YANGON UNIVERSITY OF ECONOMICS

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A STUDY ON AGRICULTURAL PRODUCTIVITY THROUGH IRRIGATION IMPROVEMENT (A CASE STUDY OF POST-CYCLONE NARGIS AYEYARWADY DELTA)

WIN HTUT

EMPA-72 (16th Batch)

AUGUST, 2019

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This thesis is submitted as a partial fulfillment towards the requirements for the degree of Master of Public Administration (MPA)

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This is to certify that this thesis paper entitled **A Study On Agricultural Productivity through Irrigation Improvement (A case study of Post-Cyclone Nargis Ayeyarwady Delta)** submitted as a partial fulfillment of the requirement for the Degree of Master of Public Administration, has been accepted by the Board of Examiners.

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A STUDY ON AGRICULTURAL PRODUCTIVITY

THROUGH IRRIGATION IMPROVEMENT

(A CASE STUDY OF POST-CYCLONE NARGIS AYEYARWADY DELTA)

ABSTRACT

The aim of this study is to analyze the potential effects of irrigation facilities namely polder embankment, sluice gates and drainage systems on the agricultural productivities in Ayeyarwady Delta region, post-Cyclone Nargis, 2008. The qualitative key informant interviews and quantitative descriptive method are used in this study, implying basically on primary data and secondary data. A sample household survey is conducted on 34 villages covered by polders in six townships namely Ngaputaw, Labutta, Bogalay, Pyapon, Daydaye and Kyaiklatt from Delta region. The questionnaire is applied in the survey to attain the potential effects of construction and rehabilitation of polder system on the agricultural productivity. The Delta is fertile and beneficial for above 30 percent of country's rice and fish production. But it is low lying virtually without protecting polders. This produce very vulnerable to rising high sea level by storm surges and may coincide with salinity intrusion and river flood, resulting in crop losses and decreased yields. The study found that polder embankment supply expansion of cultivable land with the major reclamation for rain fed paddy and tidal irrigation for summer paddy cultivation. The potential effects of irrigation facilities can also be perceived in sluices and drainages affect to decrease soil salinity and to better yield per unit area as well as to retain fresh water for cropping intensity by prolonging the growing season. The study areas have potential for further development of agriculture sector and its endeavour to food security, employment and national economy through irrigation improvement.

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ABBREVIATIONS

ADB	Asian Development Bank
ADS	Agriculture Development Strategy
AMD	Agriculture Mechanization Development
APR	Average Annual Percentage Growth Rate
ASEAN	Association of South East Asian Nations
CSO	Central Statistical Organization
DAP	Department of Agricultural Planning
DOA	Department of Agriculture
DOF	Department of Fisheries
DOP	Department of Population
FAO	Food and Agriculture Organization, United Nations
FCR	Food Conversion Ratio
GOM	Government of Myanmar
INGO	International Non-Governmental Organization
IWRM	Integrated Water Resource Management
IWUMD	Irrigation and Water Utilization Management Department
JICA	Japanese International Cooperation Agency
KII	Key Informants Interview
LBVD	Livestock Breeding and Veterinary Department
LIFT	Livelihoods and Food security Trust Fund
MADB	Myanmar Agriculture Development Bank
MAS	Myanmar Agriculture Service
MDG	Millennium Development Goals
MFA	Myanmar Fishery Association
MLFDB	Myanmar Livestock and Fishery Development Bank
MoALI	Ministry of Agriculture, Livestock and Irrigation
MPA	Master of Public Administration
MSL	Mean Sea Level
MSWRR	Ministry of Social Welfare, Relief and Resettlement

NAPA	National Adaption Programme of Action
NGOs	Non-Governmental Organizations
O & M	Operation and Maintenance
PONJA	Post-Nargis Joint Assessment Report
PPP	Public-Private Partnership
SPSS	Stastical Package for Social Science
UNDP	United Nations Development Programme
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization

CHAPTER I

INTRODUCTION

1.1 Rationale of the Study

The country's economy and the people's well-being and income, particularly in agriculturally dominated countries, strongly depend on the availability of sufficient water. In Myanmar, the most important sector in the country's economy is the agriculture including crop production, livestock, fisheries and foresting for about 70 percent of the population who live in the rural areas is earned from the main source of livelihood as a accounts for about (49) percent of the employment, (61.2) percent of workforce in rural areas and it contributed about (25.6) percent of the gross domestic product (GDP), (24.4%) of total export earnings in 2017/ 2018 which are expressed in Myanmar Agriculture Sector in Brief, 2018. It is necessary to actively participate to make speedy achievement on the welfare and well-being of the nation and on the other hand for improvement of the agricultural system. Agricultural productivity in Myanmar is still low-lying and limiting the sector's endeavour to poverty reducing and share prosperity. Poverty is prevailing throughout Myanmar's rural areas: the majority of the poor earn their incomes from agricultural activities and casual work.

According to the datas of (FAO, 2013), the Ayeyarwady delta zone is fertile region and responsible for 35% of the country's rice production but the impacts from floods due to associated crop loss and the relatively dense populations are at risk extremely in these region. Flood can be represented as a basic asset for People's well being income and culture but also it can be a drawback for social and economic development. The delta zone is strongly encountered to impact from cyclones associated with winds, storm surges and saltwater intrusion in ground water. On the 2nd May, 2008, the delta region is suffered and devastated by a major disaster, Cyclone Nargis in which Ministry of Social Welfare, Relief and Resettlement reported in 2012 that killed 84537 people with 53836 people missing, and lift about 2.4 million affected and accounted for total damage and loss is approximately 11.7 trillion Kyats, i.e 4.1 billion US$. Also, impacting severely around 50,400 Km^2 of the

low-lying delta must be protected against inundation by the sea dikes or polder embankments. When land is rectified from the sea, after the polder has been drained and the soils ripened, irrigation water has to be supplied for leaching and flashing of salinity from the soils.

The agriculture sector in Ayeyarwady Delta suffered the most extensive damage due to cyclone Nargis. The studied area, Myanmar's rice bowl or rice granary as well as a major production area for other major crops and one of the world's most diversified fishery region's (fish bowl of the nation), is home to hundreds of thousands of rural households that depend on agriculture-crops, livestock, forestry, fishing and aquaculture- as their primary and often solitary, means to provide for their family. Early recovery support is urgently needed to assist agriculture-dependent families, who risk falling into permanent destruction and food insecurity if food production is not regenerated in time.

In Ayeyarwady delta area, the yield of paddy per a unit area is low (66 basket/area) and the poverty ratio is high (33.9% in rural area). This involves higher priority for development assistances for the area. Since the disastrous damaged caused by Cyclone Nargis in 2008, support of polder dike heightening and widening of crest-works are affordable with the highest priority. To maintain the nation's food security and enhance supply capacity of rice, it is important to promote productivity of rice through land consolidation and farm mechanization, in addition to the step-up flood protection dike, polder embankment and drainage. The development of waste land, fallow and submerged land, fish farming land, double and triple cropping and provision of water, where need, the prevention of flooding from inundated areas, tidal in flows, water logging and salt intrusion areas to better yield per unit area especially in deltaic region have developed by polder embankment.

Fish farming (aquaculture) has raised speedily in Myanmar over the last two decades and plays an increasing important role in contributing and supplying fresh fish and fisheries product for domestic consumption and export as well. The Cyclone's damage to catch fisheries and aquaculture has affected the livelihoods of over one hundred thousand fishers, whose products comprise a vital source of nutrients and the most important component of the Myanmar diet second only to rice. Proximity to the sea and abundance of rivers make the delta a rich centre for fish and prawn breeding. Full-time fishing is the primary income source for approximately 20 percent of Nargis-affected households. Fisheries also supply a vital source of income

for a high proportion of the landless. Thus Ministry of Agriculture, Livestock and Irrigation (MoALI), often with help of Japanese International Cooperation Agency (JICA), puts great effort in rehabilitation and upgrading of lower delta polder systems.

Due to importance of agriculture sector, the government harmonizes priority to its development by with great potential including additional irrigation facilities to ensure water supply and protection from inundated flood and salt water intrusion. Irrigation is defined as artificially supplying and systematically displacing of land and water utilization for agriculture, and aquaculture in order to obtain higher or qualitatively better production. Irrigation has been persisted instrumental in sustainable development of agriculture and the country's social and economy. Irrigation facilities such as dams, weirs, polder embankment, sluice gates and drainage systems have been well-stacked to obtain irrigated water, prevent floods and other regional requirements. These bring about good results for national development with better economic life of the people and the smooth transportation by land and waterways necessary for social and economic development.

It is essential to explore the specific sector of potential development and possible pace of growth of farmland productivity in agriculture and aquaculture sectors. Low farm productivity alters into high rates of poverty and food insecurity. A principal means of improving food crop production must be through extending and upgrading irrigation facilities. Rehabilitation and upgrading of flood control structures including polder embankments and drainage works are most-valuable to protect the area from floods and saltwater intrusion. The analysis has been made for effect on farmland productivity by studying the irrigation improvement focus on construction and rehabilitation of Polder Embankment in Ayeyarwady delta region.

1.2 Objective of The Study

The major objective of the study is to analyze the potential effect of irrigation facilities namely polder embankment, sluice gates and drainage systems on the farmland productivities in Ayeyarwady Delta region, post-Cyclone Nargis, 2008.

1.3 Method of Study

This thesis is mainly based on quantitative descriptive method and consistent use of qualitative information. Primary data were collected through household survey of the villages with the help of questionnaire and qualitative survey interview to key informants representatives of stakeholder on focus areas. The utilization of Secondary data provided from the Departments concerned: Irrigation and Water Utilization

Management Department (IWUMD), Department of Agriculture (DOA), Department of Fisheries (DOF), General Administrative Department (GAD), Department of population (DOP), Country report of Myanmar, JICA and FAO technical papers and reports, especially concern with Delta analysis, agriculture and irrigation sectors.

1.4 Scope and limitation of the study

The study mainly focused on the farmland productivity of agriculture and aquaculture in Ayeyarwady Delta Region by implementing irrigation facilities through flood control, soil conservation, water supply, etc. The study areas and primary data were from selection criteria of priority areas, six townships, namely Phyapons, Bogalay, Ngaputaw, Labutta, Daydaye and Kyaiklatt of disastrous cyclone Nargis, 2008 hitting areas. Data collection period is started from October 2018 to May 2019. Due to time constraints, data collected do not fully quantify the response requirements and could not cover all area inclusive in rehabilitation of polder embankment. One of the constraints was that some of farmland owners have no appropriate records/ documents for their production. The compilation of this studied area relies heavily on a consistent use of qualitative information and review of secondary.

1.5 Organization of the Study

The study is organized into five chapters. Chapter one contains the introduction of the agriculture, aquaculture and irrigation sector, it describes rationale, research objectives, methodology, scope of the research and the research limitations. It proceeds further to give a brief description of the organization of each chapter. Chapter two reviews available literature of relevant vulnerability and resilience assessment of Delta alliance. It gives an overview of the concept of world agriculture, aquaculture and irrigation sector related to contribution of these sectors to food security and to social and economic development including general characteristics as globally. Chapter three describes the role of agriculture, aquaculture and irrigation sector in Myanmar mentioned about climate conditions and vulnerability, resilience, farmland productivity, food security, livelihood, support to economy and policy back up. Chapter four outlines the survey design for primary data analysis and secondary data used to achieve the stated research objectives. The survey results and discussion were described in this chapter. Chapter five mentions the main research findings and makes recommendations based on the conclusions made in relation to stated objectives.

CHAPTER II

LITERATURE REVIEW

This chapter represents the literature reviews on relevant vulnerability and resilience assessment of Delta alliance. It gives an overview of the concept of world agriculture, aquaculture and irrigation sector related to contribution of these sectors to food security and to social and economic development including general characteristics as globally.

2.1 Vulnerability and Resilience Assessment of Delta Alliance

A mix of quantitative and qualitative methods under climate change is often necessitated for global delta comparison for agricultural water management system and assessment of the vulnerability and resilience of ten Deltas such as Nile (Egypt), Makong (Vietnam), Rhine – Meuse (Netherlands), Mississippl (USA) and so on (Bart, 2010). This study developed the dynamic social, ecological and economic systems and how these conditions determine vulnerability to shocks and stresses and threaten household and community well-being, income generation, resilience, nutrition, among crop producers, landless and vulnerable households in low-lying delta areas and irrigation facilities with polder dike building practices to improve agricultural productivity.

There is multi-disciplinary research to study climate change impacts and resilience across the different level and regions, especially to the most vulnerable communities and agricultural sector, impacts of sea-level rise on soil and water salinity, agriculture, wetlands ecosystem in updating fields, fisheries, and drainage infrastructure, effects of climate changes on water resources, water scarcity, soil improvement and agricultural productivity.

The climate and topography will cause predominantly with influencing to the delta's overall risk profile, but poor agricultural productivity, debt, unsustainable fishing practices and rapid deforestation, deepen vulnerability, particularly for smallholder farmers and landless households have been challenged the development of those Delta region. The risk of flooding is related particularly to the Hazards and development constraints are mutually reinforcing and together magnify vulnerability.

Extreme weather events can cause the flooding and intrusion of saltwater to any communities who are uncovered with the inadequate coverage of flood protection infrastructure. (Mercy Crops, Welthungerhilfe, and GRET, 2016).

Shocks such as coastal storms and flooding and stresses such as salinity intrusion and deforestation are counteracting development gains in the Delta. To accomplish meaningful gains over the long run, poverty reduction efforts must also be accommodated to equip stakeholders with capacity to manage risk by reducing shock and this means that interventions should focus on awareness, access, networks, and decision-making, integrated into individual development activities.

Storms and floods, aggravated by climate change, degrade soil and water productivity for agriculture. These adverse conditions, combined with poor quality and high costs of inputs and limited agricultural extension services, lead to unsustainable farming practices that increase the stress of soil infertility. Soil infertility reinforces land weakened status to frequent shocks such as erosion and disease outbreaks increasing degradation and aggravating hazard risks, further reducing soil productivity and placing communities in a negative feedback loop towards decreased agricultural productivity and income. As the quality of soil and water is lessened, agricultural productivity is further reduced, decreasing productivity, profitability, and ability to invest in effective soil, water, weed and pest management practices, pushing communities deeper into vulnerability. The vulnerability of different social groups living in different areas of the Delta result from the interaction between development constraints and hazards. Agricultural and off-farm livelihood options in the Delta are affected by conditions, or performance, of the social, political, economic and ecological system in which individuals, households and communities are integrated.

The sea level is rising to drive in turn water salinity further inland which will be part of cause is called global climate changes. The reoccurring nature of shocks such as increasing pressure on water resources and water scarcity is being converted to a worldwide problem in most arid and semi-arid regions means vulnerable families are placed on a downward spiral toward crisis (Kahil, 2015). As a coastal and delta region climate is the most significant risk driver such as adverse weather events. The shifting and dynamic tidal cycle, for example, is a major situtation of which areas crop production is possible. Coastal storms and extreme weather events strike the regions with frequency and intensity increasing flood exposure, surface and ground

water salinity and erosion. Strong tidal and storm surges create large-scale intrusion events, salinizing drinking water supplies, inundating fields, river and streams with saline water as a result of decreased soil productivity.

Climate-related hazards can also affect the occurrence of other threats, which means that communities are sometimes forced to deal with multiple types simultaneously. Pest and disease stimulated or aggravated by unfavorable climate condition. Increasing unsettled weather conditions would increase the occurrence of unseasonal rainfall and extended dry spells, notably during the pre-monsoon. The impacts of floods, storms, pests, diseases, and unseasonable rain affect crop losses during the growing cycle, reduced yields, harvest losses and decreased quality depending on the timing.

In order to achieve and sustain food security gains in the Delta, communities must be able to better gear up and respond to climate change and extreme events. This mean being able to attain natural, human, financial, social and physical resources and proactively utilize these through a range of strategies that contribute to resilience. Resilience defined as the capacity to learn, cope, adapt and transform in the face of shocks and stresses. Capacities can be shock-absorbent, to help people, households or systems better prepare for or recover from shocks and stresses; adaptive, mitigating the very presence, nature and impacts of shocks and stresses over time; or transformative, fundamentally opening up the wider system constraints that enable coping and adaptation.

2.2 Agricultural productivity and Achieving the Millennium Development Goals

The agreements of all 191 UN member states are eight international development goals that are achieved by the year 2015 which are objectives of the United Nations Millennium Development Goals. The UN millennium Decoration was committed by world leader to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women that were signed in September, 2000. (Braun, Swaminathan & Rosegrant, 2005).

Given that the majority of poor people live in villages or depend on agriculture, and that agriculture paves the way for economic growth in the poorer nations, agricultural and rural development will underlie progress on the broad arrangement of economic and social indicators that the MDGs emphasize. In

following engage the MDGs, we should seek ultimately the elimination of hunger, poverty, and maternal and child malnutrition.

There are noticeable direct relationships between agricultural productivity, hunger and poverty(MDG – 1). Three quarters (75%) of the world's poor live in rural areas and stimulate their living from agriculture. Hunger and child malnutrition are greater in these areas than in urban areas. Moreover, the higher the proportion of the rural population that receives its income entirely from substance farming (without the benefit of pro-poor technologies and access to markets), the higher the incidence of malnutrition. Therefore, improvements in agricultural productivity intended at small-scale farmers will benefit the rural poor first.

Increased agricultural productivity enables farmers to grow more food, which modifies into better diets and, under market conditions that offer a level playing field, into higher farm incomes. With more income, farmers are more likely to diversity production and grow higher-value crops, benefiting not only themselves but the economy as a whole.

A larger supply of agricultural products also take prices down, allowing both the rural and urban poor to purchase essential foods for less money. Smaller food bills mean that landless poor people will have more them promote income and survive future economic shocks. This income and asset security assists builds a solid foundation for economic growth, by enabling people to work free from the debilitating effects of hunger and under nutrition. A flourishing agriculture sector also facilitates job creation in other areas, such as food processing and marketing sectors, and creates secondary economic effects in the nonfarm economy.

The people with the breaking out of the poverty-hunger-malnutrition trap can be tolerated by increasing of food availability and incomes and contributing to asset diversity and economic growth, higher agricultural productivity and supportive propoor policies.

Empirical research was implemented in Africa and in India for example, in Africa, a 10 percent in the level of agricultural productivity is correlated with a 7.52 percent reduction in poverty. Another example in India, a similar increase in productivity has been estimated to decrease poverty by 4 percent in the short run and 12 percent in the long run that provides stark evidence of the benefits of agricultural

productivity (Braunet al., 2005). Significant gains in agricultural productivity have provided the critical first steps in economic development in many countries.

To achieve the MDG-2 goal for education, it must be taken into account education's links to agriculture and food and nutrition security. Agriculture-led economic growth also have a broader effect by creation nonfarm jobs in food-related industries for the skilled and educated. As agriculture develops, farmer exploit more high-valued products, including animal products. Research shows that girl's education and overall improvement in women's status conduce significantly to improving the nutritional status of children.

Legal and economic rights that extend equality to women secure that they obtain the full welfare benefits of improved agriculture. Such (MDG-3)gender equality, in turn, promote agricultural productivity further.

Increasing food production (farmland productivity) and improving the quality of children's diet help reduce child malnutrition and child mortality (MDG-4). Improving food and nutrition security for poor households with the assit of agriculture and ensuring that households allocate food equitably are crucial steps in improving maternal health (MDG -5).

Agricultural productivity, food and nutrition security play important but still underrated roles in addressing struggle HIV/AIDS, malariaand other disease(MDG-6).

Agriculture-led economic growth supply public revenue that governments can use to provide safe drinking water and better sanitation, as well as higher incomes that allow individual farming households to invest in these basic needs and to ensure environmental sustainability (MDG – 7).

It is necessary to boost the creation of a global partnership for development (MDG – 8) commitments on the part of global and national actors (agricultural producer) to pursuit of pro-poor growth because of the strong connection between poverty reduction and agriculture.

The engine for broad-based economic growth such a international experience has led to a renewed focus on the agriculture sector compared to any other sector. In these sector within an economy, growth in agriculture productivity has been recognized to be pro-poor, having a direct role in raising real income of the rural poor and thus reducing poverty. The overall alleviation of a country could be considerably supported with the agriculture sectors which requires relatively high public

5investments, strategically formulated interventions and conductive policies to growth. This is very truthful for Myanmar, a country with a major proportion (about 70%) of the population who are still living in rural (FAO, 2013).

