Rice production and use among beneficiaries and non-beneficiaries of the Gulf of Mottama Project, Myanmar

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List of Abbreviations

ACIAR	-	Australian Center for International Agricultural Research
AFC	-	Agriculture & Finance Consultants GmbH
AusAid	-	Australian aid
AWD	-	Alternate wetting and drying
BANCA	-	Biodiversity and Nature Conservation Association
CLCMGoMP	-	Community-Led Coastal Management in the Gulf of Mottama Project
CNRMP	-	GoM Coastal Natural Resources Management Plan
CSO	-	Central Statistical Organization
DAP	-	Department of Agricultural Planning
DAR	-	Department of Agricultural Research
DOA	-	Department of Agriculture
FAO	-	Food and Agriculture Organization
FGDs	-	Focus Group Discussions
GoM	-	Gulf of Mottama
GoMP	-	Gulf of Mottama Project
HAFL	-	School of Agricultural, Forest and Food Sciences
HSI	-	HELVETAS Swiss Intercooperation
INGO	-	International Non-Governmental Organisation
INM	-	Integrated nutrient management
INM	-	Improved nutrient management
IRRI	-	International Rice Research Institute
ISM	-	Improved seedbed management
IUCN	-	International Union for Conservation of Nature
KII	-	Key Informant Interviews
MOAI	-	Ministry of Agriculture and Irrigation
MOALI	-	Ministry of Agriculture, Livestock and Irrigation of
NAG	-	Network Activity Group
NGO	-	Non-Government Organization
SDC	-	Swiss Agency for Development and Cooperation
SRI	-	System of Rice Intensification
SRP	-	Sustainable Rice Platform
SSNM	-	Site-specific nutrient management
USDA	-	United State Department of Agriculture
VDCs	-	Village Development Committees
YAU	-	Yezin Agriculture University

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Abstract

Aung, No No
Rice production and use among beneficiaries and non-beneficiaries of the Gulf of Mottama Project, Myanmar

Rice production plays a vital role in Myanmar agriculture. Nowadays, many farmers faced so many problems in rice cultivation and get low profits from rice prodution due to low yield with high production cost. This study contributed to the the Gulf of Mottama Project and aimed to explore current situation of rice production and socio-economic characteristics of project beneficiary and non-beneficiary households and to assess the rice cultivation practices, constraints faced in rice production, rice yield, profit of project beneficiary and non-beneficiary households in Kyaikhto, Bilin and Thahton Townships. In addition, this study investigated the influencing factors on rice productivity and profit of rice production. Household survey (n=106) by personal interviewing with 59 beneficiary households and 47 non-beneficiary households and focus group discussions were conducted in eight project targeted villages during the period of August to October, 2018. Key informant interviews were also carried out with 10 experts. Descriptive analysis, multiple linear regression analysis were used for data analysis. About 55% of the sample households' income comes from rice production and they grew 16 acres of rice on average with average seed rate of 1.5 baskets per acre. About 80% of beneficiary households applied mineral fertilizers and about 14% of the sampled households used organic fertilizer (compost and farmyard manure). The average productivity of the sample households was 39 baskets per acre with the average profit of 143,000 kyats per acre. One-fourth of the sample households keep rice for their own consumption. Seed quality problem was mostly found in non-beneficiary households. The other problems faced by the interviewed households are labour scarcity and climate change. The rice productivity of the selected fields of sampled households was significantly influenced by being project non-beneficiary households, number of land preparation (tillage). Average rice yield obtained by beneficiary households was higher than that of non-beneficiary households. The more land preparations done in the field, the less rice yield would be. Land preparation cost and rice selling price influenced significantly on the profit of rice production. The higher the rice selling price, the more profit would obtain from rice production. Moreover, the costs of land preparation was lower, the profit would be higher. It was found that 22% of the beneficiary households have log books and all non-beneficiary households have no record books. Although project farmers get higher yield and have much knowledge about sustainable production than non-beneficiary farmers, it is still needed to try hard to be sustainable rice production. It was found that there is less collaboration among government departments. As a result, researchers do not know what the farmers require exactly and most of the farmers have no knowledge about agricultural inputs and cultivation practices. Government should support enough facilities to extension agents and lay down the strong laws to punish the lawless sale. Moreover, government should work with other organizations in order to solve the constraints faced by farmers and for development of rice production of this region. This study indicates that the need of further studies on current situation of rice production in different regions of Myanmar and institutional analysis on departments concerning with Myanmar rice production.

Keywords: Myanmar, rice production, Gulf of Mottama, yield, profit

1 Introduction and project definition

1.1 Context of the thesis

Farming is the major employment in rural areas of Myanmar and a greater portion of rural communities' income is derived from agriculture. It contributes 22.1% of GDP and employs 61.2% of the labour force in 2014-2015 (MOAI 2015). However, average crop production per hectare is still low due to poor soil, inadequate water supply, improper application of fertilizers, infestation by the pests, and lack of technical know-how on crop production. Therefore, farmers' income is very low and farmers face limitations, such as timely and appropriate field operations and the input like quality inputs such as seeds, labor, pesticides and fertilizer with high labour use and poor support of agricultural services (The World Bank 2016). On the other hand, irregular rainfall patterns, poor natural resources management, and increased rural population are creating land degradation and fragile biophysical environment resulting in a decrease of crop yield (HELVETAS 2015). Therefore, there are a number of local and international organizations like the International Rice Research Institute, Myittar Foundation that are helping to improve the income of Myanmar farmers by sharing technology and knowledge about inputs and crop cultivation practices.

This thesis was carried out in the frame of HELVETAS Myanmar, Gulf of Mottama project (GoMP). The Gulf of Mottama (GoM) is a big bell-shaped estuary where three rivers (the Sittaung, Thanlwin and Yangon) flow into it. It is a precious wetland with nutritious sediments for biodiversity and the support the local livelihoods. The project helps the local by enhancing livelihood diversification and co-management of natural resources in the GoM. The project overall goal is that the unique biodiversity of the GoM is conserved and sustainably developed to benefit human communities that depend on it. This project has the following planned outcomes.

Outcome 1: Livelihoods are secured and diversified to build resilience in communities.

Outcome 2: Coastal natural resources use is sustainable and well-managed, and biodiversity is conserved.

Outcome 3: Coastal natural resources governance is coordinated and effective, and awareness on the GoM values is raised.

Under outcome1, the expected outputs are (1) improved and/or diversified fisheries and on-farm livelihoods through skills and market system development (2) developed off-farm options through skills and market system development and (3) supported communities for disaster risk management, planning and adaptation (HELVETAS 2018).

The thesis provides a contribution to output 1 under outcome 1 of the GoMP (improved and/or diversified fisheries and on-farm livelihoods through skills and market system development). This study investigate the socio-economic characteristics, the income sources, the rice cultivation practices, the conditions of sustainability of farm, rice productivity, rice selling place and profits of project beneficiaries and non-beneficiaries.

1.2 Problem Statement

Rice is not only the main food in Myanmar traditionally diet but also one of the major foods for export. It occupies about 40% of the total agricultural area and is grown on over 8 million hectares (MOAI 2014). The country's average yield is about 4.1 tons per hectare (MOAI 2010). The major limiting factors for Myanmar rice production are low seed quality and other agronomic practices such as inappropriate soil, water, nutrients, pest and diseases management (Naing et al. 2008). In the Gulf of Mottama region, rice is the mostly grown crop during the monsoon season (HELVETAS 2015). Farmers in coastal and delta areas area usually face flooding due to heavy rain, powerful tidal bores, sea water intrusion and poor drainage system in conducting their activities (Hom et al. 2015). Therefore, it is hard to get the optimum yield and the income of the farmers was low. According to the results of the field research conducted by the International Rice Research Institute (IRRI), farmers can get more yield and income by choosing suitable varieties Sin ThweLatt, IR57542-90-1-1-5 (Pyi Taw Yin), Shwe Pyi Tan, ManawThuka-2 together with good cultivation practices such as improved seedbed management (ISB) and improved nutrient management (INM) (IRRI 2016). On the other hand, it is important to get the appropriate technologies and knowledge to the farmers. Therefore, it is an urgent need to study the cultivation practices, productivity, and income and profits of rice farmers in the Gulf of Mottama region.

1.3 Objectives and research questions

The conducted work is contributing to the the Gulf of Mottama Project and the objectives were to explore current situation of rice production and socio-economic characteristics of project beneficiary and non-beneficiary households and to assess the rice cultivation practices, constraints faced in rice production, rice yield, profit of GoMP project beneficiary and non-beneficiary households in Kyaikhto, Bilin and Thahton townships. In addition this study investigated the influencing factors on rice productivity and profit of rice production.

The following research questions were developed in this study.

- What are their socio-economic characteristics of rice farmers (household characteristics) in the research site? What are their income sources?
- What varieties are mainly cultivated and use of inputs by farmers in study area?
- Which practices are conducted by in rice production?
- What are the rice productivity and profit of project beneficiary and non-beneficiary households?
- What are the constraints and challenges faced by project beneficiaries and non-beneficiaries in rice production?
- How do the households use their rice?
- What are the influencing factors on profit and yield of beneficiaries and non-beneficiaries?
- How do the farmers manage their farms to be sustainable?
- How do the organizations involve in development of rice production in Myanmar?

By responding to these research questions, the thesis contributes to outputs of the GoMP of the HELVETAS Myanmar.

1.4 Structure of the Thesis

The thesis is structured into 6 chapters.

Chapter 1 contains the content of the thesis, problem statement, objectives and research questions.

Chapter 2 addresses the state of scientific knowledge about Gulf of Mottama project, rice production in Myanmar, sustainable practices in rice production and institutions and private sector and collaboration with international organizations in Myanmar agriculture.

Chapter 3 presents the methodology used for this study including sampling, data collection and all the other activities from preparation to data analysis.

Chapter 4 comprises results and discussions of data analysis about income, socio-economic characteristics, use of inputs, rice productivity and profits, the situation of rice production and role of the organizations and institutions in Myanmar for rice production development.

Chapter 5 describes the conclusions, recommendations and suggestions for further study.

2 State of research

2.1 Overview of the Gulf of Mottama Project (GoMP project)

The GoMP project is funded by the Swiss Agency for development and Cooperation (SDC) and it was formerly known as the Community-Led Coastal Management in the Gulf of Mottama (CLCMGoMP) in Phase 1 from 2015 September to 2018 April. The Phase 2 was started from 2018 April and will be finished in 2021 December. The GoMP project is implemented by HELVETAS Swiss Intercooperation, an independent Swiss organization, and its partners Network Activities Group (NAG), a Myanmar NGO, the International Union for Conservation of Nature (IUCN), a Swiss-based environmental network, and the Biodiversity and Nature Conservation Association (BANCA), a Myanmar NGO. Mon State and Bago Region of the Gulf of Mottama Region are the main focus areas of this project. The project map was shown in Figure 1.

