sesame/corn	1 : 2.51
3	Winter Maize- summer sesame	1 : 2.35
4	Monsoon paddy – Groundnut/corn/fodder crop	1 : 2.34
5	Winter groundnut - Sunflower	1 : 2.12

Source: Department of Agriculture, Mandalay Region

APPENDEX VI

THE CULTIVATED AREAS WITH DIFFERENT TYPE OF WATER FOR FARMING

Table (I) Cultivated La-Land Area in Branch I -Patheinlay Branch

No	Village Name	Type of Farming water						Total
		MC	Rain-fed	Electric Pumping Point				
				Kangyi	Zeetaw	Kyoekyaroo	Hantooyin	
1	Ingyal	218	-	-	140	76	-	434
2	Kaungmon	817	-	-	-	-	-	817
3	Dahataw	535	-	-	-	-	-	535
4	Wathondaya	82	-	-	-	-	-	82
5	Kyarnekan	691	-	-	-	-	-	691
6	Patheinlay	225	-	-	-	-	-	225
7	Manawyama	599	-	-	-	-	-	599
8	Kangyi	40	-	159	-	-	-	199
9	Gandama	-	-	-	-	-	29	29
10	Kanpyin	-	290	-	120	-	70	480
11	Minkan	-	10	-	90	-	-	100
12	Bote	-	200	-	96	-	-	296
Total		3207	500	159	446	76	99	4487

Source: Department of Agriculture, Mandalay Region

Table(II) Cultivated La-land Area in Branch II- Myanadar Branch

No	Village Name	MC	Rain-fed	Kyun	Total
1	Sinywargyi	1644	371	-	2015
2	Nhankyae	205	413	-	618
3	Nayyitsaya	1090		-	1090
4	Ywarthit	669	132	-	801
5	Nyeinchantharsan	1180	-	-	1180
6	Kyelyaykone	332	-	-	332
7	Aungchanthar	132	-	-	132
8	Nandar	652	-	-	652
9	Paukmyaing	1111	-	511	1622
Total		7015	916	511	8442

Source: Department of Agriculture, Mandalay Region

Table (III) Cultivated La-Land Area in Branch III- Myoma Branch

No	Village Name	MC (Acre)	Rain-fed(Acre)	Total (Acre)
1	Patheingyi	414	-	414
2	Yayhtwet	225	-	225
3	Zechokone	1026	-	1026
4	Mekinkone	431	-	431
5	Yankintaung	730	-	730
6	Shintawkone	1108	-	1108
7	Yaykyi	1180	-	1180
8	Nanoolwin	515	-	515
Total		5529	-	5529

Source: Department of Agriculture, Mandalay Region

Table (IV) Cultivated La-Land Area in Branch IV- Thamantaw Branch

No	Village Name	MC (Acre)	Rain-fed(Acre)	Total (Acre)
1	Thamantaw	1861	-	1861
2	Latkaung	281	-	281
3	Botatkone	450	-	450
4	Thalaekone	743	-	743
5	Zeeote	782	-	782
6	Yaylaung	675	-	675
Total		4792	-	4792

Source: Department of Agriculture, Mandalay Region

Table (V) Cultivated La-Land Area in Branch V- Kyaukmee Branch

No	Village Name	MC (Acre)	Rain-fed(Acre)	Total (Acre)
1	Kyaukee	612	17	
2	Ngwetaung	322	58	
3	Latthit	442	-	
4	Tw/Shey	201	79	
5	Ma/Shey	1145	-	
6	Igyi	936	116	
7	Bantin	368	-	
8	Bantkwe	406	-	
9	Shwesaryan	-	150	
Total		4432	420	4752

Source: Department of Agriculture, Mandalay Region