2.3 Role of Agriculture and Aquaculture Development

As agriculture is the main source and engine of national economy growth all successive for many developing countries and their government have drawn the policies and plan give high priority to develop agricultural sector. The majority of agriculture land is used for the production of basic grains for internal consumption and Livestock feed. The country has been taking steps to gradually modify fallow and cultivable wasteland under cultivation. The development of agricultural sector is critical to the Government for the role in achieving food security and nutrition for the people. In many developing countries, the agricultural policy focuses on boosting production and productivity, promoting sustainable and climate-smart agriculture, encouraging transition from convention to mechanized agriculture and extension of irrigated area.

The agriculture sector stays basic in the economy of many developing countries and about 75% of the total population reside in rural areas and principally operated in agriculture, livestock and fishery sector for their livelihood(World Bank, 2016). The progressive achievements in the agriculture sector spreading over production, service and trade, accure to national development. And hence, countries' economic development may be incomplete without expressing the development of the agriculture sector.

Reforms to enhance agriculture productivity are necessary though not adequate for improving the welfare and livelihoods of rural communities. These have to be supplemented with increased access to social and economic services that can raise human and physical capacity to create the conditions necessary for the growth of a dynamic rural non-farm sector. These reforms could assist to not only reduce the drag on rural growth and poverty reduction but also contribute to structural economic transformation.

In order to increase the agricultural production significantly, the Government adopted three distinct strategies, namely

(1) Expansion of cultivable land in many of the unexploited areas of the country,

(2) Promotion of the yield per unit area of the crops through modern scientific methods, and

(3) Increase of cropping intensity by growing two or more crop per year.

Agriculture sector as a powerful arm in the national economy of all over the developing country, acts a powerful part in producing of overall domestic food self-sufficiency, building up to trade with foreign and in serving the raw materials to meet the domestic agro-based industries. Both the main economy of the state and the livelihood earner of the rural public are winning goals from agriculture.

And also, one of the rapid growing food production sectors in the world, aquaculture, produce its yield with a volume currently, and with expectations its distributions to food security and poverty alleviation (FAO , 1997)

Aquaculture is one of the fastest growing food production sectors in the world, with the bulk of its output currently being produced within developing countries, and with expectations for aquaculture the continue its distributions to food security and poverty alleviation (FAO,1997).

There is a strong need for agriculture and aquaculture to conduct a leading role in fracture the cycle of poverty, high population growth and environmental degradation. As agricultural productivity increase, so do the income of rural poor and vulnerable involved in the agricultural sectors. Higher domestic food production directly contributed to improvements in the caloric intake of the poor.

2.4 Contribution to Food Security and Socio-economic Development

Food security is often related to food self sufficiency and the need to grow more food. To a great extent, it must be in line with issues of poverty, employment and income generation. For many developing countries, a large percentage of the population live in rural areas and depend on agriculture for their income, increasing food production is an important element in increasing food security not only it is likely to increases income but also approach to the basic food is critical.

Food security at national level is related to the balance between food demand and food supply at reasonable prices. Food security could become over time through rising price which tend to effect the poorest first as they spend a higher properties of their income on food. The household level of food security, probably the most important households are known as food security if their demand for food is greater than their needs, defined as the totality of individual requirements. At individual level, food security classifies to food consumption as compared with need. Food security is a global phenomenon in one form or another and seasonal.

In conformity, changing economic policy and system, private initiative is induced with freedom of choice in cultivation, production, processing and marketing of crops. Technical and financial supports are supplied for expansion of land for cultivation, as well as for double and multiple cropping. All these efforts undoubtedly secure food availability at the national level and to some extent food security at household level.

Irrigation has a direct impact on agricultural production and farm income. Thus agricultural development is vital for socio-economic development of the country. Almost every agricultural project has costs and benefits that are intangible. These may consider creation of new job opportunities, better health and reduced infant mortality as a result of more rural clinics, better nutrition decreased incidence of water born disease as a result of improved rural water supplies, national integration or even national defense.

Moreover, an irrigation project is not only a system for producing crops but also a place for a community of people and families to live healthy lives while working cooperatively and contributing to the food security, and development of their nation. The agricultural development purposes for improvement of rural people by enhancing their productivity and promoting their welfare, developing the rural economy. With the progress of agriculture, the rural community have greater opportunities for a healthy, happy and irradiated life and contribute significantly to national economic growth. Thus, the government has selected agriculture as the main pillar of the economy and is consecrating tremendous efforts to achieve greater progress in this sector. Consideration is also given to equitable developments to all inhabitants, reduction of regional inequality and providing sufficient food and nutrition for the whole country.

The products of goods and services from aquaculture, which make valuable contributions to the local, national and regional economic, sold on the domestic and export markets. Moreover the fishers and fish farmers were related in primary fish production directly, a large number of local people are employed in other secondary activities like processing , net and gear making, ice production, manufacturing of fish and aquaculture processing equipment, packaging, marketing and distribution. The figure has been evaluated that the total of 540 million or 8.0 percent of the world population involved in these sector such as fishers, aquaculturists and those supplying

services and goods support the livelihood (FAO, 2009). Small – scale aquaculture contributes directly to the poverty alleviation and achievement of food security. In many countries, aquaculture's contribution as proportion of total gross domestic product (GDP) is small, but its importance to the national economy in terms of poverty alleviation and nutritional benefits is significant, particularly in developing countries.

2.5 Agricultural Productivity through Irrigation Technologies/Methods

Low lying areas must be protected against inundation by the sea dikes or polder embankments. The crest of the dike (or) polder was determined by the highest flood level people could consider. The levels of the various polders range now from 2 meter above to 6 meter below mean sea level (MSL). The drainage system for all polders consists of a series of natural waterways and excavated canals, together forming a storage and transport systems to carry out superfluous polder water to the sea or the rivers.

2.5.1 Planning of Land and Water Management

As the planning and design of the polders is an composite and complex tasks, requiring experienced professionals in several fields such as hydrologist, geohydrologist, soil scientist, engineer, agriculturist, economist, etc. It is need to combine cooperation of concrete efforts by these specialists be secured starting from collection of data, planning, design till to project implementation.

To gain substantial benefits and good return from the polder project, sufficient water management is a must, otherwise there may be negative effects to extent that farmers or fishers may extract the embankment to let water backed up by tides to come in the polder for irrigation, soil particles sedimentation and fishery.

Hydrological aspect :For designing discharge structures like discharge sluices or pumping stations, it is need to have both information about the rainfall surplus and about the possibilities to discharge the water. When a polder or a canal system discharges into the sea, it can modify utilization of the advantage of the tide. During low tide, sluice can be opened. During high tide, they have to be closed.

Geohydrological aspect :Due to the location below and nearly mean sea level, there is seepage in the deeper polders. Normally this seepage amount to less than 1 mm/day but there are exception of up to 20 mm/day. As a result of regressions and transgressions, the ground water is often brackish.

The soils, generally comprises largely of clay and silt with small percentage of sand, have to be altered, again by means of drainage together with the cultivation of reclamation crops such as rice, wheat. Where climate is suitable, rice is an excellent reclamation crop. It is somewhat salt tolerant. It is full-grown under flooded condition which allows flushing and leaching process to go on concurrently while land is under cultivation. To change from mud to farming soil, the ripening of soils consists three main processes: decrease in water content, formation of cracks and subsidence of land surface. In particular, if the groundwater is saline, the adaption of subsoil drains should be encouraged. For reclamation and ripening of soils, field drains are generally needed.

The water control system in the polder was designed and constructed according to norms relevant for agricultural and aquacultural areas. The Delta, where horse-shoe shaped embankments were made-up leaving the lower end or downstream side of polder open and sluices were made-up at the upper end. River floods can enter slowly through this open downstream side but the depth of flooding and the flooded smaller than without the open embankment. For good crops growth the groundwater should be kept about 1.4 to 2 meters below the land surface.

2.5.2 Drainage and irrigation system

The layout of the system of open or closed field drains, main ditches and canals in polders, is mainly depended upon topography, soil conditions and on agricultural economy. The water levels in the canals are determined by the depth of drainage with the different accessible uses of land. In the older polders the parceling out is often based on the natural pattern of streams and creeks.

In polders, drainage comes before irrigation and is considered more important. After impoldering is completed, the polder will have to be drained dry. In the costal (embankment) polders of Bangladesh, and several polders in Myanmar, farmers also make to use shallow dug wells (about 10 meters, depth) as source of water for domestic supply and irrigation. Natural lakes, ponds of adequate quality of water can and are used as sources of water in the polder. Often man-made ponds or tanks have been constructed to collect and store water during wet season for use during the dry season.

Drainage For reclamation: After the completion of polder embankments and sluice and the land is completely enclosed, drainage by sluicing should start. After that the construction of main drainage canal should be begun. Natural creeks or channels may

be used as main drain if their elevation and location are suitable. Smaller creeks may be used as secondary drains. Shallow and meandered creeks should be deepened to the necessary depth and straightened as appropriate and the excavated soils used for filling up other small creeks and depressions. If the main drain has to be newly excavated, in the initial stage, when the soils are still fully saturated and very soft, the depth may be kept shallow and slide shape flatter.

Drainage for agriculture: Drainage canals in polders facilitation only for rice are generally shallower than those in which dry land crops are grown. In general, the land elevation in the polder has to be adequately high (more than 1 meter above mean sea level) to enable drainage by gravity to be effected through sluices, taking advantage of ebb tide a few hours each day.

Sluice sills should be placed as low as practicable to improve hydraulic capacity. When the land elevation is low, not only drainage is more difficult but also the construction of embankments, irrigation and land and water management become more complicated and more costly. For this reason, several countries have constructed land elevation criteria for the development of their tidal lands.

The land elevation is providing for their tidal lands as follow as in India (Sundarbans), the lowest permissible level of land for reclamation is mid-way between high spring tide and high neap tide. In Indonesia, the land elevation has to be between mean sea level and high tide. In Malaysia, the elevation has to be about 1.2 m above mean sea level. In Srilanka, the minimum elevation of the reclaimed coastal area is about 0.3 m above mean sea level, whereas in Thailand, this elevation is about high neap tide. In Japan (Hachiro-gata), the minimum elevation of land inside the polder is 4.5 m below mean sea level (Schoubroeck, 2010).

The monsoon and typhoon rainfalls countries where rice is grown, the paddy field which generally have low field dikes all the time are used to store excess rainfall temporarily, in this case, the reason is lessening the cost of making the drainage system. Paddy can withstand submergence of up to 7 days without much a chain reaction, some of developing countries made the researches of rainfall datas and storage capacity which leading to make the equal amount of drainage system design according to the paddy type and species. In Japan, Hachiro-gata polder in Akita prefecture was designed to store excess rainwater on the paddy fields temporarily, equivalent to 77 min or about one-third of the maximum three days rainfall of 220mm. In Bangladesh, a drainage criteria of 25mm per day has been adopted for

areas with an annual rainfall of about 1750 mm. In Thailand, the drainage system was designed to drain the three days maximum rainfalls in 7 up to 10 days. To improve drainage and water management within the polder, a large water reservoir can be created at the closure of the river mouth or estuary by sluices for coastal or tidal land polders (Schoubroeck, 2010).

Irrigation : The main principle of irrigation is to supply water according to plants need and to protect against inundation flood and saltwater intrusion. When river is the source of water for the polder, the main canal taking water from the river should be located for enough upstream beyond the reach of sea water intrusion. Irrigation may be effected by gravity through a system of main and secondary canals and field channels.

The planning of irrigation and drainage should start at the farm level and work upstream to the main canal and head works. Whether irrigation (and drainage) will be effective and efficient relys a great deal in the planning and design of the field irrigation channels and field drains at the farm level. When land is reclaimed from the sea, after the polder has been drained and the soils ripened, irrigation water has to be provided for leaching and flushing of salinity from the soils. When irrigation is by gravity through canals, the amount of water supplied as determined by crop water requirement or evapo-transpiration, divided by irrigation efficiency to arrive at irrigation water requirement, is generally adequate for leaching, to keep the soil salinity under check.

The levels of the various polders range now from 2 meters above to 6 meters below mean sea level (MSL). The drainage system for all polders consist of a series of natural waterways and excavated canals, together forming a storage and take system to conduct super flours polder water to the sea or to the rivers.

2.6 Some issues and challenges in agricultural productivity

The farmers' major involvements center around frequent rain shortage or flood, soil erosion, shortages of farmland , water conservation (flooding & drought), lack of grazing land and fertilizers, crop disease, pest control, and poor access to markets, all of which are major constraints to agricultural production.

Severe drought or flood, which effects in massive livestock and crop loss, in addition to a significant loss of human life on a national scale, is a significant contributor to poor health and low agriculture productivity. Non-farm employment as a way to rationalize climate variabilities and thus limit food and nutrition insecurity,

particularly those households with the thread of future water scarcity. Agriculture, natural resource conservation, and other social and economic factors influence the impacts that severe drought or flood has on households.

Negative predictors of food security are difficulties to land accessibility, technology, decision-making, and being from a female-headed household. There are current conservation practices, such as dams and water harvesting, which farmers manage in their agricultural activities. Regardless of these conservation practices, which rely heavily on rainfall, the problems of drought still remains a substantial source of apprehension for many farmers.

Soil is an important resource for farmers, not only for its evident role in agricultural production but for its role in biomass energy production. Households with less land to cultivate, or those where there is significant population pressure, are more likely to absent conservation structures in the absence of appropriate policies and technology. Participation in soil conservation processes without incentives may be limited as farmers see these activities as the responsibility of the authorities. As a consequence of environmental degradation, both from increased climate fluctuations and poor management, soil nutrient depletion has a negative impact on food production potential. Although fertilizer is a popular means globally to increase soil fertility in the face of such severe soil nutrient loss, only a minority of farmers can use it. Education, farm size, and income per unit of cultivated land also tend to have a positive correlativity with the use of fertilizer in a farmer's production system. An increased grain production would promote household food security and hence a household's overall welfare.

Irrigation is closely related to food security and its use is an ancient tradition. The farmers' irrigation plans of action are often rudimentary in their construction with temporary headwork, unlined canals and storage ponds. Irrigation consents farmers to grow more than one crop per year or produce other lucrative water-intensive crops. Correspondingly, and farm size increases, the use of irrigation in the production scheme tends to decrease, but the incorporation of irrigation systems is correlated with owning a greater number of livestock. Secondary salinization is also a very real involvement for farmers using irrigation systems. In its early stages, increased salt in the soil leads to declined productivity and eventually, complete soil infertility. As a developing country, the water resources projects, particularly in the irrigation sector are mainly operated and managed by the government agencies. In this

situation, authorized persons may acquire ways and means in improving the productivity of water and land use and the achieve sustained improvement in irrigation systems.

Because agriculture for many farmers is not conveyed for commercial purpose, any cash that households would require must come from the sale of one's own livestock, alternative crop products. To take advantage a positive, liberalized crop production environment farmer will need ready access to several key production services including: (a) timely and sufficient seasonal credit to fund crop production, (b) supply of improved seed and planting materials, (c) sufficient supply of good farm inputs and fertilizer, (d) the ability to sell their crops in an open and competitive market place and, (e) access of technologies to improve farm incomes in a sustainable and resource efficient manner.

The main agricultural policies of the government displace around the expansion of cropping and industrial crops with agricultural input provision through public-private partnership (PPP). The increase the mechanized agriculture and to expand the irrigation are important measures being used to boost production and productivity as well as to increase cultivable land. National policies perform a large and varied role in the agricultural and food security issues facing. The amount of cultivated land, the number of off-farm activities, household size, distance to market, age of the head of household, food stocks, dependence on rain-fed agriculture, a reduction in income diversification, and even whether a male or female is head of household are also important factors in appraising household poverty and related health status.

2.7 Review on Previous Related Studies

Myanmar also be affected with the climate change impacts on agricultural productivity like other countries by sudden change of weather pattern. The sustainability of the crop production is facing difficulties due to the long draught and flood including weather extreme event like cyclone and storm surges. The government noticed with concurrence priority to the important of agriculture sector development by with great potential incorporation with additional irrigation facilities to ensure water supply for crops cultivation throughout the year. The irrigation facilities establish the diverse function call for provision for adequate storage of water. Irrigation system also develop dual protection from inundated areas of farm

lands and residential areas especially in delta region and along the main river system. (Mu Mu Than, 2016).

The formulation and operationalization of National Action Plan for Poverty Alleviation and Rural Development through Agriculture in much of the low-lying Delta Region which is subject to flooding, storm surges and salinity intrusion, resulting in crop losses and reduced yields (FAO and NAPA 2016). In 2008, about 140,000 people died and as many as 2.4 million people were affected by Cyclone Nargis.

Cyclone Nargis affected 50 townships, mainly in Ayeyarwady regions where badly devastated to the many of the structure in the delta. Some of the most productive part of the country vulnerable is still need the rehabilitations and leaving apart from the flooding. Flood control and drainage infrastructure will become increasingly important in the presence of global climate change. The climate change will be affected in Myanmar significantly with the suggestions of most formal assessments. There are being rised in sea levels along the coast with the intrusion of aggravating saltwater and arising of soil salinity in the coastal areas and river deltas where are increasing in flooding considerably.

It also mentions and suggest Myanmar needs to improve its ability to manage its increasingly irregular freshwater flows and minimize saltwater intrusion near the coast. Investments in progressive water control infrastructure are fundamental to protecting agricultural land and the population in flood prone areas, particularly in the fertile Ayeyarwady deltas. The government would need to make flood control infrastructure considerably to maintain the condition of existing structures and ensure the sustain ability of rehabilitated and upgraded structure of sluice gates, polder embankment and drainage systems.

The existing agriculture and its related policies in Myanmar has the potential to be an engine for rapid and sustained national economic growth, poverty reduction and the generation of surpluses for investment in infrastructure and industrialization. Currently and in the future, the irrigation facilities such a crop patterns have changed in the fields countable in acres in the million will produce good results for the nations. The double or triple cropping system will create more job opportunities along with better economic life of the people as the government has been efforting its best to support water resources for agricultural purpose. The expansion of cropping and industrial crops of the private sector in agricultural input provision are turned around

by the main agricultural policies of the government. The increasing mechanization of agriculture and developing of irrigation system determine in increasing production and productivity of agriculture and depend on the measure in increasing the area of land under cultivation (Kyawt Thuza, 2005).

One of the main objectives in the world nations, finding the solutions to problems of hunger and poverty in developing countries and food security, that are critical issue to solve in the world. Also in Myanmar, the development of livestock and fisheries sector also identified from 1994 to 2009 (Hla Aung, 2011). Food and fibre are the basic requirements to fulfill through developing the livestock and fisheries sector. As Myanmar has adopted a market oriented economic system, there are more important in the sector of agriculture, livestock and irrigation sectors to sufficient for food and beverages and fibre-self. The exports of these sectors especially the fisheries sector has contributed much to the country economy. The livestock sector are also trying to be sufficient to the demand of consumption or meal in the nation.

In this paper, in order to recommend the farmland productivity for the potential of agriculture, aquaculture development in future, it is studied on the effect of polder embankment irrigation facilities to impacts of climate changes on water resource, soil improvement and agricultural production, on post-cyclone Nargis, 2008 in Ayeyarwady delta region. The development study for the preservation of farming area is to restore agricultural production and rural life through rehabilitation of polder dikes including sluice gates and drainage in areas affected by Cyclone Nargis.The next chapter will be discussed about overview on agriculture and irrigation in Myanmar especially in Agricultural Production and Influential Factors and Potential Effects of Irrigation Facilities.

CHAPTER III
OVERVEIW ON AGRICULTURE AND IRRIGATION IN MYANMAR

In this chapter, it is described that the role of agriculture, aquaculture and irrigation sector in Myanmar mentioned about climate conditions and vulnerability, resilience, farmland productivity, food security, livelihood, support to economy and policy back up.

3.1 Goals and Strategy of MoALI

Agriculture make up above 25%of GDP, important sector in National Economy. To achieve sustainable rural development and to achieve improvement of socio-economic life of the rural populace, three former ministries, ie – Ministry of Agriculture and Irrigation (MoAI), Ministry of Cooperatives (MoCoop), Ministry of Livestock, Fishery and Rural Development (MLFRD), were integrated into one ministry namely Ministry of Agriculture, Livestock and Irrigation (MoALI) on 9th June 2016.

The new democratic government has established twelve economic policies of which two are related to agriculture: Establishing the economic model that balance agriculture and industry, and provides the entire development of the agriculture, livestock and industrial sectors, so as to enable rounded development, food security and progressive export and achieving financial stability through a finance system that can provide the sustainable long-term development of households, farmers and businesses.