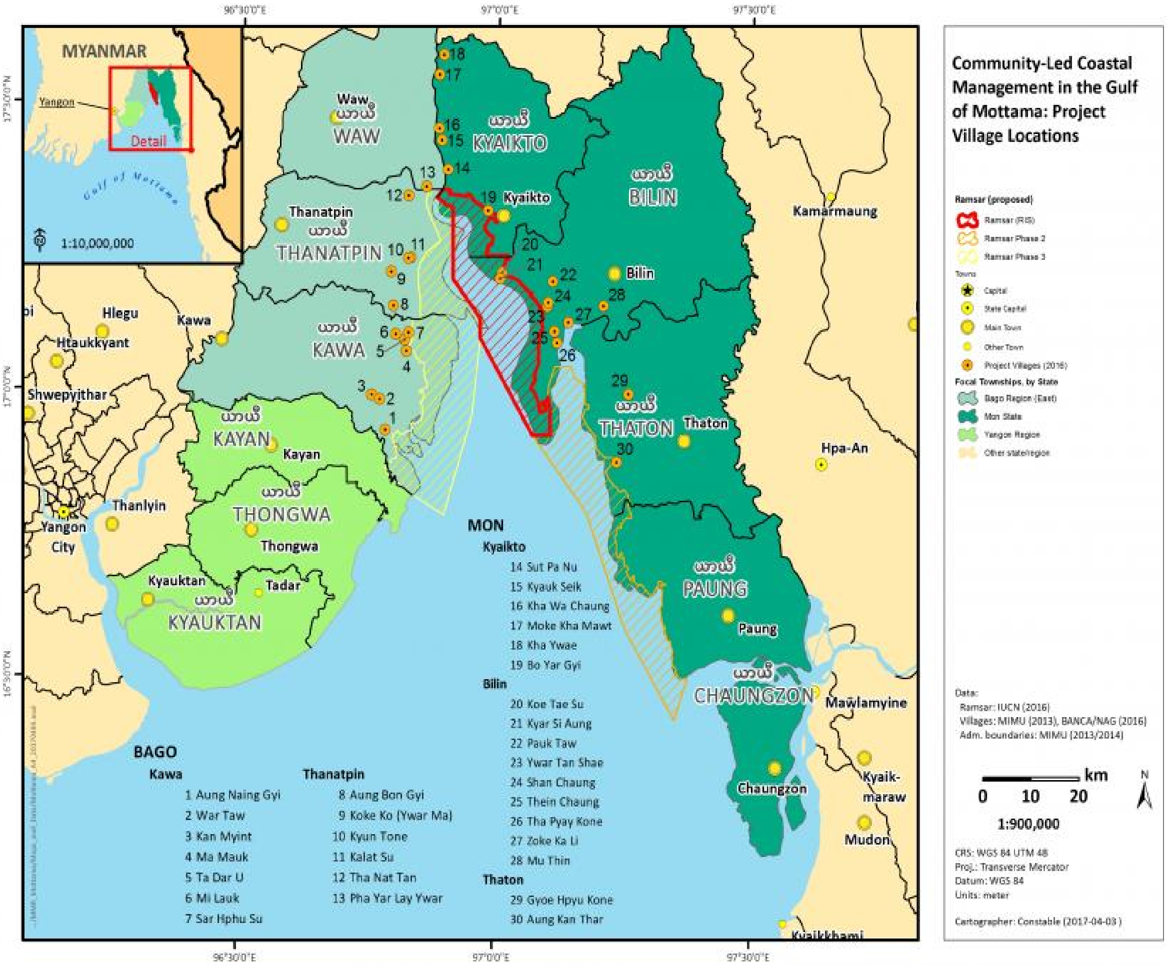

Figure 1 Gulf of Mottama Project Map (Adapted form HELVETAS 2015)

The project goal in Phase 1 was that vulnerable women and men in targeted coastal areas of the Gulf of Mottama have improved livelihood security through effective fisheries value chain development, livelihood diversification and equitable and sustainable management of resources. In Phase 2, the project aims that the unique biodiversity of the GoM is conserved and sustainably developed to benefit human communities that depend on it. (HELVETAS 2018)

At the end of Phase 1, a section of the GoM was announce as Ramsar site in 2017, the project can develop the GoM Coastal Natural Resources Management Plan (CNRMP), establish a fishery co-management protection zone by Government and communities and build the Village Development Committees (VDCS) with sub-groups (fishers, farmers and landless) in all project villages. Moreover, the technical capacity building trainings on good agriculture practices, market and alternative livelihoods was condudcted to support income-generation activities (SDC 2018)

To get the goal, the GoMP promotes the livelihoods of the local people by conserving natural resources and creating the job opportunities. On the other hand, the project supports technology and upgrades human resources together with the staff from government and other private sectors. To conserve and govern natural resources effectively, the project helped the locals to constitute the Village Development Committees and organized to hold the meetings and workshops with different stakeholders. The project guides the sustainable technologies and shares knowledge to the project beneficiaries including fishermen, farmers, landless and other disadvantaged groups (HELVETAS 2018).

After the introduction of the project to the local people in targeted villages and one member of the households who are interested to the activities of the project have to pay 1000 kyats to be a member of the project. These households are beneficiaries of project. Under the guidance of the project staff, the leaders were selected by the villagers and they have to organize themselves to form their respective Village Development Committees (VDCs). The leaders and members of the VDCs choose the leaders for fishery and agriculture. Therefore, each village has three leaders for VDC, fishery and agriculture. The officers and project staff make contact and meet with leaders and they support inputs, share technologies, offer trainings and conduct research to their beneficiaries. The project addresses the livelihoods alternatives for local people by improving fishery and non-fishery. To promote fisheries, the project assists in aquaculture and producing value added products such as drying and production of fish paste. In case of non-fisheries, the project promotes the rice cultivation by introducing sustainable farming techniques together with introduction of new varieties and systematic use of agrochemicals (pesticides and herbicides). And the project also encourages the smallholder rice farmers and landless people to raise small livestock such as pigs, goats, ducks and chicken. Moreover, project delivers log books to some village leaders in order to get the habit of keeping records. The log-books contain the following records.

- Main Livelihood Activities
- Ownership Record
- Crop Production Record
- Marketing of Farm Products Record
- Summary of Cost and Benefit Record
- Soil Conservation Record
- Compost Producing Record
- Off Farm Production Record
- Farmer Capacity Building Record
- Daily Expenditure and Income Record and
- Loan Record

The project also establishes the saving system that is integrated management by the Village Development Committees to solve the financial problem in advance. For drinking water shortage problem in the project targeted villages, issues of solid waste management are addressed and support to access safe drinking water. In the areas that have river bank erosion, the migration patterns and unemployment rates of the displaced people especially for youth are assessed and the project helps to be safe migration and to build up their livelihoods by opening the short skills-training courses and making the linkages with the factories. Otherwise, the project enhances the local disaster management plans for the local communities to be resilient to the natural disasters and to make contact with the external agencies in case of emergencies.

The project is contributing to conserve the natural resources and the communities to be resilient to the impacts of disasters through integrated management of local people, government together with local and international NGOs by enhancing new income generation activities and promoting human resources (ibid.).

2.2 Rice Production in Asia

Nowadays, Asian farmers are facing many challenges in their production including globalization, changing technologies, soil and water deterioration, water shortage, accelerated urbanization and development in agricultural infrastructure and other problems. In recent years, the agricultural productions, especially for cereals, increase with a low rate in Asia. The production systems include intensive agriculture with largely rely on agrochemicals, and using improved varieties and these are leading to the unstable production (Pinstrup-Andersen 2004).

On the other hand, climate change affects agriculture seriously and farmers should try to use climate adaptable strategies (Sarkar and Padaria 2010). Mismanagement of cultural practices induces climate change. Projected climate changes over the next century may require major adjustments to production practices. Actually, agriculture is one of the most important producers of greenhouse gases. The increasing use of nitrogen fertilizers, frequent land plowing, abundant use of chemical pesticides and fossil fuel consumption in machines are among the most important agricultural activities that lead to greenhouse gas emission and causes problems threatening public health and environment (Darwin et al. 1995). The susceptibility to climatic change depends both on the effects of climate change, and on the human activities in agricultural production (Walthall et al. 2012).

Therefore, it is necessary to carry out the systematic practices to be able to sustain the agricultural production in Asia. Actually sustainable crop production is an agricultural crop production in which the productivity of the agricultural ecosystem and other related ecosystems sustain over the long-term period (Lewandowski et al. 1999). The aim of sustainable agriculture systems is minimizing the use of external inputs and using the natural resources efficiently by reducing their potential environmental impacts (Adnan et al. 2017).

In monsoon Asia, rice is the most important crop and it contributes about 30-76 % of the total daily calorie intake. Rice farming is a major employment for people in rural areas and a greater proportion of their income derives from rice production. About 91% of the total world rice production was occupied in Asia. The top rice producing countries are in Asia such as China, India, Indonesia, Thailand, Bangladesh, Vietnam and Myanmar (FAO 2017). Farmers in Southeast Asia countries cultivate rice more than one time a year because of possessing the climatic conditions that are suitable for growing rice (Lin and Fukushima 2016).

The rice ecosystems in Southeast Asia can be classified into irrigated lowland, rainfed lowland, flood-prone rice and upland rice depending on their adaptation to agroecological factors such as depth of flooded water, rainfall and other cultivation practices. Irrigated lowland rice is grown in puddled soil in bunded fields with ponded water for at least 80% of the crop duration by using irrigation water and rainfall. The rainfed lowland rice needs the same conditions like irrigated lowland rice but depends only on rainfall for its water requirement and therefore, it is not assured to meet the its water requirement. The flood-prone rice is characterized by growing under extreme flooded condition and upland rice cultivation is grown in well-drained soil without surface water for most of the crop's duration (Bouman et al. 2007b).

In recent years, they have used more hybrid and high yielding varieties than local varieties to get high yield and have grown rice intensively especially in irrigated areas. These are leading to soil degradation such as poor soil fertility and heavy metal accumulation in soil due to heavy rely on agro chemicals, and infestation by the pests and diseases because of biodiversity reduction in rice sole cropping. In some rice growing areas, farmers are facing nutrients deficiency problem and soil salinity and alkalinity problems (Hossain and Fischer 1995). Therefore, it is important to work towards a sustainable production system in Southeast Asia.

2.2.1 Integrated rice farming systems

Under flood-prone rice ecosystem, there are so many integrated rice farming systems including, rice-fish, rice-crab, rice-frog, rice-chicken and rice- duck systems. These farming systems are traditional methods practiced in China. In integrated system with rice and fish, the amount of pesticides use is very low because of the pesticide sensitivity of fish. On the other hand, the fish serves as natural enemy to rice pests (Berg et al. 2017). They live together in the same field and mutually rely on each other because the rice plant provides feeds for fish and the fish waste could release the nutrients needed for rice growth that is leading to the low fertilizers requirement. Therefore, it is a sustainable production system because it not only increases farmers' income by diversification and reducing production cost but also generates ecological and social benefits by less use of agro-chemicals (Zheng et al. 2017).

Likewise rice-fish integrated farming system, rice-duck system is also famous symbiotic rice farming. In this system, the ducks control insects effectively and the weed control was done by eating weed plants and seeds. Duck rearing in the rice fields also improves the soil fertility level because of the faeces of ducks. Although the duck activities in the rice field promote the oxidation-reduction of the soil and that enhance the root growth of rice, these movements disturb the growth of weed plants. Then, this system increased rice yield 20% higher than the sole rice cropping and enhanced economic benefits by getting extra products such as ducks and eggs (Hossain et al. 2005). Additionally, it minimized the use of agrochemicals and decreased the labour cost for application that could reduce the negative impacts on surrounding environment and human health. The next advantage of this system is females can involve in this system and get social benefits. This system could enhance the livelihoods of poor farmers by improving their income and health conditions (ibid.).

2.2.2 System of rice intensification (SRI)

The system of rice intensification can be defined as the practices that enhance the optimum rice yield through changing the management of the rice-growing environment including soil, water, and nutrients to get its genetic potential (Satyanarayana et al. 2007). The origin of the System of Rice Intensification (SRI) is from Madagascar in the early 1980s and the French Jesuit missionary father Henri de Laulanié originally developed it. During that time, most of the farmers growing rice needed the new technologies that can provide the optimum yield with minimum use of water. An innovation in rice-farming methods has become available that can increase yields and production, so that economic and food-security goals are met, (b) reduce costs of production, so that profitability is enhanced, and (c) decrease the amounts of irrigation water required. This innovation is called SRI, the technology widely practiced by rice farmers all over the world. By using this method, farmers can get optimum yield 3 times more than the other methods. In this method, famers can reduce their production costs by decreasing agrochemicals use in their fields and that is finally leading to sustainable production (ibid.).

According to Stoop et al. (2002), there are three principles of SRI. The first principle is transplanting young seedlings (8-12 days old seedlings before the start of the fourth phyllochron) with a single seedling per clump in wider squared spacing (25cm by 25 cm up to 50 cm by 50 cm). Early transplanting could promote the potential of tillers emergence in rice plant. Shallow transplanting should be done within 15-30 minutes after uprooting. By planting single seedling per hill and wider spacing, there is no competition among plant roots to inhibit growth and plants could expose more light and air than plant transplanted in narrow spacing. Therefore, the recovery rate of the SRI seedlings is very quick and the establishment of the rice plant is good by ensuring the anchorage of rice roots into the soil. Plant can use the natural resources effectively and can provide higher yields.