Improving agriculture and enhancing productivity through irrigation facilities is one of the key strategies for eradicating poverty and improving the livelihoods of rural communities. The vision of Ministry of Agriculture, Livestock and Irrigation (MoALI) is that; an inclusive, competitive, sustainable agricultural system in which food and nutrition are guaranteed, that contribute to the further development of the national economy. In order to achieve the Agriculture Policy vision, the agricultural development strategy (ADS) promote agricultural sector growth through the three strategic pillars of governance, productivity and competitiveness; while promoting

social and geographic inclusiveness, sustainability and resilience to climate change, transparency, clear public and private sector roles, democratic farmer and private sector organizations, and accessibility to market, information and power infrastructure. The three strategic pillars are based on the concrete foundation of collaborative relationships among government, farmers and enterprises.

The overall effects of the ADS comprise of the five dimensions of (1) increased food and nutrition security; (2) poverty reduction; (3) competitiveness; (4) higher and more equitable incomes of rural households; and (5) strengthened farmers' rights. Moreover, the ADS consists three main objectives to (1) enhance governance and capacity of institutions responsible for agriculture development (2) increase productivity and farmers' incomes; and (3) enhance market linkages and competitiveness.

Government established the guideline for the Union Ministry (MoALI) to draw the agricultural development policies and action plans for agriculture projects. The 20-year (2011-2030) Development Plan in the Agriculture Sector laid down by MoALI is sum up major policies as follow:

(1) Enhancement of Agricultural productivity with high yield and quality seeds production and distribution, utilization of natural inputs for fertilizer,

(2) Enhancement of Technologies and extension services,

(3) Promotion of irrigated farming system through rectify the rain-fed conventional farming to irrigated farming.

(4) Research and Development for prgressive agricultural technologies.

(5) Improving access to market.

The long-term vision for the sub-sector of agricultural productivity is to make a evidential contribution to overall national economic and social development through sustainable growth, income generation and employment creation in the rural sector. Rural poverty eradication objectives would be emphasized through the adaption of new planning and management strategies bases on market oriented, farming system and community/farmer driven approaches in future crop production development strategies.

MoALI elucidate its basic strategy as (1) development of new farmland,(2) supply of enough irrigation water, (3) promotion and support of agriculture mechanization, (4) application of advanced technologies, (5)development and use of new varieties. Agriculture sector is an essential industry, and increasing productivity,

market-oriented economic reform, increasing high value adding and capacity development of techno craft for agriculture sector policy and strategy making are required by means of Public-Private Partnership and poverty eradication.

3.2 Status of Agricultural Productivity

Myanmar is still predominantly an agricultural country. The intense majority of Myanmar's population live in rural areas and much of the nation's wealth is generated there. Most of the country's poor are rural farmers and landless. It is therefore in the rural sector that national economic development and poverty alleviation must find its driving force.

According to the German-watch Global Climate Risk Index, Myanmar is one of the countries worldwide affected most from extreme weather and climate variability event between 1993 and 2012 (Kreft and Eckstein,2014). The most vulnerable areas such as the coast, the river delta zones and the central dry zone are impacted from weather extreme events like cyclone, river floods, storm surges and drought periods.

Climate fluctuation is a major concern for the country since the majority of Myanmar's economy and people's income and well-being are dependent on the right timing and amount of monsoon rains. Myanmar's farmers strongly depend on monsoon participation since they use the water for irrigating rain-fed rice paddies and storing the rain water for the dry season. However, extreme amounts of monsoon rains have the potential to demolish their livelihoods. Immoderate and long-lasting dry periods or extremely low amounts of monsoon rains cause water scarcity and threaten the food security of the country.

Myanmar has possession of favourable soil and water resource and range of tropical, sub-tropical and temperature growing conditions. Therefore these are compromising considerable opportunities for diversification to more remunerative cropping systems, especially in horticulture and tree crops, and from rice to irrigated pulses and oil seeds in some dry zone areas. The estimated amount of 15.5 million hectare of land is cropped annually at an intensity of about 140%. Furthermore, a significant proportion of cultivable waste land about 8.2% million hectare are theoretically available for area expansion would be suitable for conversion to suitable crop production. Government would be verify to let permitting a significant increase in production and rural employment (UNDP, 2014).

Presently, the net sown area is about 12.06 million hectares of which 4.2 million hectares, 34% of the total net sown area, is currently cultivated by small-holder farmers with an average land holding of 1.92 hectares. The fallow land is about 0.46 million hectares and waste land that can be cultivated is about 5.54 million hectares. This can be applied for expansion of agriculture land.

Table 3.1 : Land Utilization in Myanmar 2017-2018

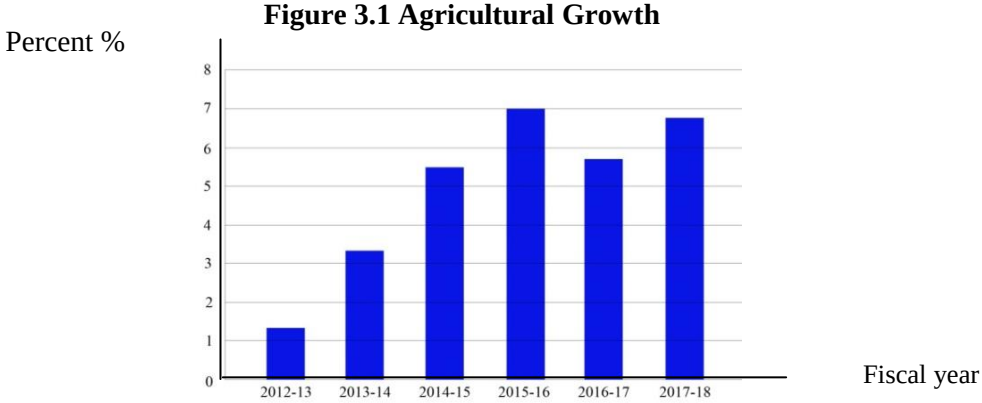
Items	Million Hectare	Percent
Net Sown Area	12.06	17.8
Fallow Land	0.46	0.7
Waste Land that can be cultivated	5.54	8.2
Reserved	18.88	27.9
Other Forests	14.51	21.4
Other	16.21	24.0
Total	67.66	100.0

Source : Myanmar Agriculture Sector in Brief, 2018

The development of agriculture land comprises reclamation of fallow and cultivable waste land, development of farmer's and protection of soil erosion. Land consolidation for productivity through proper drainage, irrigation and farm roads. Apart from the traditional small-scale crop cultivation, development of modernized large scale agriculture farming by the private sector is being encouraged.

Since 2011, Myanmar has pursued policies to encourage agriculture as one of the driving forces of rural growth. The 2015 Rice Sector Development Strategy seeks to promote rice production and productivity, with a focus on quality, export competitiveness, and private public partnerships. These positive reforms have boosted to higher agricultural average annual percentage growth rate (APR), which rose from 1.7 percent in real terms in 2012-2013 to 3.6 percent in 2013-2014 and 5.6 percent in 2014-2015, 7.0 percent in 2015-2016, 5.9 percent in 2016-2017 and 6.7 percent in 2017-2018.

Figure 3.1 Agricultural Growth



Source: DOA (2018)

It is found that agricultural growth has substantially increased year by year from 1.7 percent in 2012-2013 to 7.0 percent in 2015-2016. But the agricultural growth slightly decrease to 5.9 percents in 2016-2017 due to climate variability, flood and drought. It induces to crop failure and water shortage in the central Dry zone.

To increase agricultural productivity, cropping intensity would be altered the use of machinery for land preparation, harvesting and post-harvest activities. The Agricultural Mechanization Department (AMD) provides farm mechanization services for land preparation, transplanting, harvesting, and threshing in paddy cultivation. Thus aim to enhance the farmer's economic and social circumstances, by promoting high quality products and mitigation losses. Establishment of modern-mechanized farms throughout the country enables farmers to boost their productivity by growing two or more crops per year. It enables farmers to quickly achieve increase in crop production as well as per capital income.

Table 3.2: Utilization of Farm Machinery (Number)

Type of Machinery	2015-16	2016-17	2017-18
Tractor	20, 568	28, 143	33, 425
Power Tiller	300, 247	467, 872	487, 546
Harrows and Disc-ploughs	7, 247	13, 319	13, 329
Thresher	61, 997	80, 667	81, 741
Combine Harvester	2, 521	4, 759	6, 158
Transplanter	286	167	272

Source: Myanmar Agriculture Sector in Brief, 2018

Utilization of farm machinery and equipment for various activities of agricultural production has improved in both public and private sectors in attempts to boost the agricultural production. These efforts are being made to concord the lack of farm labour shortage, to replace the traditional way of paddy threshing, to achieve better quality products and to promote productivity by using advanced harvest technology like thresher, combine harvesters and paddy driers.

3.3 Agricultural Production and Influential Factors

The case for additional investment in agriculture, must base on a vision of dynamic, competitive and profitable sector which the value of agricultural output while supporting market and the best possible prices to agricultural producer, in

which the sector has the ability to adapt, change and grow in response to market opportunities and maximize return to the abundant resources, release of hunger and poverty which contributes significantly to national wealth and economic development. Production infrastructure regards irrigation facilities which can supply stable and adequate water for crops, farm roads (polder crest) which facilitate marketing and farm consolidation which can apply potential of agricultural mechanization.

Table 3.3 Production and Export of Pulses

Year	Sown Area (mil ha)	Yield (MT/ha)	Production (mil MT)	Export (mil MT)
2008-2009	4.28	1.23	5.27	1.45
2009-2010	4.38	1.25	5.49	1.23
2010-2011	4.50	1.28	5.79	0.83
2011-2012	4.42	1.23	5.41	1.30
2012-2013	4.45	1.28	5.70	1.48
2013-2014	4.53	1.30	5.90	1.30
2014-2015	4.55	1.32	6.00	1.46
2015-2016	4.66	1.33	6.21	1.19
2016-2017	4.66	1.33	6.19	1.31
2017-2018	4.44	1.27	5.64	1.25

Source: Myanmar Agriculture in Brief, 2018

Cultivation of pulses, with relatively low production cost and enhanced demand from domestic consumption and export, has substantially increased from 0.73 million hectares in 1988-89 to 4.66 million hectares in 2016-2017. But the area and production decreased to 4.44 million hectares and 6.19 to 5.64 million metric tons in 2017-2018 respectively, due to declined demand of export and market price.

The availability of sizable under-utilized land resources is a crucial factor in favor of Myanmar. In particular, the potential availability of six million hectare of land for expanded agricultural production provides a enormous potential for MDGs goal of reducing poverty and food insecurity. Only limited utility is currently made of Myanmar's extensive river basin and aquaculture potentials. The effective

development of these resources, and the greater role of rural communities in their utilization, provide a major potential for pro-poor with agricultural productivity.

A high proportion of rural households are characteristised by a very low resource support with a high vulnerability to production and social risks. Throughout the country mixed farming is executed, with crop and livestock enterprises closely integrated and inter-dependent. Crop production depends on livestock for draft power and farmyard organic manure to maintain soil nutrient levels, while livestock production depends on crop by-products for feed. Despite small farm sizes and a limited resource base, farmers are enterprising by nature, competent managers, and generally well informed of the costs and benefits of production and of internal market process and opportunities. Give appropriate incentives they will react to price change and new market opportunities and drive rapid growth in the sub-sector.

Approach to the development of agro-industrial sub-sector in Myanmar is accordant with market-oriented farming systems and community based approach, continuation locally determined priorities and institutions, and operation to ensuring an appropriate enabling environment, regulations and infrastructure.

It is necessary for effective irrigation system development a number of terms are used including modernization, expansion and intensification. Modernization of systems implies the creation of a water service and delivery system that is capable of irrigating a productive and diversified cropping system as needed. Expansion entails a substantial increase in the number of smallholders with access to irrigated land and irrigation facilities such as canals, wells, small-scale irrigation system and water use efficiencies on the field, schemes and basin level “ more” agricultural output per water input. The absence of adequate irrigation support service capacity must be considered as an important constraint for the poor farmers to take advantage of access to land and water resources and irrigation facilities. If the knowledge and the adoption rate of improved on-farm water management was reinforced the productivity of water in rice could have much exaggerated and food security enhanced.

Improving the efficiency of water use in agriculture also depend on corresponding off-farm improvements with incentives and technology conveyance for on-farm investment in improved soil and water management and improved seeds. Options such as enhanced seeds, low-till, alternate wetting and drying, sustainable

rice intensification, and other exists, but require coordinated improvements in water delivery systems to provide on-demand service, with the use of information technology like soil moisture sensors and satellite evapo-transpiration measurement to improve efficiency and productivity of water in agriculture.

The existing style of water management is a serious confinement to maximization of water-use efficiency. If irrigable water is insufficient, farmers make little or no profit on paddy crops at present and are often disinclined to grow a dry season crop, preferring to leave land fallow. Cropping intensities under irrigation can only increase if farmers are let to respond to market demand and price when deciding on crops to grow. Irrigation efficiency would be improved by upgrading irrigation infrastructure, providing equipment and introducing crops and cropping patterns needing less water.

Policies that govern water supply need to be improved, couple with education of irrigators and water users and pluralistic extension systems; all these are required if the productivity of agriculture through irrigation schemes is to be developed. It is also necessary to increase farming technology dissemination, quality improvement and production increase to be carried out through capacity development of human resources who can develop technologies on crop production in accordance with diversified environment of nation and high value-added products to meet highly-developed market needs.

Land is largely used for paddy production and other land use is uncommon. Crop yield losses occurs even through the effect of salinity. The salt tolerance of a specific crop depends on its ability to draw out water from salinised soils. Salinity affects production in crops, pastures and trees by interfering with nitrogen uptake, reducing growth and quitting plant reproduction. If the level of salts in the soil water is too high, water may flow from the plant roots back into the soil. This results in dehydration of the plant, causing yield decline or even death of the plant. Drainage water of salinity 2 to 2.5 ms/cm can be securely used for irrigation without long term hazardous consequences of crops or soils. It primarily affects the summer crops where as the winter crops are more strongly determined by amount of rainfall and initial level of salinity present in the soil in the autumn of the year. One effective way to reduce water logging and salinity problem is drainage. Water inside polder is actually saline but it becomes fresh again after polder, dike embankments and sluices are rehabilitated.

Aquaculture production in Myanmar has grown in the past decade. Large scale aquaculture production is characterized by low productivity and low diversity. The main focus of the production system is on the dragging, low value commercial species. Commercial aquaculture enterprises could provide employment, food security and extension and inputs that can provide a small scale household oriented aquaculture development. Production systems for fish are overlooked by extensive and semi-intensive ponds, with some marine and cage culture and rice-fish farming. Scale of production varies, but particularly in the Ayeyarwady delta region, large ponds and more commercially oriented enterprises come out to make most significant contribution to fish supply.

The government generates irrigation development a high priority in order to increase crop yields and cropping intensity. This is reflected in the large share of the development budget dedicated to the construction and maintenance of irrigation schemes under current and proposed plans for the agriculture sector.

3.4 Potential Effects of Irrigation Facilities

As agriculture stays pivotal for the overall economic development of the nation, the government has been rendering comprehensive assistance and strong support for its enhancement. The Irrigation and Water Utilization Management Department (IWUMD) has diligently stimulated the State's objectives; constructing new infrastructure, and maintaining and efficiently operating the existing irrigation facilities. In addition, one of the department's main tasks has been to actively secure in water development planning and the furtherance of irrigation for food security.

The IWUMD provides irrigation facilities to fulfill the demand for water and for flood protection using all feasible approaches, drawing upon available local resources and expertise to achieve its agricultural objectives. Main functions of IWUMD is

- To carry out construction of new reservoir projects, including hydro-electricity generation with multipurpose dams, after confirming the feasibility of the projects in accordance with the needs of local development without harming natural resources.
- To perform operation and maintenance of the existing irrigation facilities and irrigation networks for effective and efficient utilization of agricultural water,

also to carry out water resource development and furtherance of irrigation for food security, by rehabilitating dams, weirs, polder embankment, sluice and etc.

- To undertake construction, rehabilitation, operation and maintenance of flood-protection dikes and polders, embankments and tanks to ensure the safety of drinking water and for the greening of areas according to local needs.
- To provide technical assistance for operation and maintenance of village embankment and village irrigation works.
- To conduct, along with other relevant departments, the land consolidation process, to improve water management practices.
- To ensure supply of water by pump irrigation and to extend ground water exploration work to fulfill irrigation and domestic water needs, without negative impact on natural resources.
- To conduct the training of farmers in water user groups for enhancement of irrigation practice to ensure water-use efficiency as well as to educate farmers in use of water-saving technologies, within pump irrigation and ground-water tube well projects.

Performance of irrigated agriculture, which considers irrigation methods or system, must improve in order to have additional food per unit area for ever growing population. Irrigation development has contributed peneratively to national food security; to economic development and to poverty reduction. The two major approaches to performance evaluation regcognize how well service is being delivered and the outcomes of irrigation in terms of efficiency and productivity of resource use. The four factors critical to achieving high levels of accomplishment for any irrigation system are : irrigation timing, depth of application, uniformity and water supply characteristics.

The abundance of land and water resources of Myanmar in combination with the intrinsic favourable climatic condition, offer conductive foundations for the successful development of agriculture. The assurance sufficient irrigable water remains principal for generation growth of the agricultural sector. And with a view to achieve it, capital investment in irrigation facilities has been progressively developed year by year.

Up to end of June 2018, 786 irrigation facilities as shown in Table 3.4, have been completed by the department (IWUMD) across the regions and states of the country, further increasing the total irrigated land areas to 2.14 million hectares, of the

net sown area of 12.06 million hectares. So, the irrigated area is about 16% of the net sown area of the nation.

Table 3.4: Irrigation Facilities completed by the Department, and Area benefited in the States and Regions

Sr. No	States/Region	Irrigation Facilities (Number)		Benefited Area (ha)	
		1988	2018	1988	2018
1.	Kachin	5	10	7,850	12, 925
2.	Kayah	2	35	1,275	22, 102
3.	Kayin	1	20	40	8, 008
4.	Chin	1	1	202	202
5.	Mon	11	21	26,054	40, 579
6.	Rakhine	6	23	2,610	3,325
7.	Shan	7	43	46,468	82, 249
8.	Ayeyarwady	10	102	130,482	194, 665
9.	Bago	48	89	364,415	374, 440
10.	Magway	48	98	160,860	165, 666
11.	Mandalay	55	135	164,678	363, 536
12.	Naypyitaw	-	33	-	65, 877
13.	Sagaing	26	75	152,871	347, 650
14.	Tanintharyi	1	32	Water supply	2, 264
15.	Yangon	19	69	123,187	155, 102
	Total	240	786	1,180,992	1, 838, 590

Source : Myanmar Agriculture Sector in Brief, 2012 & 2018

Out of Myanmar's total geographical area of a 67.66 million hectares, about one fortieth 1.839 million hectares of benefited area remain stable for cultivation by completion of irrigation facilities, where 1.584 million hectares of farmland is serviced by 581 dams and 0.254 million hectares of farmland by 205 river-pumps and tube wells. In addition, 0.302 million hectares of irrigation is supplied by other ways. The total irrigated area is 2.14 million hectares.

Moreover, it also performs flood protection work for farmland and residential areas. About 1.63 million hectares have been defended by construction, rehabilitation, operation and maintenance of embankments, dikes, polders, drainage channels and sluice - gates along the main river systems and deltas.

Probably of greater importance historically than irrigation has been the provision of water control infrastructure to prevent flooding, improve drainage and lessen saltwater intrusion, especially in the fertile Ayeyarwady and Sittaung delta areas. Construction of embankments for flood protection in the Ayeyarwady Delta started in the 1880s. By 2018 nearly 700,000 ha of good cropland was defended by 2000km of embankments and drainage channels including sea dikes in coastal areas to protect the land from saltwater intrusion. These embankments protect nearly 30 percent of the 2.4 million ha of agricultural land in the delta. Some protected areas are irrigated during the summer using the tidal effect. Channels that supply drainage at low tide are used as irrigation canals during high tide, with the direction of flow controlled by sluice gates.

Rising sea levels along the coast are likely to compound saltwater intrusion and soil salinity in the coastal area and river delta. It is necessary that flood defences are improved-raising the height of embankments and strengthening polder dikes, replacing or repairing sluice gates, renovating or construction drains and defending riverbanks for flooding.

The department is implementing land consolidation and mechanized farming system in collaboration and integration with other department of the Ministry, to accelerate agriculture development. Land consolidation has great benefits: providing for effective irrigation networks; proper canal drainage system, easy approach to mechanization of agriculture processes; and easy transport of agricultural inputs and products. It also stimulates active farmer participation.

Irrigation is executed to maintain in different development parameters for agricultural productivity such as:

- To make up for the soil moisture deficit,
- To ensure a proper and sustained growth of crops,
- To make harvest safe,
- To colonize the cultivable waste land for horizontal expansion of cultivation, (Expansion)
- To shift the seasonal cultivation,
- To promote more intensive cultivation by multiple cropping, (Intensification)
- To improve the level of agricultural productivity by acting as an agent for adaption of modern technology, (Modernization)

- To lessen the regional and size-class inequalities in agricultural productivity that will reduce in turn socio-economic imbalances.

The water control and management system in the polder was designed and constructed according to norm relevant for not only agriculture but also aquaculture sector. Aquaculture, fisheries sector supply sustainable maximum quantities of high quality fish and generate direct benefits to rural and urban populations in the form of increased health and prosperity as well as sustainable national income from exports. The fish resources of the lakes and rivers and the adjacent floodplains support livelihoods to millions of people.

Flood protection works such as embankments, dikes, polders and sluice gates, rehabilitation works on drainage systems have been implemented and others are being planned. Polders are very essential for agriculture development and provide protection from salt-water intrusion. Constructed irrigation and drainage systems as part of the polder system furthers a food secure delta.

CHAPTER IV

SURVEY ANALYSIS

This chapter represents case study was conducted on Ayeyarwady delta region with the survey design for primary data analysis and secondary data used to achieve the stated research objectives the potential effect of irrigation facilities; polder embankment, sluice gates and drainage systems on the farmland productivities in Ayeyarwady Delta region, post-Cyclone Nargis, 2008 in order to recommend the agricultural development in future.

4.1 Background Information

The Ayeyarwady Delta region is densely populated, and plays a dominant role in the cultivation of rice in rich alluvial soil as low as just a meter above sea level, although it also includes fishing communities in a vast area full of rivers and streams. It is mainly populated by farming and fishing communities in several villages besides market towns, mostly located along the main rivers.

Polder systems in the Ayeyarwady Delta were firstly initiated by the Lower Myanmar Paddy Land Development Project I (Paddy I) financed by the World Bank in 1975-1985. The Paddy I project areas consisted of one polder in the mid Ayeyarwady Delta, ten polder systems in the southern part of the lower Ayeyarwady Delta to protect flood and tidal intrusion by construction of embankments, sluice gates, drainage excavation and some rehabilitation works. The paddy I project was completed in May 1985 and affects for a total of 185,000 acres (74,900 ha) of farmland, including the reclamation of 65,000 acres (26,305 ha) of abandoned and cultivable wasteland. Additionally, to protect flood and tidal intrusion by construction of embankments, sluice gates, drainage excavation and some rehabilitation works of four polder systems of lower Ayeyarwady Delta were implemented as Lower Myanmar Paddy Land Development Project II (Paddy II) also financed by the World Bank in 1978-1990. This Paddy II polder systems affects for total of 175,000 acres (70,820ha) of farmland, including the reclamation of 50,000 acres (20,235 ha)of abandoned and cultivable wasteland.

In May 2008, Cyclone Nargis struck part of the Ayeyarwady and Yangon Regions, which comprised some of the Paddy I and Paddy II project areas. These polder system had been severely damaged and their renovation has been done by Irrigation and Water Utilization Management Department (IWUMD) with partial support supplied by the Japanese International Cooperation Agency (JICA). Along these activities, not only the renovation of Paddy I and Paddy II project's polder systems but also the construction of new polder systems in the Ayeyarwady Delta has been implemented.

Some polder systems in Myanmar are totally closed by embankments together with sluice gates and drainage channels. The monsoon paddy cultivation in the lower delta is only possible if the land is effectively defended against intrusion of saline water through the construction of polders mainly consisting of embankments, sluice gates and drainage system. In the final stage of the rainy season the slide gates of the sluice placed end points of the drainage canal are closed to store the fresh water in the drainage canals for dry season agriculture (See in appendix 2, Map 4).

The slide gates of the sluice are kept open from mid-May to mid-September and the drainage is operated by the flap gates of the sluice to keep the water level of drainage canals as low as possible. The old river courses are functioning as major drainage channels and small artificial drainage canals are linked as required in the area with embankment. Whereas in the areas surrounded by polder dikes, artificial drainage canals are prevailing.

4.2 Profile of Targeted Townships

The huge cyclone named "Nargis" damage about 738,000 hectares of paddy fields, wiped out 85 percent of stored seed and killed over 50 percent of draught animals, over 44 percent of small boats, 70 percent of fishing gears and 15000 hectares of aquaculture ponds through salt water intrusion and flooding and also seriously affecting the lining conditions in the polders of the Ayeyarwady Delta, the major rice producing areas in Myanmar (FAO, 2009). The preservation of farming area for urgent rehabilitation of agricultural production and rural life in the project area covers 34 polder embankment. The total paddy field area is 164,347 ha (406,109 acres) and 18,000 ha (44,478 acres) of aquaculture ponds protected by the total length of polder dike is 942 km. Population in the area is estimated at 248,001 and average population per polder is estimated at 7,300 people.

Table 4.1 Benefited Area and Dike/Drainage Length of 34 Polders

Township	No. of Polder	Length of Dike (km)	No. of sluice	Length of Drainage (km)	Benefited Area		House hold	Population
					(ha)	(acre)		
Ngaputaw	4	92.0	11	100.6	9596	23711	3726	14654
Labutta	10	290.8	34	385.3	38162	94300	11213	47835
Bogalay	4	181.9	14	185.5	28311	69957	8993	41355
Phyapon	7	243.1	25	264.3	48578	120038	12048	57419
Daydaye	6	71.7	0	69.2	17746	43851	7085	29253
Kyaiklatt	3	62.9	0	103.6	24124	59612	12355	57485
Total	**34**	**942.4**	**84**	**1108.5**	**164347**	**406109**	**55375**	**248001**

***Source*:** (1) Survey KII (from October 2018 to April 2019), GAD 2018
(2) List of Drainage channel in Ayeyarwady Delta, IWUMD, 2018.

The rehabilitation and construction polder systems (34 polders embankments) project area is located in six townships and conditions in these townships are distinguished as follows. Polder area is not exactly matching with administrative boundary of township and village-tract (VT). Therefore, some polders stretch over plural VTs.

(1) Ngaputaw Township

The most of the land is cultivated with rainfed paddy and surplus production of paddy crop sufficiency is about 247%. Alternative crops are pulses, oil seed nuts and vegetables. Some vegetables are cultivated for household consumption and surplus as other source of income. During agricultural off-season, many farmers work in the fishery sector. Aquaculture, breeding of fresh water fish and shrimp farming is growing. In addition to rice farming, aquaculture, poultry and pig farms are being operated. Base on survey results, the benefited area of farmland affected by polder systems are as shown in Table 4.2.

Table 4.2 Benefited Area and Dike/Drainage Length of Polders in NgaputawTownship

	Name of Polder	Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		Household	Population
					(ha)	(acre)		
1	Alegyum (1)	21.6	3	26.7	1,669	4,125	1,019	3,947
2	Alegyum (2)	36.5	4	41.9	3,607	8,912	1,515	6,139
3	Alegyum (3)**	28.4	4	32.0	3,770	9,317	813	2,967
4	Madaukkan	5.5	-	-	550	1,357	379	1,601
	Total	**92.0**	**11**	**100.6**	**9,596**	**23,711**	**3,726**	**14,654**

Source: (1) Survey KII (from October 2018 to April 2019), and GAD, 2018
(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD,2018.

Remark: ** Rehabilitation work of Paddy II Project (W.B)

(2) Labutta Township

Farming, especially rice production is the most important livelihood in the northern part of this township. The surplus production of paddy crop sufficiency is about 379.71%. Residents residing in the coastal areas are pursued in the fishery sector. This township is not able for salt production and that some salt farms are also available. Other activities are small livestock/poultry rearing, transport, retail trade, cottage industry and so on. It has high percentage of landless people. The construction of polders, sluice gates, drainage system and some rehabilitation work for total 94,300 acres (38,162 ha) of farmland are as shown in Table 4.3.

Table 4.3 Benefited Area and Dike/Drainage length of Polders in Labutta Township

Name of Polder		Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		Household	Population
					(ha)	(acre)		
1	Thingangyi	10.4	2	-	860	2,124	155	474
2	Zinywe	9.7	-	-	376	929	159	633
3	Leikkwin	6.0	-	-	737	1,822	98	392
4	Labutta (South)	32.5	3	32.7	4,779	11,809	1,051	4,166
5	Labutta ** (North)	61.3	10	92.4	10,855	26,823	3,662	15,547
6	U GaungPu	8.4	3	-	536	1,325	50	205
7	Bitud Island (1)	22.6	2	23.6	2,471	6,105	332	1,191
8	Bitud Island (2)	29.2	4	60.5	3,543	8,756	1,777	7,315
9	Bitud Island (3)*	45.4	4	46.5	3,795	9,378	968	3,743
10	Bitud Island (4)*	65.3	6	129.6	10,210	25,229	2,961	14,169
	Total	**290.8**	**34**	**385.3**	**38,162**	**94,300**	**11,213**	**47,835**

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD

Remark: (1) * Rehabilitation work of Paddy I Project (W.B)

(2) ** Rehabilitation work of Paddy II Project (W.B)

(3) Bogalay Township

Only a few people posses most of the lands as 68% posses more than 10 acres in spite of high percentage of landless people. Main crop is paddy in the agricultural area. In addition, 37% of people work in fishery sector and 80% of households raise livestock. According to survey KII and GAD, the surplus production of paddy crop sufficiency in about 385.96% and the benefited area of farmland affected by polders construction are as shown in Table 4.4.

Table 4.4 Benefited Area and Dike/Drainage length of Polders in Bogalay Township

Name of Polder		Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		House-hold	Population
					(ha)	(acre)		
1	Daungyi*	59.6	6	83.1	11,070	27,354	2,944	15,935
2	Daungyi (East)	54.6	3	44.1	8,892	21,972	1,406	8,433
3	Daungyi (West)**	50.8	4	51.3	6,972	17,228	4,004	12,921
4	Daungyi (Upper)	16.9	1	7.0	1,377	3,403	639	4,066
	Total	**181.9**	**14**	**185.5**	**28,311**	**69,957**	**8,993**	**41,355**

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD

Remark: (1) * Rehabilitation work of Paddy I Project (W.B)

(2) ** Rehabilitation work of Paddy II Project (W.B)

(4) Phyapon Township

In this area, main income sources are agriculture, fisheries, small livestock rearing (pig, duck and chicken), causal labors and commerce. More than one third of total area, especially southern part of the township is spreaded over mangrove vegetation. Villages and agricultural lands are concentrated in the upper part of the township. According to survey KII and GAD, the surplus production of paddy crop sufficiency is about 351.8% and the benefited area of farmland affected by polder construction are as shown in Table 4.5.

Table 4.5 Benefited Area and Dike/Drainage length of Polders in Phyapon Township

Name of Polder		Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		Household	Population
					(ha)	(acre)		
1	DawNyein*	21.1	1	225.	1,746	4,315	1,295	5,850
2	Myokone*	25.5	1	27.4	2,490	6,152	962	4,019
3	Kyetphamwezaung*	72.3	7	106.6	27,835	68,782	5,044	25,687
4	Bambwezu*	40.2	7	53.1	7,372	18,216	2,173	9,604
5	Daydalu*	20.3	1	11.3	1,732	4,279	859	4,072
6	Latpanbin*	31.1	4	22.5	4,576	11,307	840	4,195
7	Zinbaung*	32.6	4	20.9	2,826	6,984	875	3,992
	Total	**243.1**	**25**	**264.3**	**48,577**	**120,038**	**12,048**	**57,419**

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD

Remark: * Rehabilitation work of Paddy I Project (W.B)

(5) Daydaye Township

Local residents engage traditional agriculture, fishery, trading and salt refining in Daydaye Township. Casual labors generally work in agricultural sector. The polder system are not closed as they are not specified to protect flooding of tidal and salt-water intrusion into the land and construction work for total of 43,851 acres (17,746 ha) of farmland as shown in Table 4.6. Based on survey results and GAD, the surplus production of paddy crop sufficiency is about 418.55%.

Table 4.6 Benefited Area and Dike/Drainage length of Polders in Daydaye Township

Name of Polder		Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		House-hold	Population
					(ha)	(acre)		
1	Myaseinkan	21.7	-	-	4,274	10,562	2,335	9,866
2	Thandi	6.8	-	69.2	1,682	4,156	372	1,651
3	Suclubbaluma	11.9	-	-	3,171	7,835	1,225	4,932
4	Hleseikchaungyi	11.9	-	-	1,266	3,128	492	2,026
5	Tamatakaw	11.3	-	-	6,417	15,857	2,589	10,459
6	Kyonsoat	8.1	-	-	936	2,313	72	316
	Total	**71.7**	**0**	**69.2**	**17,746**	**43,851**	**7,085**	**29,253**

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD

(5) Kyaiklatt Township

Main stream of the Ayeyarwady River crosswises the township north and south. Most of people make a living by farming rice and some vegetables. Moreover, other crops cultivated are coconut, betel-nut and banana. The residents of the area also employed livestock rearing (pig and duck), causal labor and commerce. According to survey result and GAD, the surplus production of paddy crop sufficiency is about 520.05% and the benefited area of farmland are as shown in Table 4.7.

Table 4.7 Benefited Area and Dike/Drainage length of Polders in Kyaiklatt Township

Name of Polder		Length of Dike (km)	No of sluice	Length of Drainage (km)	Benefited Area		Household	Population
					(ha)	(acre)		
1	Maubin Island (North)	20.0	-	32.6	10,990	27,158	5,764	27,386
2	Maubin Island (South)	7.1	-	31.5	4,085	10,094	1,990	9,248
3	Thonegwakyun**	35.8	-	39.5	8,644	21,360	4,601	20,851
	Total	**62.9**	**0**	**103.6**	**23,719**	**58,612**	**12,355**	**57,485**

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

(2) List of Drainage Channel in Ayeyarwady Delta Region, IWUMD

Remark: ** Rehabilitation work of Paddy II Project (W.B)

4.3 Survey Design

In this study, it is mainly based on quantitative descriptive method and consistent use of qualitative information which is needed to understand what the key informant representatives of the local community think about agriculture productivity by effect of polder embankments.

Primary data consist of information collected through household survey of the villages with help of questionnaire and qualitative survey of community-level key informant interview (KII) representatives of stakeholder on focus areas. Secondary data were collected from Irrigation and Water Utilization Management (IWUMD), Department of Agriculture (DOA), Department of Fisheries (DOF), General Administrative Department (GAD), Country report of Myanmar and FAO, JICA technical papers and reports, especially concern with agriculture and irrigation sectors.

By adopting the selection of one village in each polder assessed by simple random sampling method, the cluster sampling of agriculture and aquaculture (including non-farm household) to facilitate the estimation of the farmland productivity for the potential of agriculture and aquaculture development , it was two research instruments were used: the first one is in-depth interview with a wide range cross-section of community and responsible persons of concerned departments from Ayeyarwady delta region and the second one is household survey within the 34 panel villages. Table 4.8 shows the numbers of sample household by selected townships such as numbers of polder, sample village, Household, Land Area (acre), Sample Landowner(acre), Average Landowner size (acre), Average Land plot size (acre). For this survey, Numbers of Sample Household is 658.

Firstly, the key informant interview is conducted situation and difficulties of agricultural productivity and the effects of irrigation facilities. The informant had information on and to follow interesting lines of inquiry and free to amend and adapt these as necessary. A total of 50 key informant interviews were conducted at township and village-tract level of administration, village elders and others who were involved in aid decisions in the village community-based organization, market actors and responsible persons of concerned departments. Key informant interview at the village tract and township centers gathered more significant understanding of agricultural productivity effects on irrigation facilities, vulnerabilities, resilience and specifically

how they impact decisions and actions among households, government institutions and market actors.

Table 4.8 Numbers of sample household by selected townships

Particular		Total	Sample Household of Township					
			Ngaputaw	Labutta	Bogalay	Phyapon	Daydaye	Kyaiklatt
No of polder		34	4	10	4	7	6	3
No of sample village		34	4	10	4	7	6	3
No of Household		55,375	3,726	11,213	8,993	12,048	7,085	12,355
Land Area (acre)		406,109	23,711	94,300	65,597	120,038	43,851	58,612
Sample Landowner (acre)		18,401	1,240	4,125	2,785	3,865	2,234	4,152
Average Landowner size (acre)		22	19	53	25	31	20	14
Average Land plot size (acre)		1.9	1.6	1.8	1.7	2.3	1.9	2.1
No. of Sample House-hold	Land-owner Farmer	246	18	45	40	55	32	56
	Tenant Farmer	44	4	10	8	10	8	4
	Landless Farmer	234	24	60	37	38	32	43
	Non-Farm	49	4	10	8	12	10	5
	Fisher	85	10	26	10	20	12	7
	Total	658	60	151	103	135	94	115

Source: (1) Survey KII (from October 2018 to April 2019),and GAD, 2018

Remark: KII with Administration, Community-based-organization and market actors.

Secondly, household survey with the help of questionnaire were grasped with different livelihood which were categorized with farmers, fishers, laborers, small business owners (processors), women (particularly female head of households), members of local groups, youth and other vulnerable groups classified by local GADs within the 34 sample villages. Respondents from a total of 658 households, representing a population of 55,375 households were conducted so as to gain the orientations on agricultural productivity through potential effects of irrigation facilities polder systems.

These sample households of six townships from Ayeyarwady Delta were selected according to (i) different farming systems; (ii) diversity of livelihoods (eg. Different dealings between farmers and landless or farmers and fishers), (iii)

representing salinity zones (freshwater/ brackish/saline) in order to cover resource use systems such as various cropping and resource use patterns. Based on these data, about 15 to 35 households for one village from each polder (total 34 villages from 6 townships), were selected for the qualitative investigation with the using proportional cluster sampling with assistance of GAD. The main proportional cluster sampling classified into the categories such as farmers and landless, fishers playing a minor role in terms of small number. The selected sample villages were based on the raw data, which covered different livelihood activities. Household survey, mainly for landless and farmers, were conveyed in each selected village. Each village survey was composed of 15 - 35 respondents with farm holder, tenant, fisher and landless.

In each agriculture clusters about 4 ~ 18 landowner farming households and about5 ~ 15 landless farmer households were selected for each village household survey. Landowner farming households diversified with farming activities relevant to seasonal crops, plantation, livestock, poultry farming and aquaculture. Landless farmer household generally work in traditional agriculture, fishery, trading, livestock and other casual labor. Households operation of crop farms and tenure status of small holder farm size (1~5 acres), medium scale farming (5-10 acres) and large scale (10 acre and above) were selected with 100% probability, to ensure a sufficient sample to support statistically valid analysis. The analysis data was contained on profitability, expansion of farmland (extensive), promotion of yield per unit area (intensive), increase of cropping intensity, rehabilitation to land improvement (soil quality), diversification and integration to agricultural development.

In each aquaculture cluster, 2 ~ 3fish farming (aqua-farm) households and1 ~ 2 non-fish farming households who are making fish preserved products or goods and services from off-farm were selected to answer the survey questionnaire. Households operating fish farm possess over three times vaster land on average than crop farming households. Fish farming households which operate pond size from five acres to twenty acres and above were selected with 100% probability, to ensure a sufficient sample of large farms to provide statistically valid analysis. The analysis data was included on harvesting and marketing, trends in production.

Sampling criteria at the township scale was determined in terms of agro-ecology and socio-economic for agricultural productivity through irrigation facilities, namely polder embankment, drainage and sluice.

(i) Agro-Ecological Sampling Criteria:

Freshwater zone - Sufficiently away from the coast for two growing seasons and more consistent access to fresh surface water for irrigation. Production is more vulnerable to riverine floods.

Brackish, or mixed zone - Further inland, a second rice growing season is possible for some of the land. Production is vulnerable to extreme weather events.

Saltwater zone - Due to coastal proximity, rice can only be grown one time per year. Production is vulnerable to sea-level rise and salt-water intrusion.