The second principle is effective use of water. Generally, irrigated rice is transplanted into a puddled filed with standing water but in this method, seedlings are established into the muddy soils with no standing water. Throughout the growing season, the field is periodically irrigated to keep the soil usually moist, but not saturated condition that can inhibit the generation of rice roots because of disturbance to the oxidation of plant roots and soil. After panicle initiation, it is recommended to maintain 1-3 cm of a thin layer of standing water on the field. In some areas, farmers also practice alternate wetting and drying (AWD) method in which irrigation water is applied a few days after the disappearance of the flooded water. Therefore, the field is alternately wet and dry throughout the growing season. The number of days of non-flooded soil between irrigations can vary from 1 to more than 10 days depending on the number of factors such as soil type, weather, and crop growth stage. The scientists also showed that this method produces more yield than the normal water management practices.

The next principle is mechanical weeding that is done frequently beginning from 10 days after transplanting and at least two times of weeding is needed to get effective control, until the canopy closes but additional weedings could increase the yield. Establishment of plant in squared spacing helps to enter the weeder easily into the fields and enhance good soil aeration. The last SRI principle is organic agriculture in which using organic fertilizers in the place of inorganic fertilizers. In SRI method, the activities of microbes and other organisms in the soil can be improved by applying compost and other organic manures. The excretions of the organic microbes and other organisms could help the formation of soil aggregates and improve the soil fertility.

The rice grown under SRI methods in Malaysia showed higher plant height produced more tilers, biomass, yield and other yield components characters. Therefore, the SRI is the sustainable rice farming because it provided high yield by promoting soil microbial diversity. The numbers of natural enemies and the beneficial insects increased significantly as organic farming under the SRI created a safe, healthy agroecosystem by supporting the existence of a balance between pest and non-pest insect population (Doni et al. 2015).

2.2.3 Integrated nutrient management (INM)

Soil fertility is one of the limiting factors to get the optimum productivity of rice. Soil can supply not only the nutrients necessary for plant growth but also water for conducting photosynthesis. It also serves as a medium for physical support and anchoring of the root system. Depending on the soil types, their properties of retaining nutrients and water are different. At the same time, soil and water management practices affect the nutrients and water availability of rice plants and soil fertility level. In rice production, farmers apply additional inorganic fertilizers and other organic materials such as manure and compost to meet the crop nutrients needs. Balanced fertilizer application can improve the soil fertility and plant growth and finally lead to optimum yield. In Integrated Nutrient Management (INM), it takes considerations of the soil fertility maintenance and additional supply of nutrients from all possible nutrients sources (organic and inorganic fertilizers) to indigenous nutrients in the soil to get optimum crop growth and higher productivity (Man et al. 2001).

The sole application of organic fertilizers with low nutrients contents cannot meet the crop nutrients requirements. Although only inorganic fertilizers application can improve crop yield, their easy losses are leading to environmental pollution. Therefore, integrated use of inorganic fertilizers and organic sources is resulting to sustainable crop production. The integrated nutrient management improves the formation of soil aggregates and sustains the physio-chemical and biological properties of soil. It can ensure the crop to meet the nutrients requirement with indigenous nutrients and applied sources (Thein 2005).

2.2.4 Site-specific nutrient management (SSNM)

Rice is the main food of over half of the world's population. Since poor fertilizer management practices lead to the waste of plant nutrients and subsequent the farmers more cost, it is needed to know what type of fertilizers and how the farmer do practices in the fertilizer management is effective. One of the good methods for rice nutrient management is site-specific nutrients management (SSNM) approach and it was developed by IRRI for rice cultivation in Asia. It is a nutrient management for rice based on variations of crop nutrients demand grown in specific fields across different locations in a particular cropping season (Pampolino et al. 2007). In general, there are variations in soil fertility within fields depending upon soil types, locations and weather conditions and even in the same field, the fertility level is changing with time. However, it is difficult for farmers to manage fertilizer application according to these variations. Therefore, this approach has been tested in China, India, Indonesia, the Philippines, Thailand, and Vietnam since 1997.

Site-specific nutrient management (SSNM) is a nutrient management for rice depending on the specific site by accounting the nutrient supply of indigenous soil and the amount of nutrients applied may be different depending on the growing season (Dobermann and Fairhurst 2000). In this approach, farmers have to establish the attainable yield depending on cultivars and climate because yield reflects the total amount of nutrients needed to get this yield. Then, the amount of fertilizers needed to apply is calculated by considering the deficit between plant nutrient requirement and soil nutrient supply to meet crop nutrient demand. To optimize use of nutrients from indigenous soil, evaluation of existing soil fertility can be done by assessing crop nutrient uptake in nutrient omission plots. Additionally, it is needed to consider other agricultural cultivation practices, fertilizer use history and soil types. The next step is calculation of fertilizer requirement to fulfill the deficit (Dobermann et al. 2002).

Nitrogen (N) fertilizer is important in rice production. In this method, it is needed to adjust the quantity of nitrogen applied in relation to the amount of nutrients supplied by soil. In soil, nitrogen availability may be varied depending on the application method of nitrogen fertilizers. Therefore, the application rate, time, placement and kind of fertilizers used as source play very important role for nitrogen management. Apply N fertilizer several times during the growing season to ensure that the crop's nitrogen need is supplied, particularly at critical growth stages (Dobermann and Fairhurst 2000).

The first step is to calculate the crop nitrogen requirements which can vary depending on varieties, and then determine the supply of indigenous sources such as soil, and biological nitrogen fixation. By subtracting the soil supply from the crop requirement, the amount of inorganic and organic sources needed to apply can be estimated. The SSNM Approach for Fertilizer N Management in rice is use of leaf color chart (LCC) with four green color panels. By comparing the colors of fully expanded topmost leaf with LCC, farmers can adjust the rate of fertilizer N needed to apply whenever the leaf color is pale green. Farmers may know their crop N requirements easily as it is a visual and subjective indicator for plant N deficiency, (Witt et al. 2004). In general, the amount of nutrients requirements may be different depending on the growth stages and split application makes ensure the crop to meet the amount of nitrogen required for each stage. This method maintains the indigenous nitrogen supply.

Besides N management, phosphorus (P) and potassium (K) management is also important for rice production. Like N management, it is needed to estimate the need for application by predicting the amount of nutrients supplied from soil. These nutrients cannot be readily lost like N but it is important to maintain the available soil nutrients because indigenous P and K supply is mainly depending upon the overall nutrients balance. Therefore, there are relationships among P, K, other nutrients and other factors. It is needed to take account the residual effects of fertilizers (Dobermann and Fairhurst 2000). It is recommended that P and K fertilizers application should be done at the early growth stages in SSNM approach. The principles of P and K management are to ensure the crops to meet their P and K requirement without affecting the crop growth reduction, use the indigenous P and K effectively, and sustain the nutrient supply of soil by returning crop residues into the soil. Moreover, P and K management enhances pest resistance and lodging and promotes the nitrogen use efficiency. Increasing nitrogen use efficiency under SSNM approach is leading to less negative impacts on environment and getting more profits through increased yields with low production cost (Buresh et al. 2010).

For other macronutrients like Ca, Mg and S, and other micronutrients, the key management tools are prevention, diagnosis and the treatment. Cultivation practices and use of suitable varieties can reduce the nutrients deficiency and toxicity problem. The most important one is changes in soil management practices should be done when the toxicity problem occurred. On the other hand, the deficiency and toxicity symptoms can serve as a tool for nutrients management (Dobermann and Fairhurst 2000).

2.2.5 Alternate wetting and drying (AWD)

Alternate wetting and drying (AWD) is a technology developed by International Rice Research Institute with the aim of saving water in rice production. In this method, rice-growing farmers save the irrigation water by managing the time of irrigation. The field is irrigated in a few days after the disappearance of the flooded water. To determine the water level in the soil, a field water tube (30 cm long, 10-15 cm diameter) is hammered into the soil. If the water level in the tube is below 15 cm of the soil surface, the field is flooded to reach above 15 cm of the soil surface. After irrigation, the water depth will gradually decrease. When it reaches below 15 cm of the soil surface, irrigation is done again (IRRI 2017).

In AWD, the soil is not continually flooded throughout the growing season and the field is alternately wet and dry. The times of irrigation depend on the plant growth stages, soil type and weather condition. In the field practiced AWD method, the water productivity is high as the water use decreases 25.4% compared with the field with flooded water during the whole growing season (Carrijo et al. 2017). Another experiment in China resulted that use of alternate wetting and drying method in lowland rice growing area, save 40–70% of irrigation water without affecting yield (Bouman et al. 2007a).

2.2.6 Sustainable Rice Platform (SRP)

The SRP is an association consisting of 29 institutional stakeholders including research centres, private companies, government organizations and also non-government organizations from all over the world. It was started in 2011 and the SRP mainly focuses on the development of rice production system to be efficient in use of resources and resilient to climate change. The goal of SRP is to reduce the environmental impacts of rice production and consumption and enhance smallholder incomes and contribute to food security (SRP 2015).

The SRP worked out three instruments that are closely related each other. These are

- SRP Guidelines for Sustainable Rice Cultivation
- SRP Performance Indicators for Sustainable Rice Cultivation and
- SRP Standard for Sustainable Rice Cultivation

The guidelines include the practices, criteria and principles concerning with sustainable production and the twelve SRP Performance Indicators are as follows.

- Profitability: net income from rice
- Labour productivity
- Productivity: grain yield
- Food safety
- Total water productivity
- Nutrient-use efficiency: N
- Nutrient-use efficiency: P
- Pesticide-use efficiency
- Greenhouse gas emissions
- Health and safety

- Child labour
- Women's empowerment

Based on these indicators, the SRP standard contains forty-six requirements which are structured under the following eight themes.

- Farm management
- Pre-planting
- Water use
- Nutrient management
- Pest management
- Harvest and postharvest
- Health and safety
- Labour rights

The standard not only can help the farmers to assess the sustainability of farmers' practices but also can be used as a special tool to develop the farmers' adoption of sustainable practices for rice production. The points are defined depending on the difference levels of farmers' performance for each requirement. There are also essential performance levels for each requirement. The score on the SRP standard is from 0 to 100 that can be calculated by the following equations

Score on standard (0-100) = total number of points corresponding to actual performance/ Maximum number of points possible x 100

Based on score, it can be divided into two claims: "working toward sustainable rice cultivation" and "Sustainably cultivated rice". The first one refers to the farmers who get score between 10 and 99, but do not meet the essential performance levels of one of the requirements. The second refers that the farmers have to get score at least 90 and perform the essential levels for all requirements (ibid.).

2.3 Rice Production in Myanmar

Rice is a very important crop for Myanmar people with being a large part of Myanmar diet. It is mostly grown in the monsoon season but in some areas, green gram or groundnut or white cow pea are grown in November after monsoon rice and then harvested in February as a second crop. Some farmers grow summer paddy after monsoon paddy and then harvest in March. Most of the rice growing areas are mostly located in irrigated area of dry zone, and delta and coastal area and cultivated by smallholder farmers who have less than 3 hectares of land.

Although the Ministry of Agriculture, Livestock and Irrigation (MOALI) promotes the development of rice production through the support of improved seeds and other inputs with modern technologies, the rice productivity is still low without effective use of resources. Moreover, productivity of rice farmers in Myanmar remains still low in comparison to international competitors and neighbor countries. The country's average yield is about 4.06 metric ton ha-1 while the yield of Asian countries such as China is 6.58 metric ton ha-1 (DAP 2012). Paddy production in Myanmar and neighboring countries (2010-11) is shown in Table 2. The support of seed by Government was very low and farmers had seed problems in the recent year. Table 2 shows distribution of quality rice seeds in Myanmar

Table 1 Sown area, harvested area, production and average yield of rice in Myanmar

Year	Sown Area (000) (acre)	Harvested (000) (acre)	Production (000) ton	Average yield (ton/ha)	Average yield (baskets/ac)
2000-2001	15713	15573	20986.9	3.3	66
2005-2006	18259	18246	27245.8	3.55	71
2010-2011	19885	19796	32065.1	3.95	79
2011-2012	18762	18698	28552.1	3.7	74
2012-2013	17893	17270	26216.6	3.7	74
2013-2014	17999	17181	26372.1	3.75	75
2014-2015	17722	16975	26423.3	3.8	76
2015-2016	17821	16728	26210.3	3.8	76

Source: Adapted from CSO 2016

Table 2 Distribution of quality rice seeds in Myanmar

Year	baskets
2000-2001	573000
2005-2006	-
2010-2011	277000
2011-2012	168000
2012-2013	111000
2013-2014	104000
2014-2015	955000

Source: Adapted from CSO 2016

The use of fertilizers in rice production increased gradually from 1 kilogram per acre in 1966 to 57 kilogram in 1993 as the government reduced the fertilizer prices as a subsidize to farmers (Young et al. 1998). The Fertilizer Law was enacted on 1st October 2002 for the management of fertilizer utilization, production and distribution. The government has also allowed the private sector to import and distribute fertilizers. The quality check for imported fertilizers is assigned to the Land Use Division under Department of Agriculture (DOA 2013). Table 3 describes the use of fertilizer in rice production.

Pesticides use has started in Myanmar since 1960 and the amount of use was relatively very low. A Pesticide Law was enacted on 11 May, 1990 for the management of pesticide utilization, production and distribution. There is Pesticide Registration Board of the Plant Protection Division, under the Department of Agriculture. The quality test is conducted by this board before going into the market. The data of pesticide use for rice in Myanmar is mentioned in Table 4.

Table 3 Utilization of fertilizer for rice (absolute values in metric ton)

Year	fertilizer
1985	324972
1990	109098
1995	305109
1999	101568
2000	215176
2001	82556
2002	58284
2003	3911
2004	343
2005	3192
2006	6698
2007	3116
2008	10959

Source: Adapted from CSO 2010

Table 4 Use of pesticides for rice production in Myanmar

Year	Solid (pound)	Liquid (gallon)
2000-2001	-	8388
2005-2006	110	3653
2010-2011	1362281	595716
2011-2012	1883762	732086
2012-2013	5970961	129514
2013-2014	1125917	133429
2014-2015	3062964	292979
2015-2016	4026112	450467

Source: Adapted from CSO 2016

In 2010, The Ministry of Agriculture and Irrigation identified Good Agricultural Practices to get over 100 baskets per acre (over 5 ton ha-1) of paddy and these practices are as follows.

1. Raising healthy rice seedling with raised bed
2. Practice of sparse seedling
3. Covering pre-germinated seeds with well decomposed manure to protect from rain splash
4. Providing systematic care in the nursery
5. Transplant the seedling immediately after removal from nursery
6. Plant seedling no deeper than one and half inches
7. Plant 1 to 2 seedling per hill

8. Ensuring maximum effective number of tillers through alternate wetting and drying
9. Ensuring population density of 120,000 to 150,000 hills per acre
10. Continuous supply of irrigation water
11. Application of balanced inputs
12. Controlling weeds and non-effective tillers by submerging in irrigation water
13. Timely drainage for the ease of harvesting by manual labor or combine harvester
14. Minimizing crop losses at the time of harvest (DOA 2010)

According to Aung (2012), Myanmar has large potential to improve rice production by increasing the rice yields on existing fields, the construction of new irrigation infrastructure and the improved maintenance of existing infrastructure, and changing the virgin land into rice cultivated land. On the other hand, it is needed to get more adoption of modern technologies by focusing in current government policy, the agricultural credit system and setting up more intensive contact between farmers and extension workers and also promoting to get agro-inputs like seeds, fertilizers and pesticides more easily. He (ibid.) also pointed that there was a huge gap in the obtained yield by farmers and research stations due to the challenges faced in farmers' fields such as pest and diseases problems, natural disasters, poor soil and water management, lack of access to credits, inputs, machinery and labour shortage problem. The other constraints that are needed to take considerations in rice productions are late and poor crop management, ineffective extension services, lack of knowledge in post-harvest processes, unstable market and lack of strong governance with weak farmers' associations. The last but not least is role of women in rice production. Myanmar women are skillful labours especially in transplanting, uprooting, hand weeding and harvesting.

2.4 Local institutions, private sectors and collaboration with international organizations

The involvement of agricultural institutions plays a vital role for development of Myanmar rice production. The Ministry of Agriculture, Livestock and Irrigation (MoALI) is conducting the following three main tasks for development of Myanmar Agriculture.

- seed production,
- training and education,
- research and development.

The Department of Agriculture (D0A) under the MoALI is the main governmental institution responsible for providing extension services to the farmers. There are fifteen divisions of DOA including Rice Division, Plant Protection Division, Land Use Division, Agricultural extension Division and Seed Division. Every township has DOA office and the staff introduces new varieties, new practices and supports technically to the farmers (DOA 2017). The Department of Agriculture (DOA) is the institution responsible for the implementation of policies regarding extension and support (Yi et al. 2010).

The only one agricultural university that trains the national human resources to be professional agriculturists who will provide leadership to institutions in the agricultural sector is Yezin Agricultural University (YAU). The Department of Agricultural Research (DAR) is the leading institution for research and innovation. New varieties are released from this institution and it conducts research in different sites around Myanmar in collaboration with the international organizations.

In recent years, the International Rice Research Institute (IRRI) in Myanmar collaborated with Australian aid (AusAid), Australian Center for International Agricultural Research (ACIAR), the MOALI and Department of Agricultural Research (DAR) in conducting field research concerning with rice based cropping systems. The project sites were coastal and delta areas where are the main rice growing areas of Myanmar. They conducted field trials that focused on new best management practices including improved postharvest management of rice-pulses and new rice and pulse varieties with 980 farmer co-operators in lower Myanmar. The Participatory varietal selections were done with local farmers by choosing the new varieties that are adapted with local conditions and tolerant to environmental stresses both rice and pulses because the research published the guidelines for production, post production and management of rice in rice-rice systems and rice-pulses systems (IRRI 2016). This participatory approach worked well and it was easy to get the adoption of farmers (Rahman et al. 2015).

According to the on-station trials, followed by on-farm trials, there is a moderately strong linkage between research and extension, most of extension personnel at township level do not have a close working relationship with research personnel and there is no research and extension coordination body at state/regional levels (DOA 2017). Likewise, there are weak linkages between researchers and extension workers and rarely routinely visits to research stations and extension (Cho 2013). Oo (2007) mentioned that the extension agents had low rely on information and knowledge of research institutions that can offer scientific information and modern technologies. On the other hand, the researchers do not know the requirements and problems faced by farmers without listening to the voice of extension agents. Therefore, the main problem was poor linkages between research and extension system in Myanmar.

In Myanmar, private sector spending on agriculture research and development is weak (Raitzer et al. 2008). However, many of the fertilizers and agrochemicals companies are involved as private sectors in advising and giving information about fertilizers and pesticides application. Moreover, the technicians and sale-officers have more strong relationship with the farmers (AFC 2016). There is weak collaboration between government agencies and private sector in monitoring and evaluation of projects and plans especially in the areas of technology transfer for crop production and quality improvement.

3 Materials and methods

3.1 Description of the study area

Kyaikhto, Bilin and Thaton townships were selected as a study area because these are the target areas for improving rice cultivation of the Gulf of Mottama Project. These three townships are located in Mon State, in the south eastern part of Myanmar (Figure 1). According to HELVETAS (2015), the total conventional households in the selected townships are 48,336 in Thaton, 38,110 in Kyaikhto and 39,207 in Bilin Township. The household size in Thaton, Kyaikhto and Bilin is 4.71, 4.38 and 4.42 respectively. The gender ratio in Thaton, Kyaikhto and Bilin townships indicates that 47% are male and 53% are female. Based on the baseline survey of the GoMP for non-fishery value chain study in total of 15 villages in these three selected township, there were 3814 total household and 27% of households engaged in crop production in agricultural sector, 14% of respondent households were involved in fisheries, 4% of households had livestock business and 55% of selected households identified as landless. Among total households, 9% of households were woman headed. Based on the 610 selected households, 27% worked in crop production, 14% involved in fishery sector and 59% were landless, relying mainly on daily wage labour.

3.2 Data collection methods and selected villages

3.2.1 Literature review

The literature review was conducted by the author of the thesis before and after conducting the field work. Literature for this study was described in the state of knowledge and it was done to get a deep understanding on the cultural practices concerning with rice both in Myanmar and in Asia. These literatures were occupied by searching on Google scholar, Web of Science and Ovid. On the other hand, former reports and documents that are received from project manager were reviewed to know about the GoMP project in detail. Some data about the support to beneficiary farmers were got from the livelihood officer. Most literature derives from online research on google scholar and in the online data bases Ovid and Web of Science. Most empirical data about Myanmar rice production derives from annual books distributed by DoA and some data was found on the websites of CSO. In terms of research methodology this thesis is based on Oo (2007) from Yezin Agricultural University, Fehle (2017) and Afriyie (2017) from HAFL. Citavi was used for reference management and knowledge organization.

3.2.2 Sampling procedure and household surveys

Both primary and secondary sources of data were used in this study. The primary information was gathered by household interview technique. The interviews were conducted from August to October 2018 to study the cultivation practices in rice production and income of farmers in the gulf of Mottama. The project has given the technical support to some farmers in these villages since 2016 and their interest was to compare the productivity and income of the beneficiary and non-beneficiary households of the project. There were 17 project target villages in these townships. 4 villages from Kyaikhto township, 3 villages from Bilin township and 1 village from Thaton township were selected according to the support of project. These villages are shown in site numbers 16,17,18,19, 22, 23, 28 and 29 of the Gulf of Mottama project map (Figure 1).

There were total of 406 households (182 beneficiaries and 224 non-beneficiaries) in these 8 villages. Data were collected from 106 respondents of the study area through personal interview by using structured questionnaires. The total interviewed people of selected villages are shown in Table 5. Both female and male rice growers were selected. All sorts of cultivation practices, technical and socio-economic data were collected by interview with 1:1 ratio of beneficiaries and non-beneficiaries were selected from each village to compare the income and rice productivity of these two groups. A purposive random sampling method was used to select households for personal interview.

Information about rice production technology, cost and benefit of rice production and sources of income and other relevant demographic information such as farmers' age, education level, family members, family labour, farm size, seasonal income and home assets have been collected. Detailed data on use of fertilizer, chemicals, paddy yield, social capital, participation in training and farming practices such as land preparation, use of seed rate, chemical fertilizer, transplanting method, harvesting, storage and selling were gathered. Besides, the constraints faced by farmers in paddy production, costs and returns information were also collected.

The entire survey was done by the author and a volunteer from the GoMP project and 90% of respondents were interviewed by the author. After the interview, the author checked the volunteer' data and conducted the data entry together with that volunteer.

Table 5 Total interviewed people of selected villages

Township	Village	No. of beneficiaries		No. of non-beneficiaries	
		Male	Female	Male	Female
Kyaikhto	Boyargyi	7	1	8	1
	KaYwel	4	2	4	2
	MokeKaMaut	6	1	7	
	KhwarChaung	3	3		
Bilin	YwaTanShae	6	3	1	3
	PaukTaw	6	1	6	
	MuThin	3	6	9	
Thaton	GoePhyuGone	3	4	6	
		38	21	41	6
Total		59		47	

3.2.3 Focus Group Discussions (FGDs)

A total number of 14 FDGs were conducted in the surveyed area. Two FGDS, one for beneficiaries and one for non-beneficiaries, involving six to nine persons who were selected for household interviews were conducted in each village except Khwar Chaung and Ywa Tan Shae. Only FGD of the 6 beneficiaries was done in these two villages because there were no enough non-beneficiaries farmers for FGDS. These FDGs were conducted to know the differences in their knowledge about sustainable rice production between beneficiaries and non-beneficiaries.