Table 4.9 Polders in townships by Agro-Ecological Zone

Townships	Name of Polder by Agro-Ecological Zone		
	Fresh Water	Brackish Water	Salt Water
Ngaputaw	-	-	Alegyun (1) Alegyun (2) Alegyun (3) Madaukkan
Labutta	Bitud Island (2) Bitud Island (3)	Leikkwin Labutta (North) Labutta (South) Bitud Island (1)	Thingangyi Zinywe U Gaungpu Bitud Island (4)
Bogalay	-	-	Daungyi Daungyi (East) Daungyi (West) Daungyi (Upper)
Phyapon	Kyetphamwezalung Banbwezu	Daydalu Latpanbin Zinbaung	DawNyein Myokone
Daydaye		Thandi Suclubaluma Hleseikchaun-ggyi Tamatakaw	Myaseinkan Kyonsoat
Kyaiklatt	Maubin Island (North) Maubin Island (South) Thonegwakyun	-	-

Source: Survey KII (from October 2018 to April 2019),and IWUMD (2018)

Freshwater contains less than 1 % salt by some definitions. Brackish water contains less than 3% salt where fresh and saltwater are mixed. And saltwater

contains more than 3% salt. Salinization of agricultural lands is particularly distributed in arid and semiarid environments where crop production demand irrigation schemes.

Farming system are diversified with paddy production predominating during the monsoon while other crops are produced during the cool (winter) season and dry(summer) season for major crops such as rice, pulses and maize. Crop cultivated across all season and percentage practicing farmers in agro-ecologic zone are as shown in Table 4.10.

Table 4.10 Seasonal Cropping Pattern in Agro-Ecologic Zone

Particular		Agro-Ecologic Zone		
		Fresh Water	Brackish Water	Salt Water
Monsoon Season	Mainly rice	38%	49%	97%
	Rice or Pulses	41%	48%	3%
	3 or More Crops	21%	3%	-
	Sub Total	100%	100%	100%
Off-season	Summer Paddy and Winter Crops	89%	48%	32 %~ 68% (depend on available water)
Total Cropping Intensity		189%	148%	97% ~ 168%

Source: Own Survey KII (from October 2018 to April 2019) and DOA (2018)

According to this table, Seasonal Cropping Pattern in Agro-Ecologic Zone is seen by percentage practicing farmers across all season. It describes cropping pattern with the productivity of rice in three zones in percentage: fresh water zone, brackish water zone and salt water zone.

In Salt Water Zone, during the high intensity of rainfall, salty water intervention and the salinity (Electric conductivity) of soil are extracted by rain water from salinity affects by leaching. Thus monsoon rice can be cultivated as in (97%) including with rice or pulses and others crops as in (3%). Otherwise depending on availability of water, pulses and oil seeds of winter crops including summer paddy can be 32 % ~ 68% during off-season in salt water zone.

In Brackish water zone, rice is not mainly cultivation because in which 49% is for only rice, rice or pulses is the second percentage (48 %) and so total cultivation is

(100%) including just 3% is for 3 or more crops . Moreover during off-season,48% of area can be cultivated for pulses and oil seeds of winter crops in brackish water zone.

In Fresh Water Zone, all kind of cropping patterns are the best productivity in monsoon such as 38% for mainly rice, 41 % for rice or pulses and 21% for 3 or more crops. Also 89% of area can be cultivated in off-season. It means that cropping intensity is varied in agro-ecological zone such as farming system with crop production normally in fresh water zone- 100 % productivity during the monsoon and 89 % in off-season so that total area for crop production is 189%, whereas in brackish water zone - 100 % productivity during the monsoon and 48 % in off-season so that total area for crop production is 148%. And in salt water zone - 100 % productivity can be seen during the monsoon but 32 % ~ 68% of farm land productivity can be seen in off-season only as it depends on available of water so that total area for crop production is from 132% to 168% in this zone and unless enough water can provide, cropping area will be 97 % in salt water zone.

Average cropping pattern are during monsoon was higher than other season due to rain and irrigation water availability. The crop during the monsoon season is mainly paddy. For the post-monsoon (winter/summer) season, some farmers show summer paddy while others grow pulses and oilseed crops as shown in Table 4.10.

(i) Socio-Economic Sampling Criteria:

Crop farming household - The primary livelihood strategies are rice production combined with small-scale livestock production,

Landless households - The primary livelihood strategies comprise daily unskilled labour (including through migration), fishing, and small-scale livestock production.

Both the economic and agricultural portions of the questionnaire were given to heads of household, male or female, or the oldest present male. To determine household welfare, asset ownership has been ascertained to be a better predictor than estimated income. The agricultural questionnaire comprises average landholdings, income spent on livestock, irrigation, pest management, seed and fertile use, and a variety of conservation practices which many studies have focused on independently.

Data were entered into a Microsoft Excel spread sheet and then imported into the Statistical Package for Social Science (SPSS) version17.0. Descriptive statistics were computed for all quantitative and most qualitative variable.

4.4 Resilience and Achievement

After cyclone Nargis, emergency reparation works for all damaged polder dikes have been implemented to recover the original height of the embankment by IWUMD. It is evaluated from the field inspection that the crest elevation of polder dikes had already lowered considerably by about 0.6 ~ 0.9m (3.0 ~ 4.0ft) on the average before the cyclone Nargis, from their original heights when constructed by Lower Myanmar Paddy Land Development Project, Phase I and II in 1980's, due to settlement of embankment, erosion by rainfall, wind-drift and others. Under these conditions, high tides and high waves of the river caused by the Nargis had overflowed the polder dikes and sluice gated caused a great deal of damage to the inside of the polder. In addition, up to 40% of the ponds have revolved saline or turbid due to flooding by the cyclone. However, these sanitation facilities are now completed or under rehabilitation and people are expecting to get water from safe water source.

It is, however, considered that the crest elevations are not safe enough, because at the original design and construction in the early 1980's, the heights of embankment are designed to defend a flood of 20 years recurrence period only. Intrusion of saline water appeared several times in the past causing considerable damages to the farming of the empoldered area. It seems that and an occurrence similar to Nargis will greatly affect the delta area again and so as to safeguard with new JICA design strengthening height and width of polder dikes, (See in appendix 2).

In severe period after Nargis, 2008, non-rehabilitation of damage and leakage on most of sluice gates, salt concentration of water in the drainage are saved high due to saline water intrusion through damaged sluice, making difficult to better the preservation farming activities in the served areas. In addition, inundation on farm occurs due to poor drainage caused by irrepressible sluice gate and astronomical tide through wet/dry season. At the sluice facilities, leakage is kept through flap gates as well as slide gates. Function of gates has been appraised by evaluating the difference in water level (WL) and salinity or electric conductivity (EC) of soil between both sides of flap and slide gate. Salinity is a negative factor for cultivating agricultural crop that affects seriously crop production. The rehabilitation project developed contains the reclaiming of farmland for the construction of polder dikes, sluice gates and drains for controlling water flow between the land and rivers.

The outcome results of the soil salinity test before and after rehabilitation of polder dikes, sluices and drainage are given in Table 4.11, 4.12, 4.13. Polders are categorized according to the secondary data value of the EC (e).

Table 4.11 Salinity (Electric Conductivity) of soil in Fresh water zone

Township	Polder	Sample Village	EC(e) Value (ms/cm)			Rank
			2008	2010	2018	
Labutta	Bitud Island (2)	Ley-ein-tan	11.64	2.94	2.78	A
	Bitud Island (3)	Kabarkwin	12.15	2.82	2.75	A
Phyapon	Kyetphamwezaung	Okkapar	9.52	3.45	2.95	A
	Banbwezu	Kow-ein-tan	8.61	2.65	2.55	A
Kyaiklatt	Maubin Island (North)	Hlaingtar	4.65	1.54	1.50	A
	Maubin Island (North)	Tharyawel	8.36	3.02	2.95	A
	Thonegwakyun	Tamatpyay	7.24	2.39	2.19	A

Source: Water Quality and Soil Quality Survey (IWUMD), 2008, 2010, 2018 Data

Based on the pattern of distribution of rainfall which usually starts mid-May, the required period of rainfall is roughly approximated as follows;

Rank A has no special restriction for growing paddy from the salinity point.

Rank B requires leaching by flooding with rain water in the plots about one month duration with frequent drainage.

Rank C requires leaching by flooding with rain water in the plots about one and half months duration with frequent drainage.

Rank D is special case and the data has lack of creditability. If this data is sure, more than two months duration of leaching would be essential.

Table 4.12 Salinity (Electric conductivity) of Soil in Brackish water zone

Township	Polder	Sample Village	EC(e) Value (ms/cm)			Rank
			2008	2010	2018	
Labutta	Leikkwin	Leikkwin	12.56	5.01	3.28	B
	Labutta (North)	Daminchaunglay	16.25	3.27	3.10	B
	Labutta (South)	Kyarkan	15.33	3.42	3.30	B
	Bitud Island (1)	Zeebyu	12.21	3.80	3.51	B
Phyapon	Daydalu	Ngoat ta htaung	9.32	4.57	3.53	B
	Latpanbin	Latpanbin	8.55	3.99	3.61	B
	Zinbaung	Tinpalwair	9.12	3.42	3.20	B
Daydaye	Thandi	Baygyi	10.35	3.39	3.15	B
	Suclubaluma	Hnarkhaungchaung	9.33	4.80	3.63	B
	Hleseikchaunggyi	Lay	9.75	3.52	3.21	B
	Tamatakaw	Toe	10.23	4.52	3.55	B

Source: Water Quality and Soil Quality Survey (IWUMD), 2008, 2010, 2018 Data

Table 4.13 Salinity (Electric conductivity) of Soil in Salt water zone

Township	Polder	Sample Village	EC(e) Value (ms/cm)			Rank
			2008	2010	2018	
Ngaputaw	Alegyun (1)	Hponyokone	18.35	9.49	3.42	B
	Alegyun (2)	Hpobagankone	22.18	10.36	5.04	B
	Alegyun (3)	Ingaday	22.46	10.87	4.92	B
	Madaukkan	Madaukkan	30.51	18.69	6.70	B
Labutta	Thingangyi	Nalinkyaw	32.25	22.34	8.45	B
	Zinywe	Koebo	32.46	22.46	6.15	B
	U Gaungpu	Kangyidaunt	29.84	14.27	4.91	B
	Bitud Island (4)	Leik-i	15.28	4.01	3.53	B
Bogalay	Daungyi	Daungyi	11.28	3.28	3.15	B
	Daungyi (East)	Hpoe-nyo	13.16	4.92	4.05	B
	Daungyi (West)	PaungPe	15.78	6.70	4.53	B
	Daungyi (Upper)	Kamarkula	16.84	8.40	4.61	B
Phyapon	DawNyein	DawNyein	45.65	42.88	10.34	C
	Myokone	Hpa-yar-kone	18.24	11.86	6.32	B
Daydaye	Myaseinkan	Akeichaungwa	22.65	12.46	7.82	B
	Kyonsoat	Kawet	18.67	10.64	6.21	B

Source: Water Quality and Soil Quality Survey (IWUMD), 2008, 2010, 2018 Data

The project area is raised with affluent rainfall in monsoon season. Therefore, before transplanting paddy in the beginning of wet season, it is practically possible to hold off one or two months until the paddy fields are leached by flooding of the rain water. It is the most applicable method for reducing the salinity of the soil.

According to FAO Field Guide states the leaching water requirement for the each salinity level and yield loss are as follows Table 4.14.

Table 4.14 EC (e) Value and yield loss, rain water requirement

Rank	Initial EC (e) Value (mm/cm)	Yield loss (%)	Rain Water Requirement(mm)	No of Polders		
				2008	2010	2018
A	Less than 3	5	Non	-	6	8
B	3 < EC (e) < 4	10	200	-	9	13
B	4< EC (e) < 6	20	300	-	6	6
B	6< EC (e) < 10	20~50	315	10	3	6
C	10< EC (e) < 15	more than 50	430	8	6	-
C	15< EC (e) < 20	more than 50	540	8	1	1
C	20< EC (e) < 25	more than 50	650	3	2	-
D	Greater than 25	more than 50	900	5	1	-
	Total			34	34	34

***Source*:** FAO Field Guide and Soil test Survey Result

For the claim and suggestion about farming conditions by townships in 2009, 2014 and 2018 are shown in the following Table 4.15 and it is found that progressing change of farming conditions from poor to fair and fair to good exist.

Table 4.15 Farming Conditions by Townships, in 2009, 2014 and 2018

Townships	Respondents	Farming Condition (2009)			Farming Condition (2014)			Farming Condition (2018)		
		Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
Ngaputaw	(18+4+24)	-	14	32	4	20	22	14	22	10
Labutta	(45+10+60)	-	35	80	15	60	40	35	65	15
Bogalay	(40+8+37)	-	28	57	18	50	17	22	51	12
Phyapon	(55+10+38)	3	35	65	23	45	35	35	48	20
Daydaye	(32+8+32)	2	22	48	12	33	18	18	35	19
Kyaiklatt	(56+4+43)	7	37	59	19	54	29	29	58	16
Total	(296+44+234)	12	171	341	91	262	153	153	279	92

Source : Survey data, 2019

The primary crop across the delta region is paddy rice, grown across one or two harvest cycles each year depending on the location and on the farmers. Farming conditions are defined as:

Good; ability to cultivate both summer and monsoon paddy, alternative summer crops, access to improved seeds and a high proportion of paddy land without flood risk either due to location of polders embankments,

Fair; good approach to water for irrigation, access to improved seeds, ability to invest in farming inputs, and a medium proportion of paddy land that was not flooded,

Poor; experiencing too much rainfall resulting in lots of fallow land due to flooding, lack of any embankments, and high accident of univalve and other pests damaging crops.

4.5 Effectiveness of Polder Embankment and Agriculture Productivity

4.5-1 Soil improvement and boost cropping yield

The key informant interview is conducted with responsible persons of IWUMD, DOA and GAD of Ayeyarwady delta region. **The main questions are related matters such as benefits or assistance to the community from polder rehabilitation project ; the views of community because of our agricultural system benefits from subsidies, such as irrigated water, soil quality improvement, quality seeds, fertilizer, pest protection** and so on (See in Appendix 1). Their response are interpreted as follows:

Based on survey result, the potential effect of the polder dike embankment and sluice rehabilitation or construction, reduce the electric conductivity EC (e) values, and improve soil quality and consequently promote the yield per unit area.

Table 4.16 Average EC values and Cropping Yield in 34 Polders

Township	Avg. EC values			Monsoon Paddy yield (basket/acre)			Summer Paddy yield (basket/acre)		
	2008	2010	2018	2008	2010	2018	2008	2010	2018
Ngaputaw	25	12	5	15	25	69	30	50	92
Labutta	25	10	4	22	30	61	30	60	99
Bogalay	15	6	4	28	35	67	35	65	97
Phyapon	15	6	3	30	38	71	35	68	94
Daydaye	15	6	3	32	35	58	40	70	99
Kyaiklatt	7	3	2	35	55	62	45	85	106

Source: (1) Average EC value from IWUMD data

(2) Average Paddy yield per acre from field survey and GAD data

According to the secondary data from (IWUMD), and field survey data and GAD data Table 4.16 shows Avg. EC values, Monsoon Paddy yield (basket/acre) and Summer Paddy yield (basket/acre), in which, duration of time series are 2008, 2010 and 2018. From this Table, it can be seen that, in the three conditions of Avg. EC values in 2008 (the severe period after Nargis), in 2010 (the period after Polder Rehabilitation), and in 2018 (the period after Polder Rehabilitation& sluice gates, drainage excavation), average cropping yield of paddy (monsoon paddy and summer-paddy) are increased year by year because of decreased in Avg. EC values and construction work of polder embankment including sluice and drainage system. The data shown in table are from the result of questionnaire with household survey and informant interview with the persons from IWUMD, DOA& GAD, region/district/ townships. During survey question, indirect questions or similar questions are used in interview and questions which are mostly related with the context of questionnaire format. Such kind of data and the work together with survey and KII are interpreted as the result in table.

Cropping yield of paddy in Ayeyarwady Region is still degraded. According to Agricultural Census 1985-86 to 1995-96 average cropping yield of paddy (monsoon paddy, 30~40 baskets/acre and summer-paddy 80~90 baskets/acre in Ayeyarwady Delta region) is 63 baskets/acre. In flow of saline water into paddy field by Nargis aggress decreased agricultural production to minimum 10~20 baskets/acre.

However, after rehabilitation or construction work of polder embankment including sluice and drainage system, cropping yield has restored with 40~50 baskets/acre in 2009-11 wet season and gradually increase. Based on the consequence of household survey in selected sample villages in 34 polders, cropping yield of 2008 monsoon (wet) season was drastically decreased due to the soil salinity of Nargis effect and has restored with support by rehabilitation and construction work of polder embankment as shown in Table 4.16.

Productivity of summer paddy is high due to proper high temperature (25°~35°C) and longer sunshine hours which enhances photosynthesis of the plants. In the low land delta region, saltwater intrudes into the paddy field in November. It affects and reduces paddy productivity.

Table 4.17 Average Cropping yield (basket/acre) by Agro-ecological zone (2018)

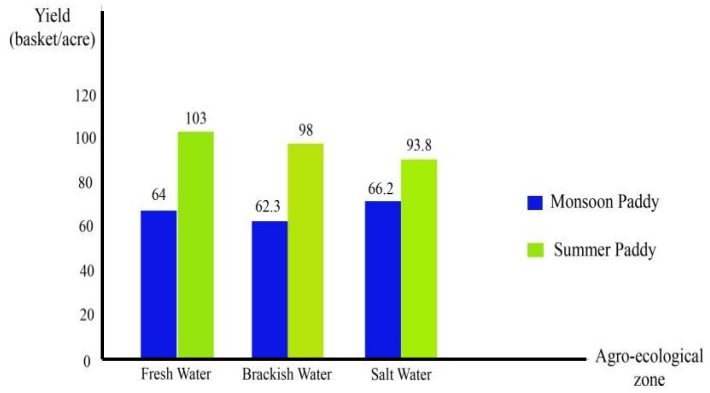
Township	Fresh water		Brackish water		Salt water		Average Yield	
	Monsoon	Summer	Monsoon	Summer	Monsoon	Summer	Monsoon	Summer
Ngaputaw	-	-	-	-	69	92	69	92
Labutta	61	102	59	100	63	95	61	99
Bogalay	-	-	-	-	67	97	67	97
Phyapon	69	101	71	93	73	88	71	94
Daydaye	-	-	57	101	59	97	58	99
Kyaiklatt	62	106	-	-	-	-	62	106
Average Yield	**64**	**103**	**62.3**	**98**	**66.2**	**93.8**	**64.6**	**97.83**

Source: Own Survey and GAD Data

From this table, average paddy yield in monsoon is the highest productivity in Salt Water Zone (the highest figures is 66.2)among the three zones of Agro-ecological zone. In summer paddy yield results are shown that the average yield 103 is the maximum productivity in fresh water zone. The results in table are from working together with survey& KII. According to survey results, it is found that monsoon paddy yield in the salt water is higher than those achieved in other two and summer paddy yield in the fresh water is higher than those achieved in other two, as shown in Figure 4.1. However the summer paddy yield in Brackish water is in moderate stage which is slightly higher than those in salt water and slightly lower than those in fresh water zone. All irrigation water contains some salts which may remain on the soil surface or on leaves of plants after evaporation. Salts are more likely to be leached from the soil in high rain fall, monsoon season and therefore high quality irrigation

water with low levels of salts will have a greater effect on the soil and yield.

Figure 4.1 Average cropping yield comparison



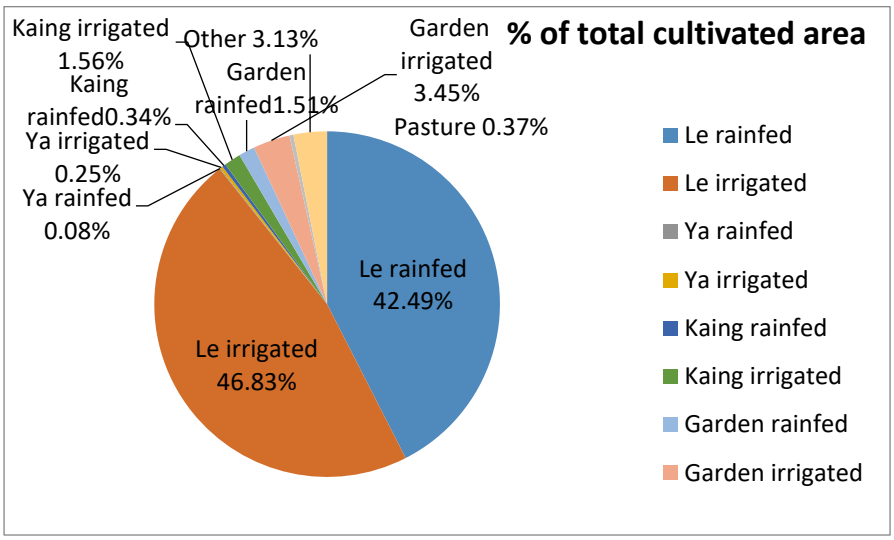
Source: Own Survey and KII (from October 2018 to April 2019)

Reposing to improved farming techniques, and better paddy strain, yield per hectare increased in the study area. Comparatively the yield per unit area of summer paddy is much higher than that of monsoon paddy due to receiving longer sunshine hours which enhances photosynthesis of the plants.