The author served as a facilitator and started the FGD by asking the farmers' target yield. And the section opened with keeping crop calendar and farm records, training attendance, soil test, land preparation, invasive species, seed variety, water management, nutrient management, fertilizer use, pest management, pesticide use, herbicide use, harvesting, post-harvest management, rice stubble and straw management, application, storage and disposal of chemicals and labour rights were discussed to investigate their farm sustainability by using the standard on sustainable rice cultivation (Version 1.0) of the Sustainable Rice Platform.

3.2.4 Key Informant Interviews (KII)

KIIs were carried out to improve the quality of information for use in project and program design, implementation, and evaluation. Information and data about the Gulf of Mottama project, situation of Myanmar rice farmers, farmers' cultural practices in rice production in the GoM region and other regions of Myanmar, responsibility of department of irrigation and drainage and extension agents of DoA and the varieties released by DAR. Different questionnaires are used for each expert depending on their expert. 10 experts who are listed in Table 6 were interviewed. Direct interviews were made with most experts and some experts were asked via phone.

Table 6 Name and Position of experts

Name	Position	Organization	Location
Karin Eberhardt	Consultant (Former Head of Agriculture and Fishery Sector)	Swiss Agency for Development and Cooperation	Yangon
U Tun Zaw Htay	Agriculture officer	HELVETAS Myanmar	Mawlamyine
U Kyaw Kyaw Naing	Staff officer	Department of Irrigation and drainage	Ya Me Thin
Dr. Kyaw Ngwe	Professor and Head	Yezin Agricultural University	Nay Pyi Taw
Dr. Aung Kyaw Myint	Associate Professor	Yezin Agricultural University	Nay Pyi Taw
Daw Ei Phyu Thae	Lecturer	Yezin Agricultural University	Nay Pyi Taw
U Cho Win	Assistant Staff Officer	Department of Agriculture	Bilin
U Nay Myo Thu	Assistant Staff Officer	Department of Agriculture	Bilin
Daw Than Than Win	Deputy Assistant Staff Officer	Department of Agriculture	Kyaikhto
Daw Khin Sandar Cho	Junior Research Assistant	Department of Agricultural Research	Nay Pyi Taw

3.3 Data analysis

Data entry was done by using the Microsoft Excel program. The analytical techniques used in this study were descriptive analysis and regression analysis using the squared root transformation to the dependent variables (rice yield and profit) to estimate the influence of dependent variables for each model. Microsoft Excel was used for descriptive analysis and the regression model and some descriptive analysis were run in R programming.

3.3.1 Descriptive analysis

We use descriptive analysis to describe the demographic and socio-economic characteristics, sown areas, average sown areas, cultivated varieties, inputs used in rice production and general constraints faced by beneficiary and non-beneficiary households of the Gulf of Mottama Project.

3.3.2 Regression Analysis

In this study, we use multiple linear regression function to determine the influence of project membership and other cultural practices on yield and profit of the rice fields of selected households.
For yield function, the dependent variable was squared root form of rice yield of the selected fields of sampled households and independent variables were membership (beneficiary=1, non-beneficiaries=2), variety type (Pawsan=1, Byawtthukha=2, kyarpyan=3, Manawthukha=4, Nagayar=5, others=6), number of tillage, establishment methods (transplanting by hand=1, transplanting by fork=2, direct seeding=3), seed rate and use of herbicides (Use=1, Not use=2). The regression function is as follow:

$$\text{sqrt } Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + F_{1i} + F_{2i} + F_{3i} + F_{4i} + \mu_i$$

Where:

sqrt = square root

i = i^{th} field in the sample

Y = rice yield (baskets)

X_{1i} = number of tillage

X_{2i} = seed rate (baskets)

F_{1i} = project membership (beneficiary=1, non-beneficiaries=2)

F_{2i} = rice variety type (others= 1, Pawsan group=2, Byawtthukha group=3, kyarpyan group=4, Manawthukha group=5, Nagayar group=6)

F_{3i} = establishment methods (transplanting by hand=1, transplanting by fork=2, direct seeding=3)

F_{4i} = use of herbicides (Not use=1, Use=2).

β = Unknown parameter to be estimated

u_i = Disturbance term or error term

For profit function, the dependent variable was squared root form of profit of rice production by sample households, six independent variables which related to profit were shown in as follow:

$$\text{Sqrt } Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + F_{1t} + F_{2t} + F_{3t} + F_{4t} + \mu_t$$

Where;

t = t^{th} field in the sample

Y_t = Profit (000 MMK/acre)

X_{1t} = land preparation cost (MMK/acre)

X_{2t} = price per basket (MMK/basket)

F_{1t} = project membership (beneficiary=1, non-beneficiaries=2)

F_{2t} = rice variety type (others= 1, Pawsan group=2, Byawtthukha group=3, kyarpyan group=4, Manawthukha group=5, Nagayar group=6)

F_{3i} = use of herbicides (Not use=1, Use=2).

F_{4i} = selling place (selling at village level=1, selling outside village=2)

β = Unknown parameter to be estimated

ut = Disturbance term or error term

3.4 Limitations of the Research Process

A number of limitations and challenges were faced in questionnaire preparation, data collection, entry and analysis.

It was observed that the local differences in cultivation practices and terminology within my first field visit to Mon State. They had only rainfed cultivation in the monsoon season without irrigation. And it was difficult to understand the method of rice cultivation due to the use of local terms in inputs such as fertilizers, pesticides, seeds and machinery. Therefore, the questionnaires were changed many times to be relevant with the local conditions.

During data collection, there were no farm records in most of farmers and they took time to answer the questions precisely. Confusing in answering the yield, income and cost of rice production was occurred. It was hard to describe their activities and cost in detail and calculations for some farmers had been done while asking them the questions. The next one is that there was asking the same question several times because of the accent of local people. Absence of some selected farmers was found in a village because of the special festival and new farmers were resampled and substituted in the place of them. The women participation was low because most of the farmers are male in these villages. Some knowledgeable farmers influenced on the illiterate farmers during focus group discussions. For key informant interviews, some experts had no enough time to give the complete answers and it was not easy to meet them and compensated interviews with their junior staff from the same department were conducted.

Differences in terminology were also a problem at the time of data entry, especially concerning with the units for counting the seedlings and yield. It took time to exchange their yield and calculate the income.

The most difficult time was analysing the data because of so many variables that we collected in survey. The program we used, R, is hard to use in the beginning for data management before starting analysis. It took so much time. In formulating the regression model, it was difficult to select a number of variables that would influence on yield and profit. After doing regression diagnostics, we transformed the independent variables into squared root form to adjust the models. Therefore it was very hard to interpret the regression coefficients of squared root transformed models and for data visualization. To solve these big problems, we have to choose which practices were most used by the selected households to interpret the results.

4 Results and Discussion

The Gulf of Mottama Project (GoMP) is working with rice farmers in 17 villages distributed over three districts (Kyaikhto, Bilin and Thaton) in Mon State. These beneficiaries of the Project were selected on the basis of their own interest. GoMP beneficiaries get access to technical knowledge through training of farmer leaders. In addition, the Project provides inputs (fertilizer, seed) on credit to beneficiaries. In 2018 she project started to facilitate Farmer Field Schools to its beneficiaries. We studied the question, if and to what extent project activities changed the rice production practices of farmers and how this influenced productivity. To this end, we interviewed both beneficiary households and non-beneficiary households in 8 villages out of the 17 project villages.

In this section, the detailed socio-economic and demographic characteristics of beneficiary and non-beneficiary households are described. The rice production practices and their influence on yield, destination of rice, economic performance of rice and sources of income for households are analyzed.

4.1 Demographic and socio-economic characteristics and income sources of the beneficiaries and non-beneficiaries' households of the GoMP

4.1.1 Socio-economic characteristics of the interviewed households

In our sample, the average age of the household heads was 53 years, with little difference (not significant) between beneficiaries and non-beneficiaries (Table 7). Household heads had on average 27 years of experience with rice farming, again with little difference between beneficiaries and non-beneficiaries (Table 7).

Table 7 Averge age and experience in rice production of the household heads

Items	Beneficiaries (n= 59)	Non-beneficiaries (n= 47)	t-test (p-value)
Average of household head's age (years)	51.7	54.5	0.249
Average rice farmers' experience (years)	25.2	27.9	0.373

In this study, education level of the household heads was categorized into five groups: (1) "Illiterates" referred those who had no chance to attend the school, (2) "Primary level" referred formal schooling up to 5 years, (3) "Middle school level" intended formal schooling of 6 to 9 years, (4) "High school level" referred formal schooling of 10 to 11 years and (5) "University education" referred to those who passed the state matric exam and studied at college or university. About 12% of beneficiary and about 32% of non-beneficiary of heads of the interviewees' household are illiterates. The respective percentages of each education level for both groups are shown in Figure 3. The Fisher's exact test showed that there was significant difference in education level of household heads between project beneficiaries and non-beneficiaries.

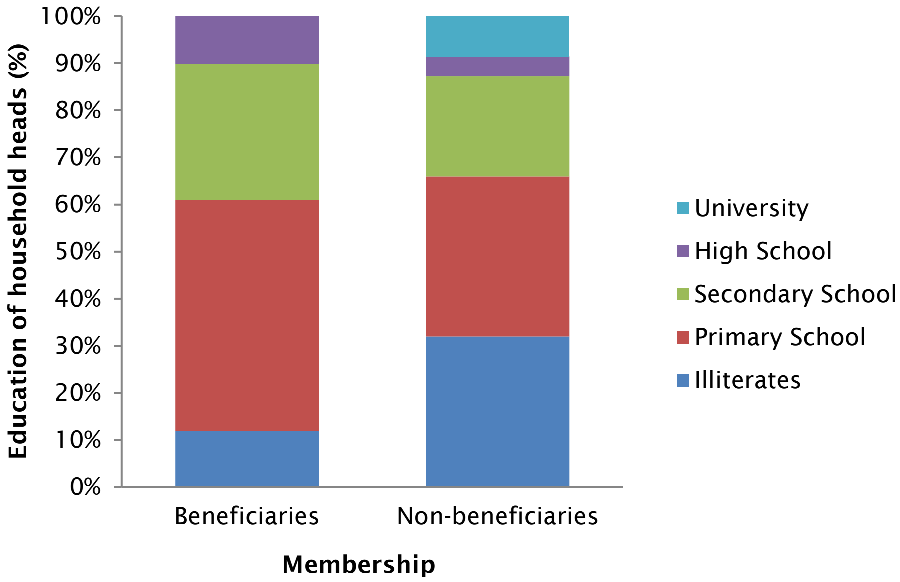

Figure 2 Distribution of education level among household heads of beneficiaries and non-beneficiaries (P=0.009, **Fisher's exact test**)

4.1.2 Average farm size, family size, agricultural labours and household structure of project beneficiary and non-beneficiary households

The average farm size in the sample was 17 acres, with no significant difference between beneficiaries and non-beneficiaries (Table 8). Likewise, the average family size of interviewed households was about 5, and there is no significant difference between beneficiaries and non-beneficiaries (Table 8). The sample households have about 1.34 agricultural labours on average and it was not significantly different between beneficiary and non-beneficiary household (Table 8).

The family members were divided into three groups: pre-schoolers (from 1month to four years old), children (from five up to seventeen years old) and the adults (eighteen years old and above) and their respective average value is shown in Table 8. About 69 % of beneficiary households' members were adults and 77% for non-beneficiaries and the family composition was a little bit different (not significant) between beneficiary and non-beneficiary households (Figure 4).

Table 8 Average farm size and household structure of sample households

Items	Beneficiaries (n= 59)	Non-beneficiaries (n= 47)	t-test (p-value)
Farm size (acres)	16.8	17.9	0.768
Total household members (No. of persons)*	5.1	4.6	0.104
1. Pre-schoolers (No.)	0.2	0.1	
2. Children (No.)	1.4	1.0	
3. Adults (No.)	3.5	3.6	
Family agricultural labor (No. of persons)	1.4	1.3	0.102

* Numbers of sub-categories do not exactly add up to Total household member due to rounding

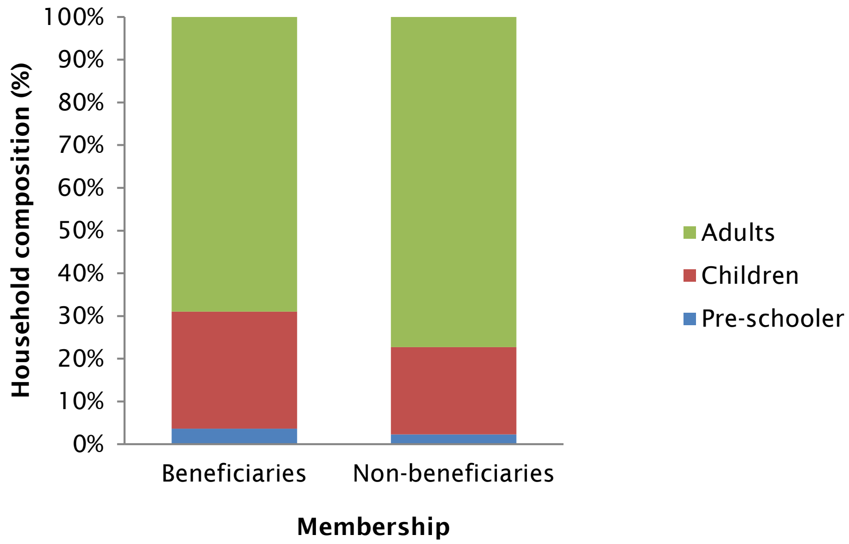

Figure 3 Household composition of the selected beneficiaries and non-beneficiaries households (p-val ue = 0.106, **Pearson's Chi-squared test**)

4.1.3 Percent share of total household income of project beneficiary and non-beneficiary households

In our study, the household income of sampled households was the sum of the income received from all sources. The household income was divided into four main sources; income from rice sales, income from other crops sale, income from livestock sale and incomes from non-agricultural activities. Income from rice was got by subtracting the cost of inputs for rice form the earnings by selling rice. Income from other crops was calculated by subtraction of total cost for rubber, pomelo, betel, rambutan, cashew nut, cucumber and eggplant from the total revenue from each crop production. Income from livestock was that the total earnings from cattle, pig, duck, chick production and fishery minus was income from selling goods, government or company staff, labor income, motorcar, motorbike driver and handicraft, other home based work and remittance.

The average income from sales of rice, other crops, livestock and non-agricultural activities were 1,700,000 MMK, 614,000 MMK, 299,000 MMK and 1,045,000 MMK per households, respectively. There was no significant difference between beneficiary and non-beneficiary households in all these average incomes derived from each sources (Table 9).

Table 9 Average household income from all sources by beneficiary and non-beneficiary households (in Thousand MMK)

Income source	Beneficiaries (n= 59)	Non-beneficiaries (n= 47)	t-test (p-value)
Rice sales	1,682	1,719	0.945
Other crops sales	46	76	0.565
Livestock sales	394	206	0.129
Non-agricultural activities	1,140	950	0.415

Percent share of the household income for beneficiary and non-beneficiary households is shown in Figure 5. In both beneficiary and non-beneficiary households, the main source of income was income from rice which contributes 52% and 59% of the household income respectively. The non-agricultural income was occupied about 35% of total income of beneficiaries and 31% for non-beneficiaries. In both type of households, the household income derived from sales of other crops and livestock was relatively less than others. They contributed only about 1% and 12% of total income of beneficiaries and 3% and 7% of total household income of non-beneficiaries respectively. The percent share of the household income derived from four different income sources was not significantly different between beneficiary and non-beneficiary households (Figure 5).

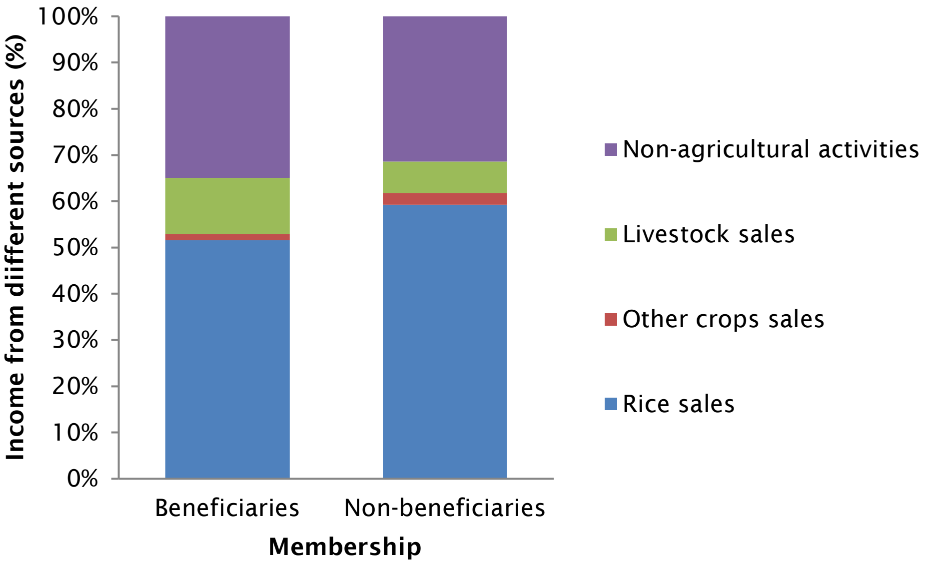

Figure 4 Percent share of income sources of beneficiary and non-beneficiary households (P=0.412, **Fisher's exact test**)

4.2 Sown area, varieties and inputs used by project beneficiary and non-beneficiary households in 2017 monsoon rice production

4.2.1 Average rice sown area of project beneficiary and non-beneficiary households

The average sown area of monsoon rice by interviewed household was about 16 acres. There was no significant difference in the average sown area between beneficiary and non-beneficiary households (Table 10).

Table 10 Average rice sown area of beneficiary and non-beneficiary households during 2017 monsoon season

Item	Beneficiaries (n= 59)	Non-beneficiaries (n= 47)	t-test (p-value)
Average sown area in acres	14.90	16.57	0.550

4.2.2 Cultivated rice varieties by project beneficiary and non-beneficiary households in 2017 monsoon season

The interviewed households cultivated twenty six rice varieties in 2017 monsoon rice production season. The 32% of beneficiary households cultivated Nagayar variety and it was followed by Taungpyan (27% of B households). Taungpyan was mainly grown by 30% of non-beneficiary households and the second mostly cultivated by 26% of non-beneficiary households was Pawsanbaykyar. Figure 6 shows the percent of rice varieties cultivated by beneficiary and non-beneficiary households. The description for each variety is mentioned in Table 11.

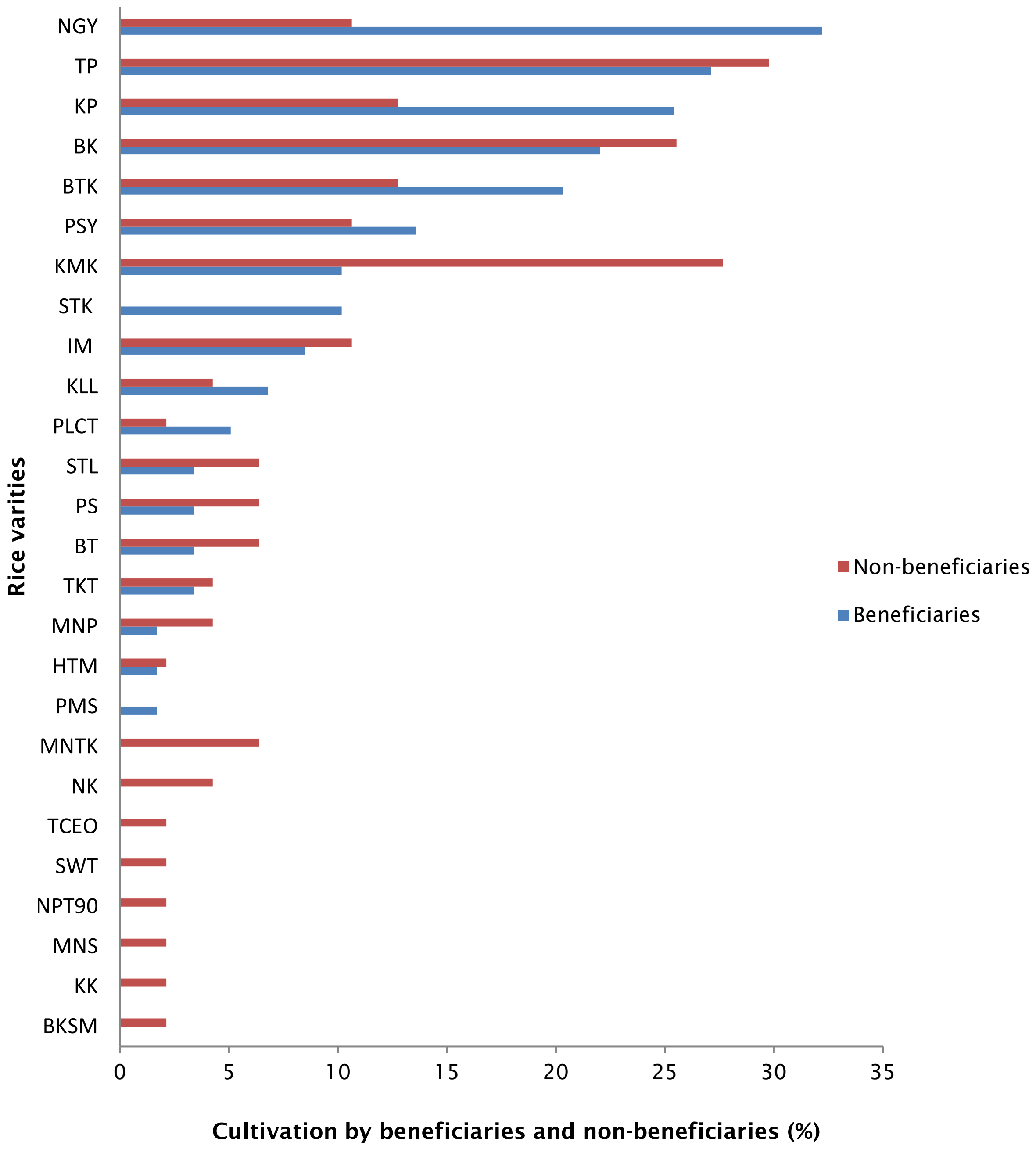

Figure 5 Cultivated rice varieties by sampled households with their respective percentage of cultivation during 2017 monsoon rice season (p value = 0.412, Fisher's exact test)

Table 11 Description for cultivated rice varieties

Code	Variety name	Parents	Breeding line no.	Origin	Year of release
BK	Pawsanbaykyar	Pawsanhmwe Mutation		Myanmar	1955
BKSM	Bangkoksanmar			Bangkok	
BT	Byawttun	Sinthukha Mutant		Myanmar	
BTK	Byawtthukha	SinthukhaMutant		Myanmar	
IM	Inmayaebaw	local		Myanmar	1976
KK	Kaukkyi	local		Myanmar	
KLL	Kalarlay	Ngwetoe (pure line selection)	(C 53-39)	Myanmar	1953
KMK	Kamarkyi		(D 17-88)	Myanmar	1917
KP	Kyarpyan	local		Myanmar	
MNP	Manawpyat				
MNTK	Manawthukha	Taichunj65/*2MayangEbos 80	(Mahsuri-M)	Malaysia	1978
NGY	Nagaryar	local		Myanmar	
NK	Ngakywel	local (D-25-4)	(D-25-4)	Myanmar	1925
MNS	Manawshare				
NPT90	Naypyitawkosare			Thailand	
PLCT	Pyi lonechanthar	local		Myanmar	
PMS	Pyimyanmarsein	IRRI 126/ IRRI 135	IR10T107	IRRI	2015
PS	Pawsanhmwe	local (pure line selection)	local (D44-8)	Myanmar	1945
PSY	Pawsanyin	Pawsanhmwe Mutation		Myanmar	
HTM	Hotelhmwe	local		Myanmar	
STK	Sinthukha	Manawthukha/IRBB21		Myanmar	2009
STL	Seinthalay	C4 63/ C4113	(x69-2-27)	Myanmar	1976
SWT	Shwewartun	Yarkyaw2mutant (IR 5 Mutant)		Myanmar	1972
TCEO	Thaiceo			Thailand	
TKT	Thukhatun	local		Myanmar	
TP	Taungpyan	local		Myanmar	

Source: Adapted from DAR 2015

4.2.3 Inputs used in monsoon rice cultivation by beneficiary and non-beneficiary households

According to the survey, 79% of households used chemical fertilizers for rice production. Among chemical fertilizers, urea was mainly used by both beneficiary and non-beneficiary households. Compound and T-super were used by about one fourth of beneficiary households. The potash was used by only 8% of the total households. 14% of the sampled households used organic fertilizer (compost and farmyard manure). One tenth of the beneficiary households used pesticides and herbicides. The number of herbicides used beneficiaries was relatively less than that of non-beneficiaries. One fourth of the non-beneficiaries used herbicides for rice production. The number of households that used each chemical fertilizer, pesticide and herbicide are not significantly different between beneficiary and non-beneficiary households (Table12).