4.5-2 Cropping pattern and intensity

Based on survey data of Table 4.8 , the average cultivated area of households for the studied 34 polders area is 22 acres for landowner and average 7.3 acres for total households. Total cultivated area of households in the surveyed townships; rain fed, 42.49%, and "*Le*" irrigated, 46.83% and other land types represent around 10% are "*ya*" (oil seed crop land), "*kaing*" (vegetable and flowers land), garden, grazing land and fishpond as shown in Figure4.2.

Figure 4.2 Land use as percentage of total cultivated area



Source: Own Survey (from October to April 2019)

The key informant interview is conducted with responsible persons of DOA and GAD of Ayeyarwady delta region, related questions are about **how much the effects of irrigation facilities are ; polder embankment, sluice gates and drainage system for the better future agriculture productivity**(See in Appendix 1) and their answers are summarized in the adjacent paragraph.

The average cropping intensity for surveyed area was 72% in 2008, and increase to 141.68% after rehabilitation work of polders and up to increase 168.18% in JICA design polder regions as shown in Table 4.18. Particularly, production of beans, pulses which are feasible in dry condition, has been increasing. The production of pulses has increased more than 400% (from 1.3 mil metric tons in 1988-89 to 5.64 mil. metric tons in 2017-18)after construction and rehabilitation of polder.

Table 4.18 Cropping pattern and intensity (acre), 2018

Descriptions			Townships						Mean Average
			Ngaputaw	Labutta	Bogalay	Phyapon	Daydaye	Kyaiklatt	
Sample house-hold (HH)			18	45	40	55	32	56	41
Average Sample Land size (acre)			19	53	25	31	20	14	22
Σ Sample (HH x acre)			342	2385	1000	1705	640	784	902
Average Cropped Area (Acre) & Intensity	Pre Mon-soon	HH	4	10	10	15	8	11	10
		Avg.area	1.75	5.2	3.9	3	3	2	2.7
		HH x acre	7	52	39	45	24	22	27
		%	2	2.2	3.9	2.6	3.8	2.8	3.0
	Mon-soon	HH	17	44	39	53	31	55	40
		Avg.area	17.3	48.3	23.6	30.3	18.1	12.6	20.53
		HH x acre	294	2125	920	1606	561	693	821.1
		%	86	89	92	94	88	88.4	91.03
	Post-Mon-soon (win-ter/ sum-mer	HH	15	42	35	52	28	53	38
		Avg.area (WB)	7.35	24.75	12.9	18.5	12	6.69	11.31
		% (WB)	32.2	43.58	45.15	56.42	52.5	45.22	47.65
		Avg.area (JICA)	10.8	40.9	21.9	26.7	17.8	11.7	17.6
		% (JICA)	47.4	72	76.65	81.1	77	73	74.15
Average Cropping Intensity %	World Bank Design polder	Σ HH x acre	411.25	3216.5	1410.5	2613	921	1070	1278
		%	120.25	134.86	141.05	15326	143.91	136.42	141.68
	JICA design polder	Σ HH x acre	463	3895	1725.5	3040	1083	1335	1517
		%	135.38	163.30	172.55	178.26	169.28	170.29	168.18

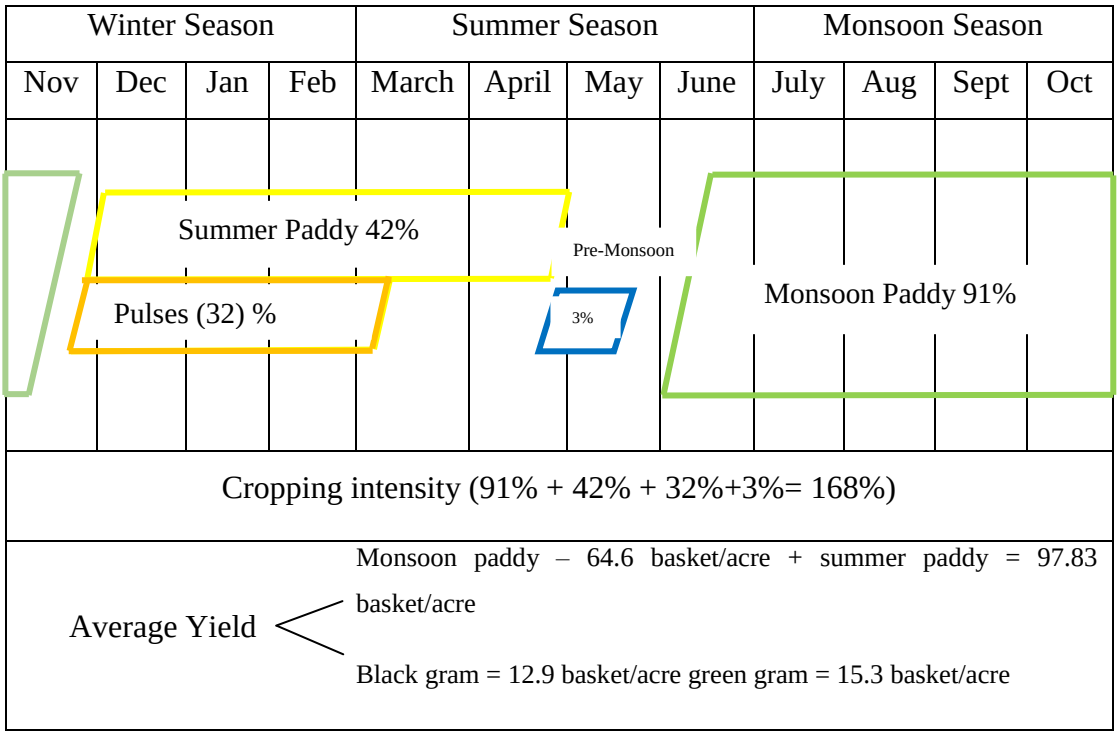
Source: Own Survey (from October 2018 to April 2019), DOA and GAD Data,2018

This mean that farmers in that region regularly cultivate more than one monsoon crop per year. Depending on water availability, soil quality and market

demand conditions, the average cropping intensity deviates across the region as shown in Table 4.18. If farmer can grow only one crop per year, they fallow their fields after harvest. Among the irrigation systems, more than 60% of households have approach to the traditional flood irrigation system and it is the main irrigation technique used preponderantly in rice cultivation. Owning to the irrigation facilities and water availability, farmer are able to execute double or triple cropping in survey areas. The effect of polder rehabilitation project, the Ayeyarwady Delta has realized a gradual expansion of its area under irrigation in order to intensity the crop production.

Cash crop production like vegetables is primary income source mainly for landless farmer. Restrictions of vegetable production are limited cropping is relying on high quality water distribution and/ or soil quality and moisture contents, low storage stability, limited demand and high investment cost etc.

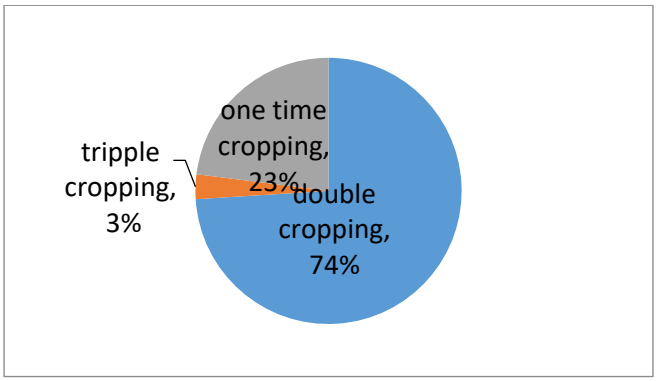
Figure 4.3 Present Cropping pattern and intensity in Ayeyarwady Delta



Source: Own Survey Data (from October 2018 to April 2019)

The total crop intensity in the studied survey area (JICA design construction polder area) is approximated monsoon crop 91% pre-monsoon crop 3% and post-monsoon (winter/summer) crop 74% including pulse 32% and summer paddy 42%. An average crop yield survey conducted in April 2019, exposing the surveyed sample households, show in the Figure 4.3.

Figure 4.4 Percentage of Cropping Pattern in Ayeyarwady Delta



Source: Own survey data (from October 2018 to April 2019)

All the farmers covered by household survey crop monsoon paddy 91%, and 74%of the farmer additionally cultivate either summer paddy or pulses (ie, double cropping is 74%). In fact, summer paddy cultivation is totally rely on the availability of irrigation water and pulses cultivation depends on the soil residual moisture. Figure 4.4 shows the cropping patterns; namely 3% farmers cultivate triple crops, 74% farmers do double crops (monsoon paddy + summer paddy or monsoon paddy + pulses) and the rest, 23% grow only one time crop, that is monsoon paddy.

Diversifying and intensifying new adaptable and promising crop with appropriate practices could provide farmers with alternative income sources. The objective of the intervention was to investigate possibilities for growing winter crops in areas that are protected from salt water intrusion and where there is accessibility of fresh water nearby with the support of polder dikes, sluices and drainage system.

4.6 Survey Results and Discussion

According to the result of the Present Condition survey carried out in 34 villages from October 2018 to April 2019, where one village was selected from each polders as sample village, agriculture is remarked as the main source and fisheries as the second main source of income in all sample villages. Based on the demographic survey of the studied area, literacy rates of male and female in Ayeyarwady Delta are 91.6% and 88.2%, respectively and it can be mentioned that educational level in this region is relatively high of the national average rates. According to interview, women's primary tasks are housekeeping, taking care children and so on. If households own land tiller's right and land preparation, wives help in farming their lands such as transplanting and harvesting.

4.6-1 Irrigation Concept in Ayeyarwady Delta

Based on data supplied by IWUMD and DOA, paddy is cultivated during monsoon almost all the farmland (low land) within the Ayeyarwady Delta. In monsoon season irrigation is not needed, but drainage and protection from flood are necessary. Polder embankments and sluice gates safeguard the farmland from the flood and saline water intrusion. Summer paddy is grown with a help of irrigation by gravity, tidal irrigation, and by pumps.

Irrigation is exercised during summer season mostly in delta, and the irrigation method is to depend on the change of river water level by tidal effect. When the river water proceeds high, sluice gates installed along a polder is opened and withdraw river water for irrigation purposes. It indicates most of the canals in this area work as delivering of irrigation water, discharging dual purposes and leaching the saline water intrusion (reducing EC) for soil quality improvement.

The key informant interview is conducted with responsible persons of IWUMD and GAD of Ayeyarwady delta region, **the questionnaire are concerned with the suggestion from community for the relevant actions based on rehabilitation work of irrigation facilities on post-cyclone Nargis, 2008 and present situation** and they give suggestion about challenges of climate and landscape changes due to water utilization system.

To achieve substantial benefits and better production from the polder systems, it is necessary to operate and maintain the polder systems effectively. While operating and maintaining polder systems, community stakeholder involvement is crucial. There are challenges ahead for future development of polders in the area such as struggle between farmers and fishermen inside the polder for water sharing of their respective purpose. Upstream development activities in the Ayeyarwady River, together with achievable sea level rise, and salt-water intrusion many impact on island so that observation of tidal range, height, inflow and salinity of supply water at the intake sluices around the Island should be done regularly. An integrated approach for optimal and multi-sectional use of fresh water is a necessity in the time of climate change.

Climate and Landscape condition alters the concept of water utilization system. In monsoon period, heavy rainfall stimulates serious inundation and flood damage. Therefore, in Ayeyarwady Delta, drainage system is more essential than irrigation system. Monsoon paddy cultivation can be sustainably practiced in such

areas where well-maintained drainage canal system and polder are existent.

During the surrounded water level in the river ascend up to as high as RL10 to 12 feet, rather the polder and sluices work in protecting the inside area free from flood and saline water intrusion (see in appendix 2, Map 4). On the adverse, the water level of surrounded river declines after the flood period, and row the inundated water inside the polder can be released to the river through drainage canal and sluice gate. In the post monsoon season, the farmers placed nearby the drainage canals can get irrigation water through sluice gate during December to April by tidal irrigation method, when the water level of river is higher than the inside of farmland's elevation. Proper gate operation and good drainage system can conduce to the increasing of agricultural production.

4.6-2 Agriculture productivity with Irrigation improvement

In addition to the target yield, there should be enlargement of irrigable areas and/or crop diversification with rehabilitation of irrigation facilities. Irrigation is exercised during summer season depend on the change of river water level by tidal effect. When the river water proceeds high, sluice gate installed along a polder is opened and withdraw river water for irrigation purposes. It indicates most of the canal in this delta area as drainage as well as delivering of irrigation water, discharging dual purposed and leaching the saline water intrusion for soil quality improvement.

Farmland consolidation comprises of several works such as enlargement and rearrangement of farmland plots, establishment of irrigation and drainage canals, and farm road construction. This arrangement facilities the acceleration of farm mechanization and also rationalized water management, together conducting to high productivity of farm produces.

The key informant interview is also conducted with responsible persons of DOA and GAD of Ayeyarwady delta region, h**ow much effect the agricultural productivity and communities' socio-economic impact**. There could be somewhat effect or impact on the low- lying Delta region.

The studied area of the low-lying Delta region is affected to flooding, storm surges and salinity intrusion, resulting in crop losses, reduced yields. The way has been paved for the double or triple cropping in a year at the same plots with intensive yield and expansion of cultivable farm lands 164,347 ha (406,109 acres) and 15000 ha (37,065 acres) of aquaculture pond protected by 34 polders embankment as shown in Table 4.19.

The Delta polder region is located within the tropical zone near the equator and temperature (the hottest month April and May with mean 30°~35°) and rain fall (annual 100~150 inches, 100~130 days) so that the area are very appropriate for summer paddy cultivation, heavy sufficient irrigation water is acquirable, due to near river and creek. The region also has a wide fertile low and, proper soil for paddy cultivation. Therefore, the surplus production of paddy crop sufficiency is about 250~520% with cropping intensity 140% ~168%.

Table 4.19 Potential Effects of Polder Systems

Township	Benefited Area (acre)	Avg. Crop yield (basket/acre)		Cropping Intensity		Surplus production sufficiency%
		Monsoon	Summer	W.B design polder	JICA design polder	
Ngaputaw	23711	69	92	120.25	135.38	247.00
Labutta	94300	61	99	134.86	163.30	379.71
Bogalay	69957	67	97	141.05	172.55	385.96
Phyapon	120038	71	94	153.26	178.26	351.80
Daydaye	43851	58	99	143.91	169.28	418.55
Kyaiklatt	58612	62	106	136.42	170.29	520.05
(Total)/Average	**(406109)**	**64.6**	**97.83**	**141.68**	**168.18**	

Source: Survey, IWUMD, DOA and GAD Data

4.6-3 Agriculture related difficulties

For the claim table 4.20 is the summarized feedbackof the interview regarding the **barriers/ problems facing agricultural productivityand the respondents give their opinions regarding irrigation system, infrastructure, shortage of labor, market access and so on.**

Table 4.20 The Barriers/problems Facing Agricultural Productivity

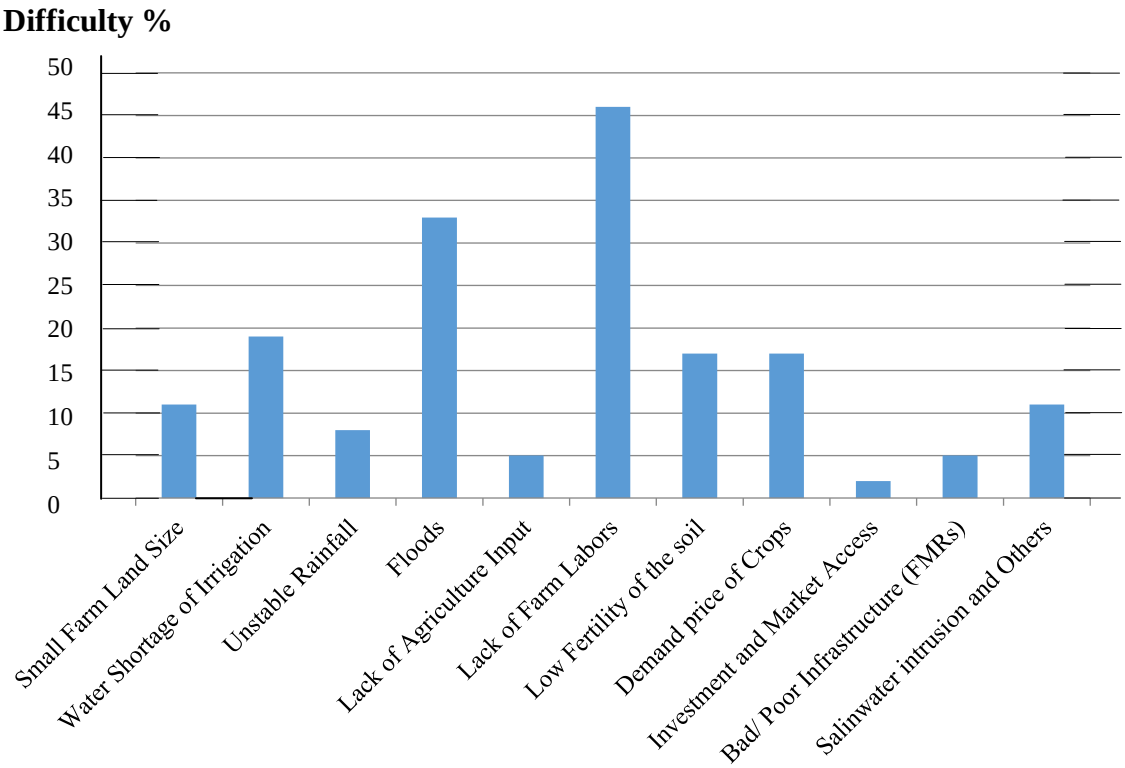
Barriers/ Problems	Respondents	None	Moderate	3rd Biggest	2nd Biggest	Biggest	Mean Value
		0	1	2	3	4	
Water Shortage of irrigation	658	-	-	287	246	125 (19%)	2.75
Floods	658	-	-	186	255	217 (33%)	3.04
Unstable rainfall/ Drought	658	-	30	326	249	53 (8%)	2.49
Infrastructure is poor	658	-	185	317	123	33 (5%)	2.01
Salt intrusion soil	658	-	76	225	278	79 (12%)	2.55
Small-Farm size	658	78	347	151	10	72 (11%)	1.47
Agriculture Inputs	658	33	155	228	117	125 (19%)	2.22
Lack of farm labor	658	92	79	116	68	303 (46%)	2.62
Price of crops and demand	658	-	-	287	259	112 (17%)	2.73
Investment and Market Access	658	-	84	296	193	85 (13%)	2.42
Fertility of soil	658	15	176	258	97	112 (17%)	2.17

Source: Own survey from October 2018 to April 2019

Based on sample farmers' answer the present condition of related agricultural productivity barriers in the studied delta area can be interpreted as follows. Flood is first placed (mean barriers value, 3.04) of the sampled farmers replied it's their one of major problems in their farming. Water shortage of irrigation is ranked at second (mean barriers value, 2.75), salt intrusion soil is third position (mean barriers value, 2.55) and unstable rainfall or drought stands at fourth (main barriers value, 2.49) and all are above moderate value one. It expresses that there is needs of rehabilitation or construction polder dikes, improvement of the sluices and drainage facilities for the purpose of flood mitigation and protection.

Similarly based on respondents replied statements(biggest problems) of related agriculture difficulties in the survey area, can be expressed as following Figure 4.5.

Figure 4.5 Severeness of Agriculture Difficulty in Ayeyarwady Delta



Source: Own Survey Data (from October 2018 to April 2019)

The current farming in Myanmar is distinguished by labor intensive agriculture and most farm households depend on farm labors. However, with the current economic development, the tendencys of labor movement from rural areas to urban areas and oversea, or from agriculture sector to industrial and construction sector could be speed up, making it difficult to secure farm labors.

According to Figure 4.5, lack of farm labors stands first position with 46% of sample farmers' responded data, which indicated dues needs of farm mechanization.

Other results of difficulties are floods (33%), water shortage of irrigation (19%), high price of agriculture inputs (19%), low fertility of soil (17%) and demand and price of crops (17%). A combination of occurrence of flood, unseasonable rain, water shortage of irrigation changes in resource productivity of soil, water and then restrain the agricultural productivity. It suggests need to irrigation facilities for flood protection and inundation reduction, and partly gravity irrigation and pump irrigation during most of the dry seasons.