Table 12 Households using inputs for 2017 monsoon rice cultivation (percentage)

Items	Beneficiaries (n= 59)	Non-beneficiaries (n= 47)	Statistical test	p-value
Compound fertilizer	24	17	Pearson's chi square	0.545
Urea	69	62	Pearson's chi square	0.526
Triple Superphosphate	20	26	Pearson's chi square	0.688
Potash	12	4	Fisher exact	0.293
Chemical fertilizers	78	79	Pearson's chi square	1.000
Compost and FYM	22	6	Pearson's chi square	0.196
Pesticide	8	11	Fisher exact	0.748
Herbicide	10	23	Pearson's chi square	0.115

4.3 Constraints faced by beneficiary and non-beneficiary households in rice production

In conducting land preparation, 11% of interviewed households had labour scarcity problem, 8% for beneficiary households and 15% for non-beneficiary households, with no statistical difference between these two groups of households. Concerning with seed, 20% of total households had bad seed quality problem and 8% have poor access of seeds. As project supported good quality seeds, 72% of interviewed households have no problems with seeds. Only 5% of beneficiary households faced problems with bad seed quality and poor seed access but 38% of non-beneficiary households had bad seed quality and 11% for poor access of quality seeds, with a highly significant difference between beneficiaries and non-beneficiaries (Figure 7).

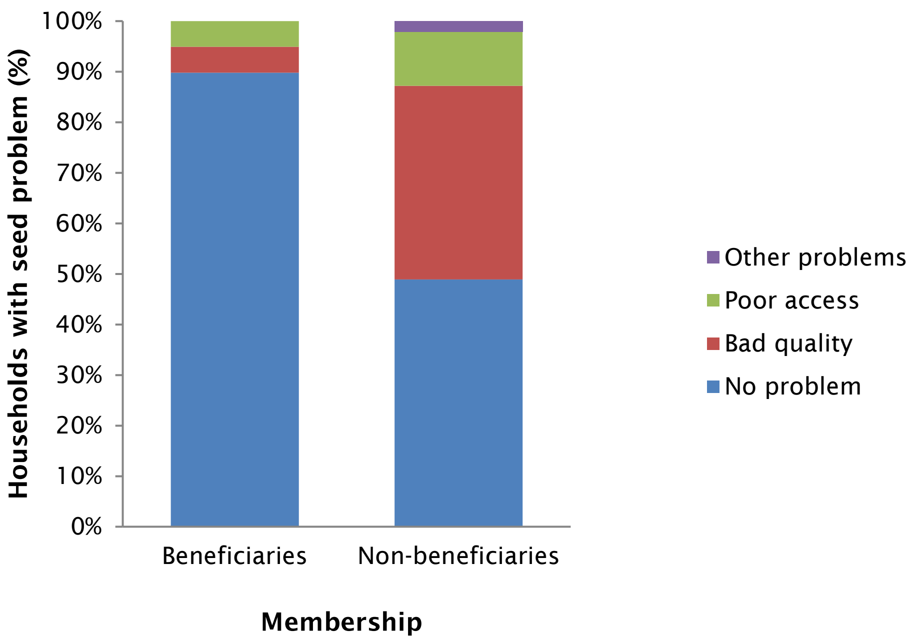

Figure 6 Percentage of beneficiary and non-beneficiary households who faced problems concerning with seeds (p-value = 5.69e-06, Pearson's chi square test)

Although the GoMP project shared the knowledge of compost making to project beneficiary households, there were problems to practice use of compost for rice production in 93% of interviewed households. 61% of the beneficiary households thought that making compost took long time and they had no time to do compost. But about 79% of NB households had no knowledge about compost and this was the main problem for making and using compost. The number of households who faced problems with compost making and use was significantly different between beneficiaries and non-beneficiaries (Figure 8).

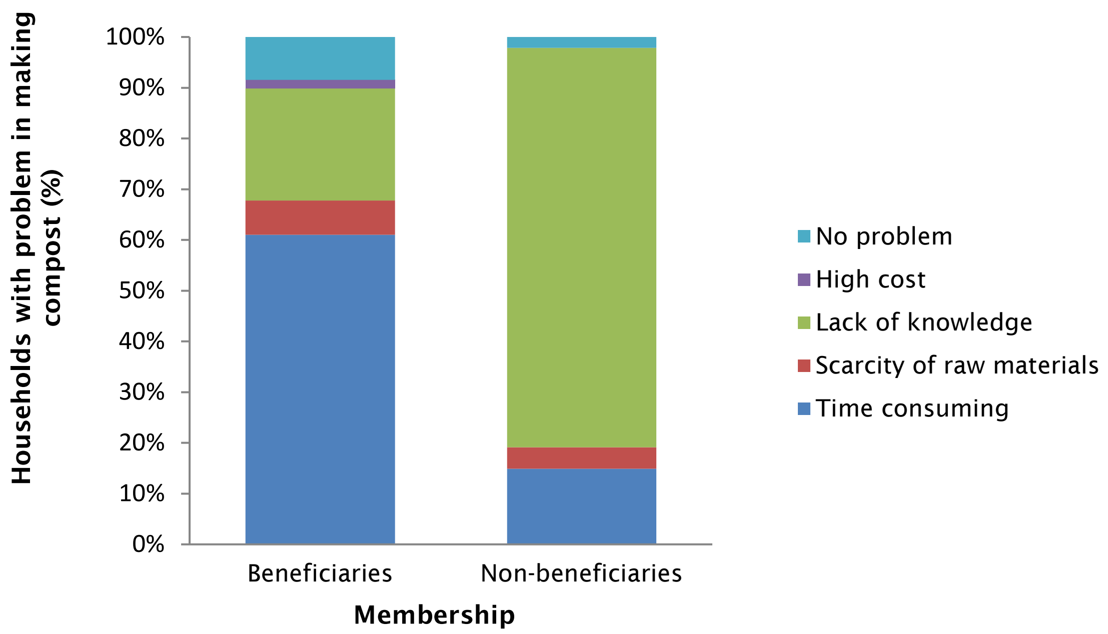

Figure 7 Percentage of sampled households who had problems to make compost (p-value = 2.45e-08, Fisher's exact test)

The major constraint mentioned by 26% of interviewed households was labor scarcity in transplanting and harvesting, 29% for beneficiaries and 23% for no-beneficiaries. 11% of households had problem concerning with climate change, 14% for drainage problem, 7% for finance and 19% for other problems like pest, rodents, diseases, storage and post-harvest problems. In our sample, there was no significant difference in number of households who faced general constraints in their rice production between beneficiaries and non-beneficiaries (Figure 9).

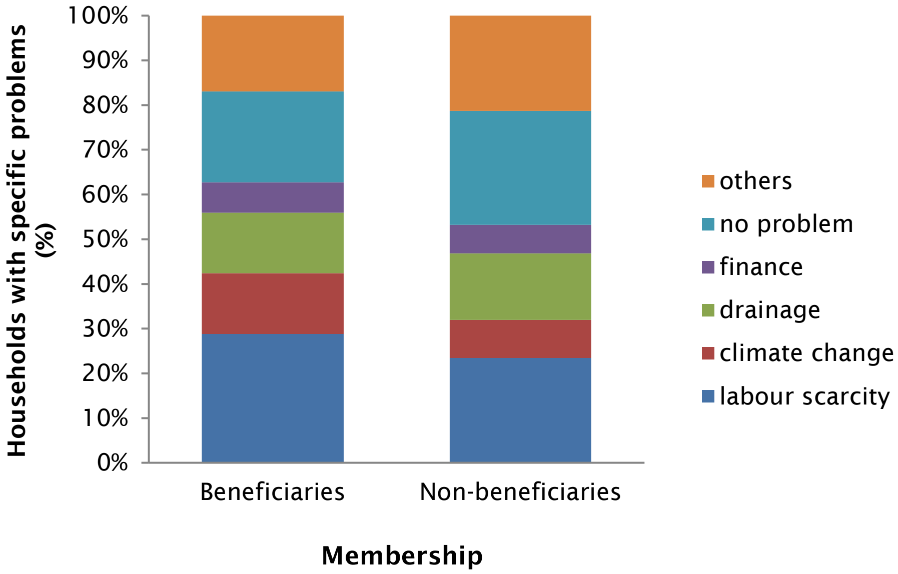

Figure 8 Percentage of beneficiary and non-beneficiary households who faced constraints in rice production (p-value = 0.918, Fisher's exact test)

4.4 Destination of rice by beneficiary and non-beneficiary households in 2017

In this study, estimated rice consumption was calculated by using the rate of rice consumption 150 kg milled rice per capita per year. It was found that 78% of total interviewed households keep rice from their production for their own consumption with no significant difference between beneficiary and non-beneficiary households (Figure 9). Of these, the 63% of households keep enough to cover their annual consumption, on average 2075 kg. 67% of the beneficiaries keep enough rice for their consumption, on average 2085 kg and about 2065 kg of rice was kept by 57% of non-beneficiaries for own consumption, respectively. There was no significant difference in number of households who keeps enough rice for own consumption between beneficiary and non-beneficiary households (Figure 10).

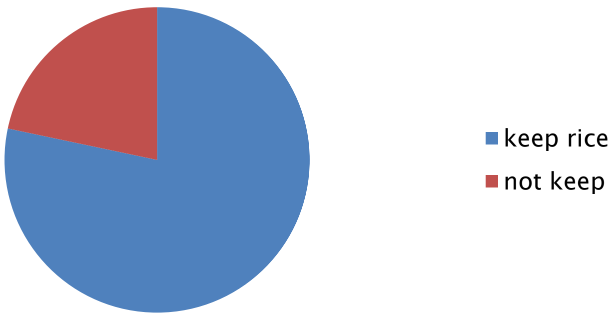

Figure 9 Percentage of selected households that keep rice for own consumption (p-value = 1, Pearson's chi square test)

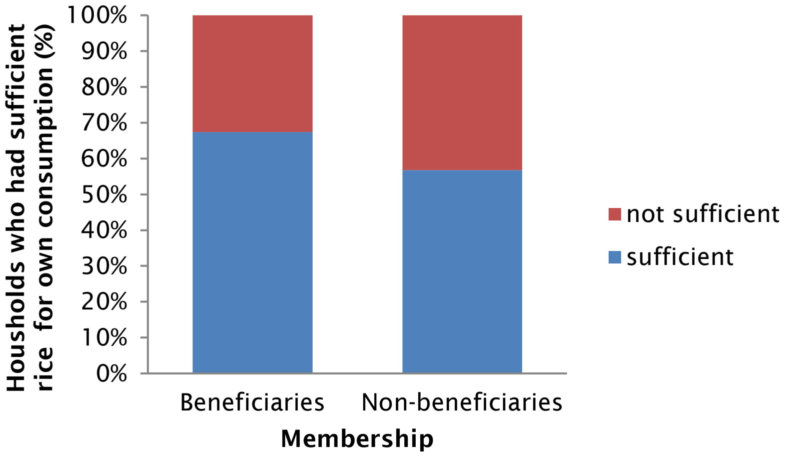

Figure 10 Percentage of beneficiary and non-beneficiary households keeping enough to cover their own consumption (p-value = 0.443, Pearson's chi square test)

4.5 Factors influencing on rice yield and profit of GoMP beneficiary and non-beneficiary households in 2017 monsoon rice production season

This section provides the factors that influenced yield and profit of 2017 monsoon rice production in the study area. The regression analysis was done to determine the influence of cultural practices on yield and profit of rice fields of sampled households. For yield regression equation, the squared root form of dependent variables (yield) was estimated by the variables which are membership, variety types, number of tillage (ploughing and harrowing), establishment methods, seed rate and use of herbicides. In regression model of profit, the squared root form of profit was estimated by membership, variety type, land preparation cost, use of herbicides, selling place, and price per basket. Squared root transformation of dependent variables was done to be normal distribution and constant variance in both models.