The delta area has rather full-fledged increase of and volatile rainfall pattern, increase of river peak discharge, cyclone including Nargis, which occurred in 2008, and further increase of saline water intrusion along coastal areas associated with sea level rise, and effect of global warming and climate change. Rehabilitation and upgrading of existing irrigation facilities and flood protection infrastructure could lead to much more efficient water use, modifying larger areas to be irrigated at relatively low cost.

More secure land tenure could further advance the use of technology and private investments that can have dynamic effects on agriculture productivity. Most of Myanmar's farms are small, up to 2 hectares, with 2-3 fragmented land plots, which makes it difficult for them to apply economies of scale in mechanization and marketing.

4.6-4 Livelihoods of farmer and landless

Lowland rice farming is the major livelihood capability for the farmers in the Ayeyarwady Delta. Crop types rely on soil quality and water accessibility by polder dike protection work. Paddy is the primary crop through, locally, some farmers prefer pulses and oilseeds crops following paddy. Some farmers own orchards as secondary livelihoods. Beside agriculture, fishery, livestock rearing, petty trading and service such as motorbike taxi are also secondary livelihoods for farmers.

Table 4.21 Farming Conditions in severe period after Nargis, 2008

Township	% of cultivated land		Avg; Yield (Basket/acre)
	Monsoon	Winter/Summer	
Ngaputaw	45%	3%	15 ~ 20
Labutta	49%	5%	15 ~ 20
Bogalay	51%	4%	15 ~ 20
Phyapon	35%	10%	20 ~ 30
Daydaye	42%	7%	18 ~ 25
Kyaiklatt	75%	20%	25 ~ 40
Average	55%	7%	20 ~ 25

Source : Own survey from October 2018 to April 2019

It can be realized farming conditions in severe period after Nargis strucking parts of the Ayeyarwady delta area, caused decreasing in agricultural productivity due to flood and salt water intrusion, and then decline paddy yield (20 ~ 25 basket/acre) and cultivated farm land (55% in monsoon season and 7% in summer season).

Farming is most primary activity for both landowners and landless farmers to secure food especially rice and to earn income. Landowning farmers usually get income selling surplus of harvested crop after keeping food for household consumption and landless farmers gain income working as casual labor for agriculture.

Table 4.22 Profitability of Monsoon Rice by Farm Size

Particular/Items	Small Farms	Medium Farms	Large Farms
Number of farms	120	91	79
Revenue, MMK/acre	343,500	327,500	332,500
Yield, monsoon paddy, basket/acre	68.7	65.5	66.5
Yield, summer paddy, basket/acre	99	94	98
Total cost, MMK/acre	270,500	257,500	248,500
Labor use, day/acre	108	107	104
Labor productivity, MMK/day	7,000	5,600	5,800
Net Margin, MMK/acre	73,000	70,000	86,000

Source: Survey KII (from October 2018 to April 2019)and GAD, 2018

According to survey results, profitability of Monsoon rice by farm size, the large farm are higher than those achieved from small farm and medium farm, because of culture system of traditional to mechanization and technology know how. Water quality, climate, soil type, crops, irrigation systems and methods, other management practices, yields and labor use are available for agricultural productivity and profitability.

As shown in table 4.23, there spondents give their opinions regarding **the key factors to get benefit in farm production improvement.**

Table 4.23 Key factors to get benefit in farm production improvement

Issue	Total Respondents	Strongly Agree	Partially Agree	Neutral	Partially Disagree	Strongly Disagree	Mean Value
		5	4	3	2	1	
Production Cost	658	238	342	78	-	-	4.24
Quality of Seed	658	176	285	197	-	-	3.97
Culture System	658	87	314	142	115	-	3.57
Experience	658	65	356	191	46	-	3.67
Technology know-how	658	128	379	147	4	-	3.96
Adequate Water & soil quality	658	522	128	8	-	-	4.78
Weather/ environment	658	503	142	13	-	-	4.74
Diseases/ Pest/ Fertilizer	658	232	356	70	-	-	4.24
Market access (local and export)	658	263	311	84	-	-	4.27

Source: OwnSurvey data, (from October 2018 to April 2019)

According to survey data, production cost and access to financial services sustains the ability to enhance and diversity livelihood options. Diversification within agriculture production improvement can also be a valuable adjustive capacity of experiences, culture system of traditional to mechanization and technology know-how. Farmer can be better equipped to manage shifts in water quality and sufficient irrigation, soil condition and customer markets with access to a greater variety of input products including quality seed varieties, pesticides and fertilizer as well as sustainable demand and price of output-products. It is also necessary to water efficiency improvement in times of climate change, weather and environment.

For the landless, the primary livelihood is crucial labor in agriculture (in rice farms and orchids), fisheries and livestock rearing. Fisheries are primary livelihoods for the villages situated near rivers, creeks or lakes. Besides working as causal labor small trading, livestock rearing, fisheries, sewing and ferry service are secondary livelihoods for landless.

The key informant interview to responsible persons of DOA, DOF and GAD of Ayeyarwady delta region , questioning **the constraining factor, most satisfying factor of farming for the community and the main crop and the reason of particular one. And they answer the constraining factor for farming as well as factor affecting the crops and aquaculture production.**

The delta is one of the world's most productive agricultural and fishery regions. Primary products from the delta contribute over 25% of the Gross Domestic Product and the delta is Myanmar's rice bowl, producing 30% of the nation's rice and promote to export earning. A restricting factor for farming is the salinity of surface water and in large parts of the delta and the problem of acidification of sulphate rich silty clay soil, extreme climate and water regime events like longer drought spells, earlier and more.

Severe floods, higher temperature, sea level rise and salt water intrusion are involving the crops and aquaculture production. Aquaculture pond areas expanded in Delta, mostly in the brackish water, or saline water intrusion areas and fresh water fish cultivation is a flourishing business.

The rehabilitation of polder project is based on a livelihoods approach with the overall purpose to assist the most affected communities to recover their food production, resume income generation and increase resilience to future shocks, while building capacity at institutional level to better provide their livelihoods.

Summing up, according to field surveys results, irrigation facilities improvement in Ayeyarwady delta region; polder embankment and sluices protect the inside area free from flood and saline water intrusion. Due to tidal effect, the flooded water inside the polder can be released to the river through drainage canal and sluice gate and then removed the saline water intrusion for soil quality improvement. In addition the drainage canal in this delta area use as retained fresh water to deliver irrigation water for summer season crops. This ways and means has been made for cropping intensity with intensive yield and expansion of cultivable farm land so as to promote the agricultural productivity.

CHAPTER V
CONCULSION

This Chapter mentions the main research findings and makes recommendations based on the conclusions made in relation to stated objectives.

5.1 Findings

Ayeyarwady Delta is internationally recognized rice producing area of Myanmar, and takes the significant responsibility for the nation's food security. Climates change is expected to exacerbate the current problems through a sequence of many aspects like changes in long term average Ayeyarwady River flows in delta region, higher consumptive water use, rising sea level, salt water intrusion steering to problems with soil and water salinization, erosion and accretion and changes in wave and current patterns effect for agricultural productivity.

The part of the Lower Myanmar Paddy Land Development Project, Paddy I and II financed by World Bank in 1980's seriously damaged by Cyclone Nargis in 2008, all land developed systems such as sea water (salt intrusion) protection polders, dikes, drainages and sluices are decline in quality, and consequently farmers in the polder frequently suffer from inundation under intensive rainfall and causing damages of crops. Upgrading and rehabilitation have being implemented including with strengthening of polder embankment, dredging of drainage channel, upgrading of hydraulic facilities sluice gate and so on. To sustain and enhance supply capacity of rice, it is essential to increase productivity of rice through land consolidation and farm mechanization, in addition to the strengthening of flood protection polder dike and drainage.

Irrigation schemes in Ayeyarwady area is complex; primary purpose is flood protection inundation reduction and drainage improvement, and partly gravity irrigation and pump irrigation during most of the dry seasons. Under the rehabilitation project, the benefits to be acquired may vary depending on the increase of yield per a unit area, the extent of crop diversification for high value added crops and increase cropping intensity, reduce of fallow land and expand irrigated farm lands.

Monsoon paddy is grown throughout the areas while summer paddy is limited where irrigation water is available in dry season. Pulses are currently cultivated under residual moisture during winter season, and with irrigation water supplied there is a high potential of increasing the yield.

According to survey results, fishery stands as the secondary source of income after farming in all survey villages in the polder delta region. Fishing and processing of fishery products support an opportunity for landless people to earn income for their livelihood. Based on information from the key informant's survey, prawn is provided first priority for earning income. Dry prawn, fried fish and prawn paste making industries are executed in most of the surveyed villages.

Findings of this study are concluded as follows:

(a) As Ayeyarwady Delta is the Low Lying and Costal Area in Myanmar, there are the impact of climate change, extreme weather condition, flood and salt water intrusion into ground water so that it has been many aspects or challenges on current patterns of agricultural productivity, especially, in paddy field and fishery in livestock as well as on resilience and vulnerable group of people in rural life.

(b) The polder system with dike, embankment and sluice rehabilitation or construction preserve flood so that the monsoon paddy cultivation including the Paddy I and Paddy II can be cultivated well in usual flood area and it can be modified fallow land and waste land into farm land expansion such as agriculture and aquaculture ponds.

(c) Polder system which is to protect salt water intrusion in agriculture land can release the electric conductivity EC (e) values, and improve soil quality and promote the yield per unit area annually.

(d) According to the above findings, Cyclone Nargis strucking part of the Ayeyarwady Regions, which included some of the Paddy I and Paddy II project areas, caused decreasing in paddy productivity in Ayeyarwady Delta region due to flood and salt water intrusion, the survey results express that most farmers cultivated paddy just enough to cover household consumption, so to be left in fallow land before rehabilitation of polder system .It can be seen Farming Conditions are about half of cultivation in monsoon paddy yield and just only 7% in summer paddy yield.

(e) Rehabilitation and upgrading of existing irrigation facilities and flood protection infrastructure could lead to much more efficient water use, enabling larger area to be irrigated at relatively low cost.

Summing up, according to interviews and field survey's results, topographically, deltaic polder region lies on low fertile land existing drainage condition support irrigation water for summer paddy cultivation and polder embankment protect inundating flood water for monsoon rainfed paddy cultivation. The temperature and rainfall received, cover with meadow soils are appreciative for paddy cultivation including other crops. Sluice and drainages also affect to reduce soil salinity and improve soil quality to promote yield per unit area and to increase cropping intensity for agricultural productivity.

5.2 Recommendations

The findings presented above have a number of important implications for the design of policies and intervention aimed at promoting the growth of agricultural productivity through irrigation improvement.

In pursing the UN MDGs, it is recommended to seek ultimately the elimination of hunger, poverty and maternal and child malnutrition through increasing agricultural productivity. The authorities concerned have become essential to simplify and analyze newly and successively created policies and legal institutions related to agriculture, current state of ever-changing production and marketing of agricultural products, pushing economic renovation forward, enhancing income-generating opportunities, regenerating ecological stability and productivity, upgrading rural development infrastructure and improving community resilience to mitigate the risk of climate change.

It is necessary that the government focusing its concentration on measures to increase sown acreages and to utilize modern agricultural techniques and high-yielding seed varieties as well as to use various methods to ensure the availability of farmland productivity and sufficient water for agricultural purpose in order to measure highly complementary towards rural development, food security and ultimate enhancement of living standard and socio-economic development.

In addition, for the formulating of the development plan of reconstruction of polder dike and sluice, it is very consequential to comprehensively study the safety (quality), cost and construction schedule of rehabilitation plan and recommend the

most suitable and practicable design and construction plan based on the technical standard and construction technology. Therefore, various aspects such as technical standards in design and construction, implementation procedures, implementing body, administrative arrangement, environmental soundness and so on should be inquired and verified through the implementation of polder dike embankment and sluice rehabilitation.

The challenges and basis of planning of income generation must regard income opportunities that would require lower investment cost and something that require low or limited technology so that these landless people who have not much income, skills and experience. To cope with difficult to assure farm labors, the current labor-intensive agriculture should be transposed to modern capital-intensive agriculture with farm mechanization, introduction of quality seeds and well managed fertilizer/ chemicals, introduction of improved post-harvest techniques, and also improvement of irrigated farm land and supply/distribution chain, etc.

This is still time to decrease the potential for catastrophic floods in the future, it should implement by improving flood protection infrastructure, such as polder embankments.

Finally, the followings are recommended for the effect of polder system;

(a) Polder system should be reinforced with well-designed such as the polder dike embankment, sluice gates and drainages with annually maintenance and monitoring programme because polder system is able to preserve and protect flood, salt water intrusion in vulnerable area of Ayeyarwady delta region . And also there should be forecasted and estimated the potential effect of the polder dike embankment and sluice rehabilitation or construction like JICA design in order to overcome the usual experienced in rise of and volatile rainfall pattern, increase of river peak discharge, cyclone including Nargis.

(b) It is necessary to expand cultivating land in control area by expending farmland area in the rest of low-lying area, preservation of flood land with embankment, fostering to develop drainage system for increase cropping intensity for agricultural productivity where paddy cultivation together with fishery production, protecting saline water intrusion along coastal areas associated with sea water rise.

(c) It is necessary to be good conditions in Sluice and drainages system as for preventing salt water intrusion, leached by flooding of the rain water for reducing the salinity of the soil. And it is essential to have an awareness plan for all inclusive participation including skill labor and local people.

(d) In order to promote productivity and minimize adverse effects such as salinization, it should be intervened with **modernization of irrigation system**. Irrigation modernization is a process of technical and managerial upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms, with the aim to improve resource utilization (labor, water, economic, environmental) and water delivery service to farms.

(e) **The reengineering of the irrigation operation** should comprises of designing the most cost-effective answer to the redefined water service within the scheme. It should consider: (i) The spatial distribution of the effective demand for the water service. Hazards (salinization, water-logging) and opportunities (recycling of water), (ii) the efficiency in controlling water depth, the ease of monitoring and implementing operation. (iii) analysis of existing public expenditure in agriculture, and improving irrigation infrastructure's management, (iv) agricultural productivity and cultivated area should be increased to meet boosting yield per land area with less environmental impacts which lead to suitable agricultural production through systematic irrigation and input uses, (v) the systematic management and efficient use of irrigation facilities should be promoted to maintain irrigation water efficiency, and soil quality. (vi) in addition, it is necessary to explore new frontiers for optimizing the use of water resources, crop growth and soil water balance in agriculture through “Precision Irrigation, PI System”.

In conclusion, Polder, Dike, Embankments, sluice gates, drain and other flood control measures need to be surveyed to determine rehabilitation and improvements required, both in the short and long terms. Proposals should be prepared for phased implementation of the required works over the next 20 to 30 years. It is essential that flood protections are improved-raising the height of embankments and strengthening them, replacing or repairing sluice gates, renovating or reconditioning, constructing drains and protecting riverbanks so as to promote agricultural productivity and nation’s socio-economic development.

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APPENDIX (1)

Questionnaires

The questionnaire is designed to get information in your personal opinions and views about agricultural/ fishes aquaculture production, effects on polder/dike rehabilitation project before and after cyclone Nargis, 2008. All answers will not be reveled and replies will be kept confidential and the respondent's views will be analyzed along with those of hundreds of others. We plan to use this information as the requirements for my degree of Master of Public Administration.

1. Date of interview ----------
2. Name of Farmer/Fisher to be interviewed ----------
3. Name of Farm ----------
4. Address of Farmer/Fisher ----------

Please tick which you choose

5. Gender : male ☐ Female ☐
6. Age : Below 30 years ☐ Between 30-40 years ☐
   Between 40-50 years ☐ Above 50 years ☐
7. Educational Qualifications:
   No Education ☐ Primary/Secondary ☐
   Matric ☐ Graduate ☐
   Any other, (please specify) ----------
8. Occupation/Field of economic activity for income
   Main : ---------- Secondary : ----------
9. Are you a holder of an agricultural/aquacultural farm (plots) or are you a member of a household with an agricultural/aquacultural farm (plots)?
   Yes ☐ No ☐
   If yes, Size of land holding under operation
   Below 1 acre ☐ Between 1 ~ 5 acre ☐
   Between 5 ~ 10 acre ☐ Above 10 acre ☐
10. Does any member of this household engage in the following?
    Crop growing ☐ Livestock rearing ☐
    Poultry keeping ☐ Fish Farming ☐

11. Land tenure and total area

Own ☐ Lease ☐ Joint occupation ☐ Tenant ☐

Acre -------- Acre --------- Acre ---------- Acre -------

12. Total area of farm land

For agricultural production ---------- acre

For fishery, aquacultural production ---------- acre

For garden and others ---------- acre

13. What is the main source of water supply?

(a) Monsoon season, rain fed ☐, irrigation ☐, well ☐

(b) Winter season, rain fed ☐, irrigation ☐, well ☐

(c) Dry season, irrigation ☐, well ☐, other specify -----

14. What is your area of involvement in agricultural activity?

Farmer ☐, Processor ☐, Backyard Gardener/Landless Farmer ☐

15. In what types of agricultural farming activity are you involved.

Paddy ☐, Pulse ☐, vegetable/fruit ☐, Oil seed ☐

Livestock ☐, Horticulture ☐, Fishery/Prawn ☐, other specify ----

16. What is your main reason for your involvement in agricultural activity?

Household consumption ☐

Commercial/Sale (Income) ☐

Agro-business production ☐

17. What is your main reason for your involvement in Livestock breeding?

Household consumption ☐

Commercial/Sale (Income) ☐

Agro-business production ☐

18. What is your main reason for your involvement in fishery/aquacultural activity?

Household consumption ☐

Commercial/Sale (Income)

Agro-business production ☐

19. Did anyone in the household earn money for the following activities?

Producing cash crops ☐

Raising Livestock ☐

Catching /collecting fish products ☐

20. Whether the household grows specific annual crops?

Yes ☐ No for wet season and dry season for each crop ☐

Why, reason for ----------

21. Whether the household practice fisheries?

Yes ☐ No for fish/prawns and crab ☐

22. Is anyone in this household a farm operator who produces double or triple cropping patterns or fishery activity intended for sale?

Crop: Yes ☐ No ☐

Fishery: Yes ☐ No ☐

If yes, his activities (briefly express) ----------

23. Does your household operate any land for agriculture purpose?

Yes ☐ , No ☐ ,

If yes, the total area of the land in

Le ( ) ----------acre, Kaing ( ) ----------acre

Yar ( ) ----------acre, Garden ( ) ----------acre

24. Do you have more full-time or seasonal employees for your farm?

Full time ☐ , Seasonal ☐

If so, how many? ----------

If paid, salaried, how much do the employees earn? ----------MMK.

If paid, hourly, how much do the employees earn per hour? ---------- MMK.

25. Are there any differences your farm productivity between cyclone Nargis periods before and after five years(2007-2012)and present adjascent five years (2013-2018)?

Periods	Farm Land production (acre)	Yield per acre (basket)		Cropping intensity (%)			
		Mon-soon	Summer	Mon-soon	Winter	Summer	Total
2007							
2008 after Nargis							
2009-2012							
2013-2018							

26. Are there any progressing change of your farm conditions (good, fair, poor) by effect of polder system rehabilitation works in 2009, 2014 and 2018?

---

27. (a) Cost and benefit per Acre (Average), Agriculture

Planting cost ---------- Kyats Yield per acre(monsoon) ---------- baskets

Labour cost ---------- Kyats Yield per acre(summer) ---------- baskets

Seed cost ---------- Kyats Yield per acre(average) ---------- baskets

Apparatus cost---------- Kyats Selling price (average) ---------- kyats.

Total cost ---------- Kyats Total revenue --------- baskets

Total benefit = Revenue - Cost = Kyats/acre

28. (b) Cost and benefit per Acre (Average), Aquaculture

Feeding cost ---------- Kyats Yield per acre --------- Viss.

Labour cost ---------- Kyats Selling price (average)------- Kyats

Seed cost ---------- Kyats Total revenue ------- Kyats.

Apparatus (O&M) cost ---------- Kyats. Total cost ---------- Kyats

Total benefit = Revenue - Cost = Kyats/acre

29. What are the key factors to get benefit in farm production improvement?

Please give your opinion regarding the following statements. Please tick the appropriate box.

Issues	Strongly Agree (0)	Partially Agree (1)	Neutral (2)	Partially Disagree (3)	Strongly Disagree (4)
Production Cost					
Quality of Seed					
Culture System					
Experience					
Technology know-how					
Water quality and adequate					
Weather/ environment					
Diseases/Pest/Fertilizer					
Market access (Local and export)					

30. Which method do you use for irrigation water?

Pumping ☐ Siphoning ☐ Sluice gate ☐ Other (specify) ☐

31. What kind of sustainable agricultural practices do you incorporate into your work? (Briefly express)

---

32. Do you have any support from the organizations?

Seed/variety ☐ Fertilizer ☐ Credit ☐

Training ☐ Other (specify) ----------

33. Do you think which farming you have gained maximum benefit?

Crop farming ☐ Fish farming ☐ Other (specify) ----------

34. What is the barriers/problems facing agricultural productivity. Please give your opinion regarding the following statements and tick it.

Barriers / Problems	None	Moderate	3rd Biggest	2nd Biggest	Biggest
Water shortage of irrigation					
Floods/Drought,					
Unstable rainfall/Drought					
Infrastructure is poor					
Salt intrusion soil					
Small farm size					
Agriculture Inputs					
Lack of farm labors					
Price of Crops and demand					
Investment and market access					
Other (Please specify)					

35. What are the costs and benefits before and after cyclone Nargis affect?

---

36. What is the biggest challenge in operating your farming?

---

37. Your suggestion for improving agriculture/aquaculture production/ development in future.

Additional questionnaire for Key informant interview

1. What would be the suggestion from community for the relevant actions based on rehabilitation work of irrigation facilities on post-cyclone Nargis, 2008 and present situation?
   ---
2. How effect the agricultural productivity and communities' socio-economic impact?

   ---
3. What is the constraining factor of farming for your community?

   ---
4. What is the most satisfying factor of farming for your community?
   ---
5. What crops do your community grow? What's your main crop and why that particular one?

   ---
6. What has been your community most consistent crop in terms of making a good profit?

   ---
7. What kind of assistance did your community get from polder rehabilitation project?

   ---
8. Do you think our agricultural system benefits from subsidies, such as irrigated water, soil quality improvement, quality seeds, fertilizer, pest protection?

   ---
9. What are the effects of irrigation facilities, polder embankment, sluice gates and drainage system for the better future agriculture productivity?

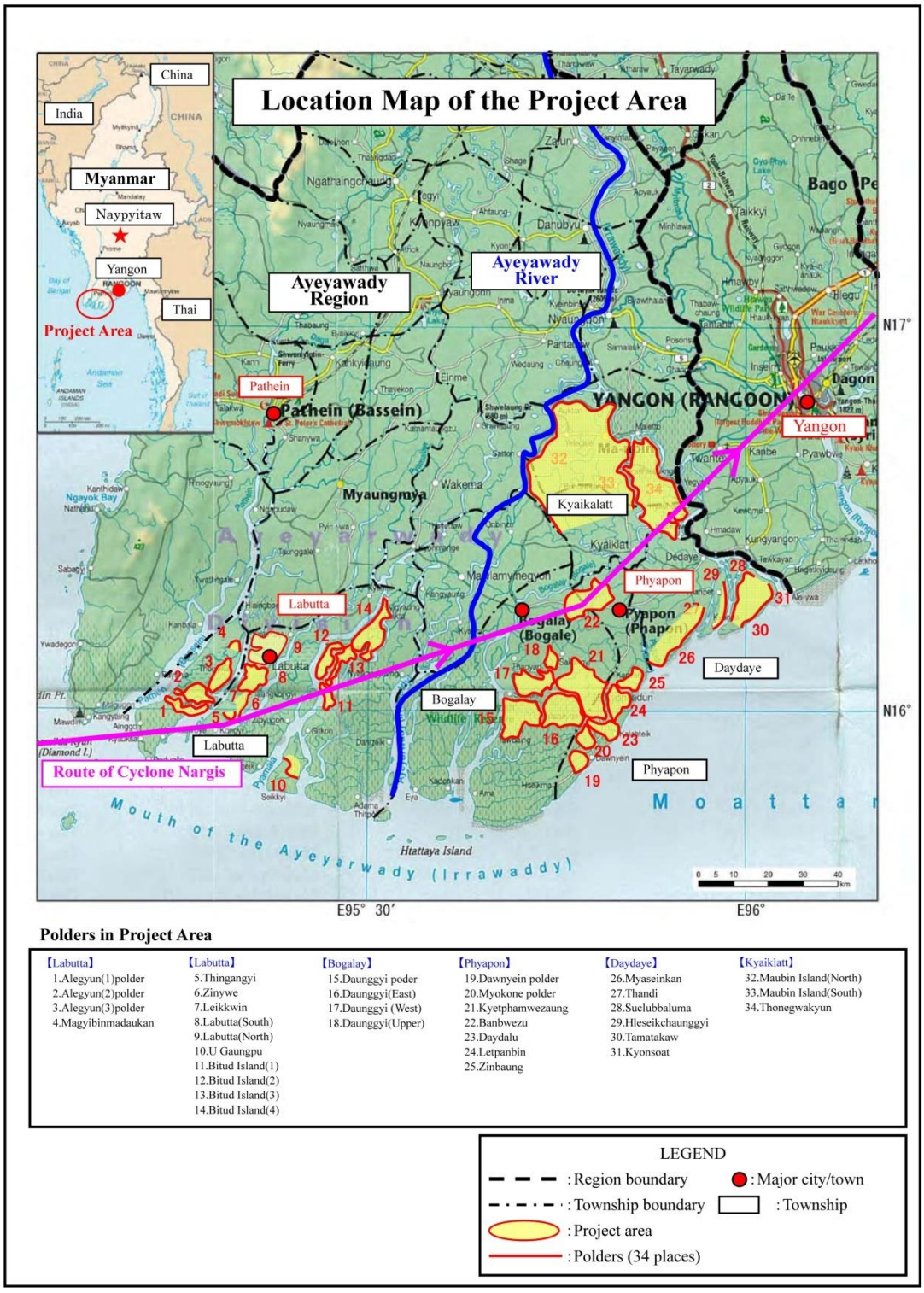
   ---
10. What would be the suggestion from community for the better future polder/dike implementation and agriculture and fish aquaculture production/ development?

(Thank you very much for your cooperation)

APPENDIX (2)

Map (1)

Location Map of Polder Rehabilitation Project



Polders in Project Area

【Labutta】
1.Alegyun(1)polder
2.Alegyun(2)polder
3.Alegyun(3)polder
4.Magyibinmadaukan

【Labutta】
5.Thingangyi
6.Zinywe
7.Leikkwin
8.Labutta(South)
9.Labutta(North)
10.U Gaungpu
11.Bitud Island(1)
12.Bitud Island(2)
13.Bitud Island(3)
14.Bitud Island(4)

【Bogalay】
15.Daunggyi poder
16.Daunggyi(East)
17.Daunggyi (West)
18.Daunggyi(Upper)

【Phyapon】
19.Dawnyein polder
20.Myokone polder
21.Kyetphamwezaung
22.Banbwezu
23.Daydalu
24.Letpanbin
25.Zinbaung

【Daydaye】
26.Myaseinkan
27.Thandi
28.Suclubbaluma
29.Hleseikchaunggyi
30.Tamatakaw
31.Kyonsoat

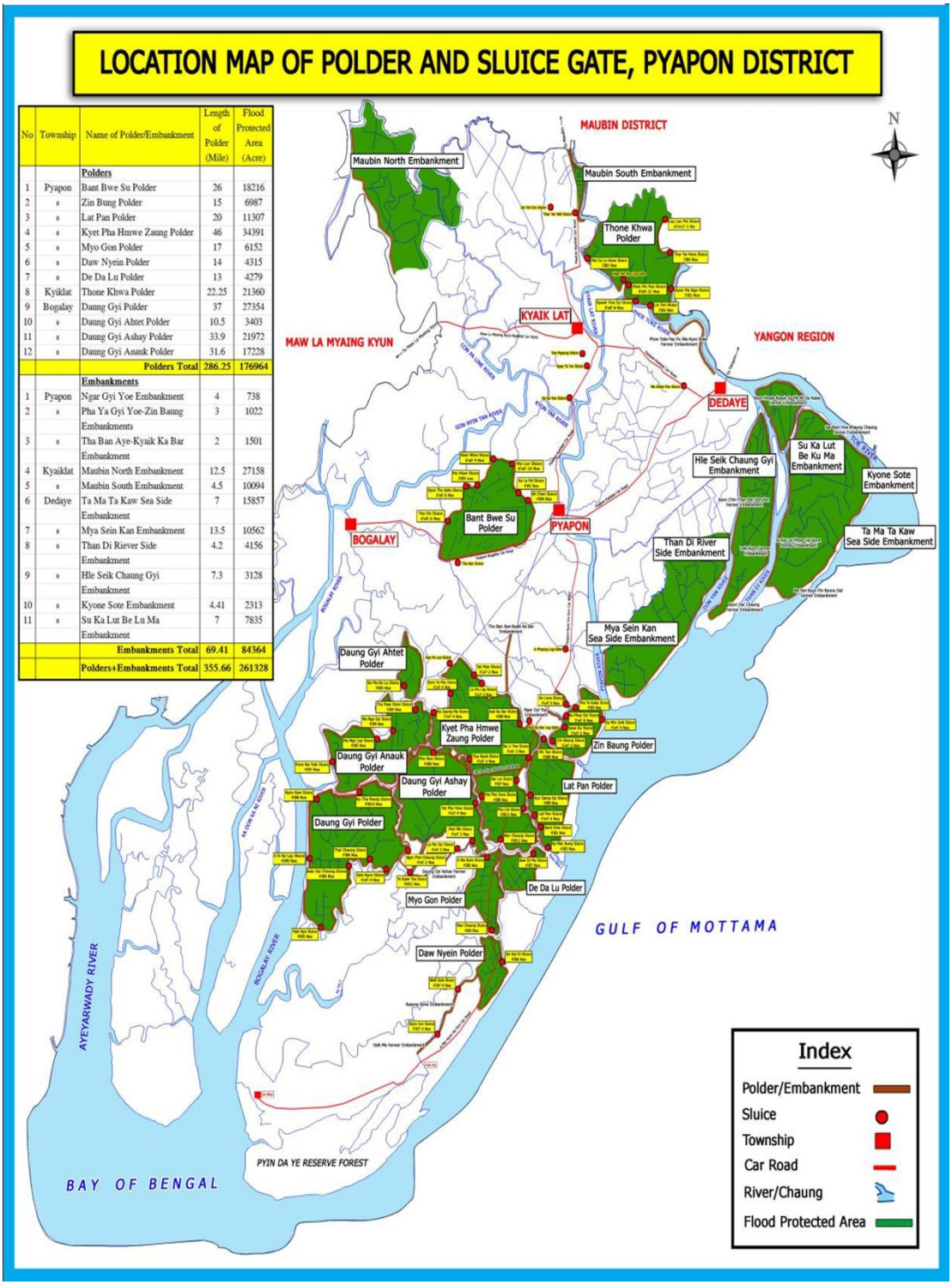
【Kyaiklatt】
32.Maubin Island(North)
33.Maubin Island(South)
34.Thonegwakyun

LEGEND
: Region boundary
: Major city/town
: Township boundary
: Township
: Project area
: Polders (34 places)

APPENDIX (2)

Map (2)

Location Map of Polder (Pyapon, Kyaitlatt, Bogalay and Daydaye,)

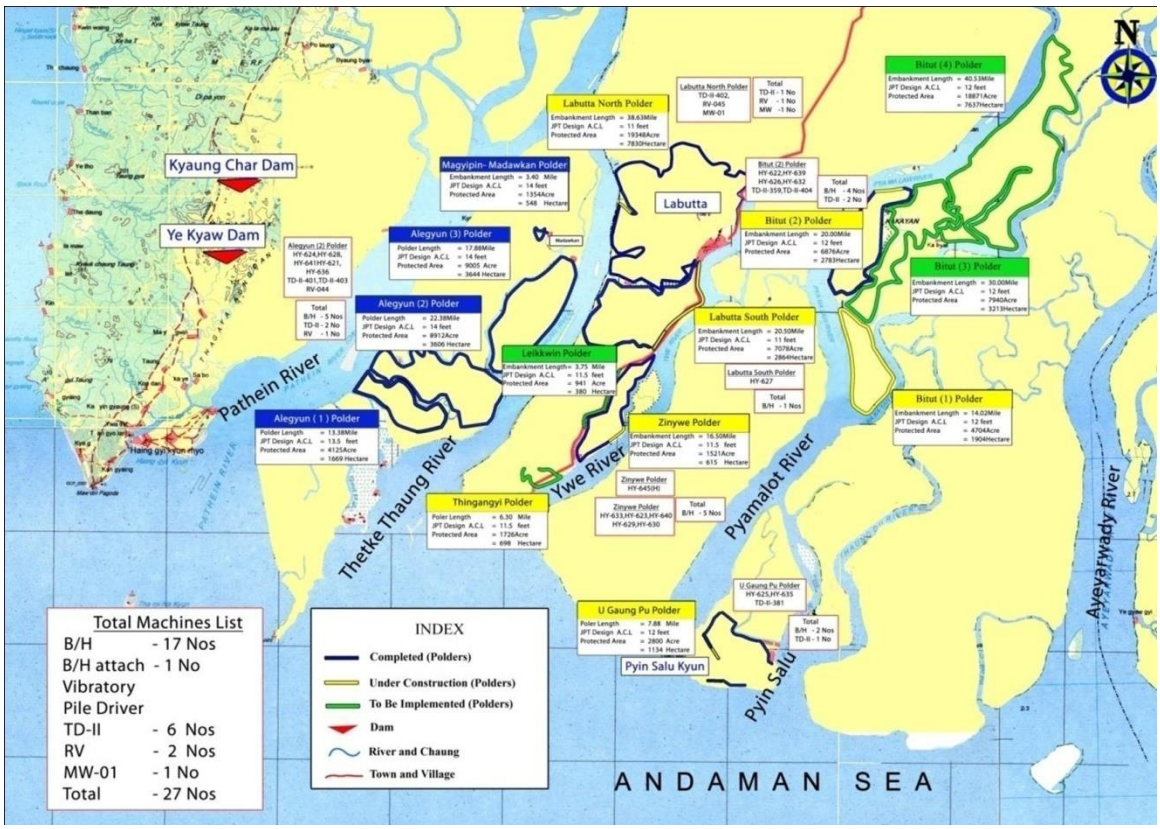


No	Township	Name of Polder/Embankment	Length of Polder (Mile)	Flood Protected Area (Acre)
		Polders		
1	Pyapon	Bant Bwe Su Polder	26	18216
2	〃	Zin Bung Polder	15	6987
3	〃	Lat Pan Polder	20	11307
4	〃	Kyet Pha Hmwe Zaung Polder	46	34391
5	〃	Myo Gon Polder	17	6152
6	〃	Daw Nyein Polder	14	4315
7	〃	De Da Lu Polder	13	4279
8	Kyiklat	Thone Khwa Polder	22.25	21360
9	Bogalay	Daung Gyi Polder	37	27354
10	〃	Daung Gyi Ahtet Polder	10.5	3403
11	〃	Daung Gyi Ashay Polder	33.9	21972
12	〃	Daung Gyi Anauk Polder	31.6	17228
		Polders Total	**286.25**	**176964**
		Embankments		
1	Pyapon	Ngar Gyi Yoe Embankment	4	738
2	〃	Pha Ya Gyi Yoe-Zin Baung Embankments	3	1022
3	〃	Tha Ban Aye-Kyaik Ka Bar Embankment	2	1501
4	Kyaiklat	Maubin North Embankment	12.5	27158
5	〃	Maubin South Embankment	4.5	10094
6	Dedaye	Ta Ma Ta Kaw Sea Side Embankment	7	15857
7	〃	Mya Sein Kan Embankment	13.5	10562
8	〃	Than Di Riever Side Embankment	4.2	4156
9	〃	Hle Seik Chaung Gyi Embankment	7.3	3128
10	〃	Kyone Sote Embankment	4.41	2313
11	〃	Su Ka Lut Be Lu Ma Embankment	7	7835
		Embankments Total	**69.41**	**84364**
		Polders+Embankments Total	**355.66**	**261328**

APPENDIX (2)

Map (3)

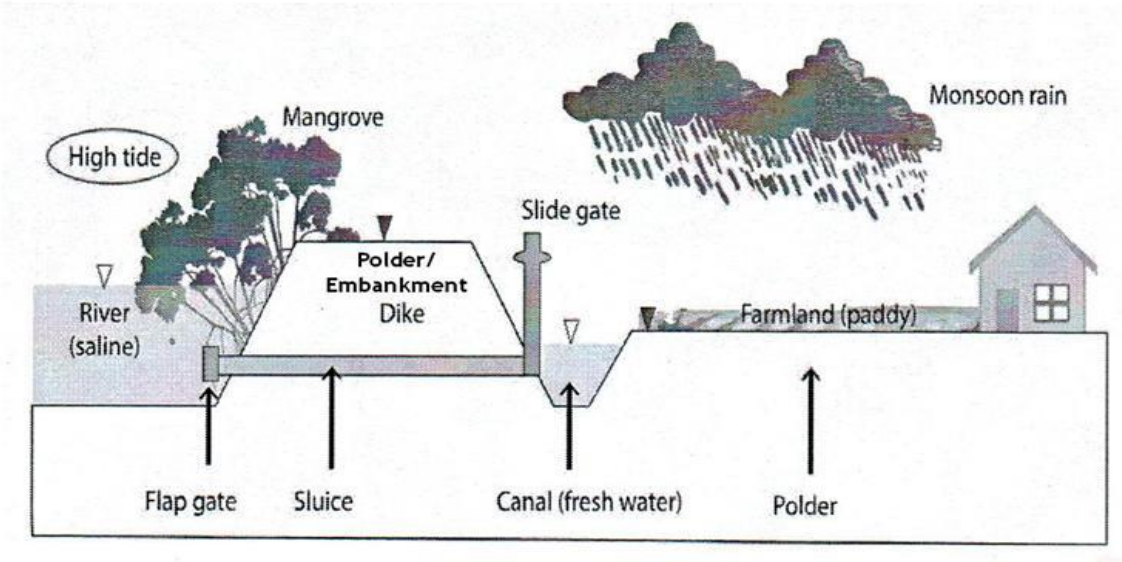
Location Map of Polder (Ngaputaw and Labutta)



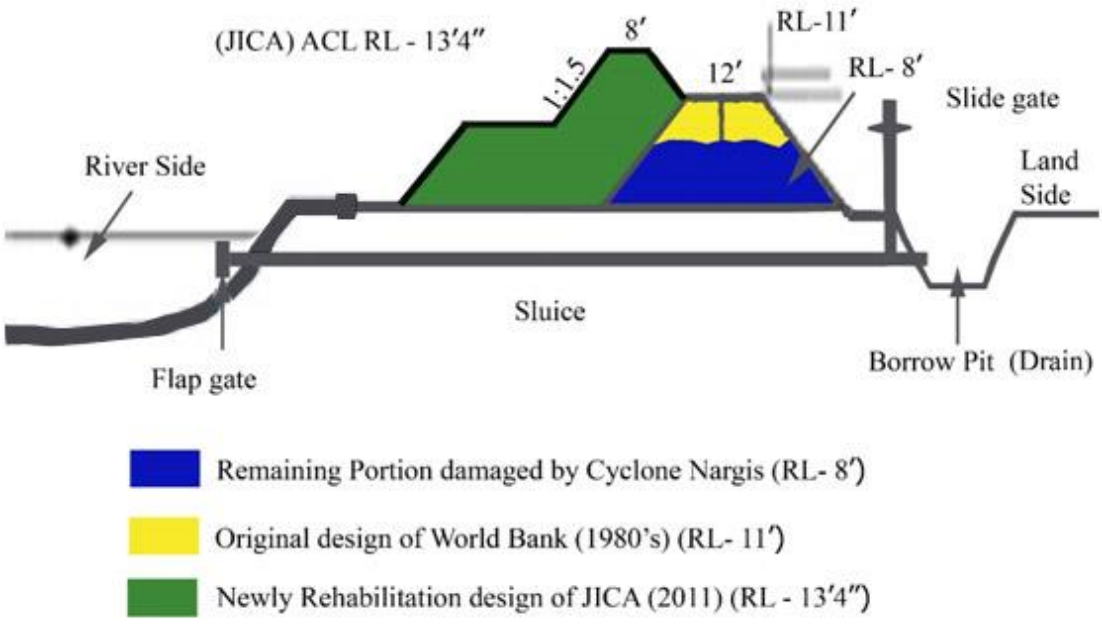
APPENDIX (2)

Map (4)

Polder Dike Schematic Section



Cross-Section View of Polders (JICA)



Source: World Bank and JICA Survey Team Report (2009)