According to the descriptive statistics, there were 212 field plots which composed of 56% of beneficiaries owned fields and 44% of non-beneficiary households' fields. In the selected fields, the households cultivated 26 different varieties (Table 11) and these were considered into 6 groups: Pawsan, Byawtthukha, Kyarpyan, Manawthukha, Ngayar and others. The most cultivated variety type was Kyarpyan group and it occupied about 25% of all selected fields and it was followed by Pawsan group, about 20%, Byawtthukha group (11%) and Nagayar (11%). The least cultivated variety group was Manawthukha group (about 3%) and the others occupied 29% of all selected fields. 50% of households did land preparation (ploughing and harrowing) one time by using animals and machines, 44% practice two times of tillage, 8% practiced 3 times and 5% did tillage more than 3 times.

The interviewed households practiced direct seeding for 68% of the selected fields because of the labour scarcity and high labour cost. In 28% of the selected fields, farmers transplanted rice by using transplanting forks and only 2% by hand. The average seed rate was 1.5 baskets per acre. The sampled households did not used herbicide in 86% of their field. Rice yield obtained by beneficiary households (41baskets per acre) was higher than that of non-beneficiary households (36 baskets per acre). The selected fields produced the average yield of 39 baskets per acre and had the average profit of 143,000 kyats per acre, the average land preparation cost was 16,000 kyats per acre, and the average selling price of rice was 6900 kyats per basket.

4.5.1 Determinants on yield in monsoon rice production in study area

According to the regression analysis of rice productivity, there was a highly significant influence of being project non-beneficiaries (p= 0.00596) at 1% level. The fields of beneficiary households produced 5 more baskets of rice than that of non-beneficiary. Land preparation time also influenced negatively and significantly on yield at 5% level (p= 0.04833). The average monsoon rice yield obtained by beneficiary households was higher than that of non-beneficiary households. The more land preparations done in the field, the less rice yield would be. In comparison of the calculated yield for rice field where direct seeding was done with 1 basket per acre of seed rate and herbicide was used, both beneficiaries and non-beneficiaries' rice fields with 1 time of land preparation (tillage) obtained about 3 more baskets than rice fields where tillage was done twice. Doing tillage more than necessary may lead to loss of soil nutrients and resulting in reducing yield. The beneficiary field with 2 time of land preparation produced a little more yield than the non-beneficiary field with 1 time of tillage (Table 7). It could be due to the different ways of tillage (ploughing and harrowing). The beneficiary households know more about conservative tillage as they attended the trainings by the project.

Table 13 Yield (basket per acre) calculated with the model for direct seeding plots which used 1 basket per acre of seed rate and no herbicide use

	Beneficiary households	Non-beneficiary households
Tillage (1 time)	**35.89**	**30.93**
Pawsan	31.44	26.80
Byawtthukha	37.14	32.08
Kyarpyan	36.12	31.13
Manawthukha	32.08	27.39
Ngayar	40.59	35.30
Others	37.97	32.85
Tillage (2 times)	**32.81**	**28.07**
Pawsan	28.57	24.14
Byawtthukha	34.00	29.16
Kyarpyan	33.02	28.26
Manawthukha	29.17	24.70
Ngayar	37.31	32.23
Others	34.79	29.90
Tillage (3 times)	**29.86**	**25.35**
Pawsan	25.81	21.62
Byawtthukha	31.00	26.39
Kyarpyan	30.07	25.53
Manawthukha	26.39	22.15
Ngayar	34.16	29.31
Others	31.75	27.09

Figure 11 shows the difference in calculated yields of fields where herbicides applied and not. Although these are not statistically different, herbicide used fields produced more yield numerically than fields where herbicides were not used. Likewise time of tillage, the herbicide used fields of non-beneficiary farmers produced less yield than the beneficiaries' field where no herbicide was used. It may be due to the improper use of herbicide of non-beneficiaries households. Some non-beneficiary households applied unregistered herbicides and their rice may be burned due to inaccurate application.

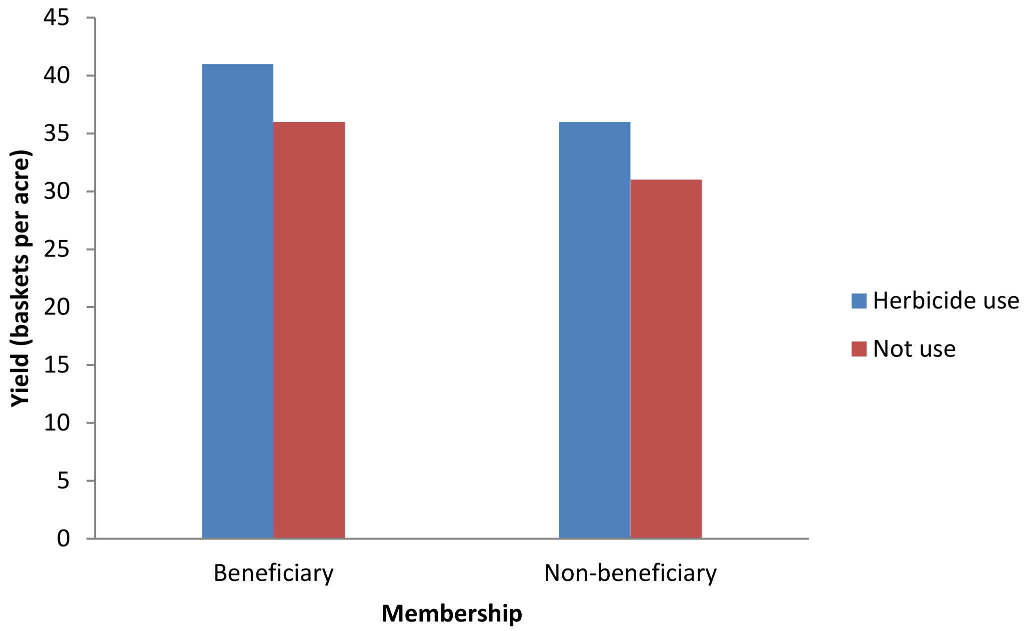

Figure 11 Comparison in average yield of herbicide used and not used plots in 1 time of tillage and direct seeding with seed rate of 1 basket per acre

4.5.2 Determinants on profits in monsoon rice production in study area

The regression analysis for the profit function of rice production results that the rice production profit of rice fields of selected households was negatively and significantly influenced by land preparation cost (p= 0.00363) at 1% level. There is no statistically difference in profits between beneficiary and non-beneficiary households (p= 0.20881). Cost of land preparation affected the profit with land preparation costs of 20,000 MMK, the profit was 12,000 MMK lower than with costs of 10,000 MMK in both beneficiaries and non-beneficiaries (Table 14).

The biggest influence on rice production profit of selected households is selling price (p= 4.72e-10), with fields that sell rice with price of 7000 MMK per basket having about 32,000 MMK per acre lower than with price of 8000 MMM per basket (Table 15). Depending on the varieties, the time and place of selling rice, the selling price is changing. The good quality rice can get higher price and the higher the price the more profit farmers will get.

Although there is no significant influence of selling place on profit statistically (p= 0.14628), the fields that sell rice at village levels provide numerically higher profit (about 38,000 MMK more) than selling outside village (Table 16).

Table 14 Profit (1000 MMK) calculated with the model for rice sales at village level, no herbicide use and selling price 7000 MMK per basket

	Beneficiary households	Non-beneficiary households
Land preparation cost (10000 MMK per acre)	**151**	**132**
Pawsan	118	100
Byawtthukha	163	143
Kyarpyan	154	135
Manawthukha	118	100
Nagayar	197	176
Others	158	139
Land preparation cost (20000 MMK per acre)	**139**	**120**
Pawsan	106	89
Byawtthukha	151	131
Kyarpyan	142	123
Manawthukha	106	89
Nagayar	183	163
Others	146	127

Table 15 Profit (1000 MMK/acre) calculated with the model for land preparation one time and no herbicide use plots

	Beneficiary households	Non-beneficiary households
Selling price (paddy) 7000 MMK per basket	**132**	**114**
Selling at village level	151	132
Selling outside village	113	95
Selling price (paddy) 8000 MMK per basket	**163**	**144**
Selling at village level	183	163
Selling outside village	143	124

According to the model, the herbicide use also influenced on profit (p= 0.01866), with rice fields where herbicide was used having about 60,000 MMK per acre higher profit than the others (Table 16). Herbicide use in direct seeding field may reduce the growth of weeds and assure uniform plant growth and finally leading to get the optimum yield.

Table 16 Profit (1000 MMK) calculated with the model for plots with land preparation cost 10000 MMK per acre and rice selling at village level

	Beneficiary households	Non-beneficiary households
Herbicide (use)	**212**	**191**
Pawsan	175	155
Byawtthukha	226	204
Kyarpyan	216	194
Manawthukha	175	155
Nagayar	263	240
Others	220	199
Herbicide (not use)	**151**	**132**
Pawsan	118	100
Byawtthukha	163	143
Kyarpyan	154	135
Manawthukha	118	100
Ngayar	197	176
Others	158	139

4.6 Sustainable Rice production in selected villages in the GoMP area

This section presents the situation of sustainable rice production of project beneficiary and non-beneficiary farmers during focus group discussions. These one-day-meeting and discussion were hold in all 8 villages where the household survey was done and some of the non-beneficiary households could not possible to join due to poor transportation and lack of information about meeting. The exact number of farmers who had attended trainings concerning with rice production are also shown in Table 17.

4.6.1 Farm Management

All farmers participated in FGDs did not have crop calendar that is the advanced planning for field operation. It was found that farmers have no target yield and they have no plan to adapt with the changing circumstances. Sometimes, they have to do land preparation and rice sowing more than one time due to climate change and flooding. One to two of the project farmers in each village have log books which are distributed to key farmers by the project. Although these books are designed for the whole process of rice cultivation, some farmers did not record well. They think it took time and it was difficult to record their activities in details. Therefore, most farmers have no record books and some keep the average costs and the inputs they used on their mind. Otherwise, one-third of the project farmers attended the trainings concerning with land preparation, nutrient management, post-harvest operations, good agricultural practices, seed production, gender issues and human right while one to two non-beneficiaries from each village attended the annual meetings with government staff from department of agriculture. As they have no record books, they do not know exactly how much they cost for rice production and have no target yield.

Table 17 Participants for focus group discussion (FGD) on sustainable rice production

Township	Village	Membership	No. of participants		Training attendants
			Male	Female	
1. Kyaikhto	1. Boyargyi	Project Beneficiaries	5	1	4
		Non-beneficiaries	5	1	1
	2. KaYwel	Project Beneficiaries	6	4	5
		Non-beneficiaries	4	2	0
	3. MokeKaMaut	Project Beneficiaries	4	3	6
		Non-beneficiaries	6		2
	4. KhwarChaung	Non-beneficiaries	5	3	5
2. Bilin	1. YwaTanShae	Project Beneficiaries	4	6	8
	2. PaukTaw	Project Beneficiaries	5	1	2
		Non-beneficiaries	6	1	0
	3. MuThin	Project Beneficiaries	5	2	4
		Non-beneficiaries	5	1	0
3. Thaton	1. GoePhyuGone	Project Beneficiaries	5	6	5
		Non-beneficiaries	6		0

4.6.2 Pre-planting

Before planting rice, all farmers did not analyze the content of heavy metals such as arsenic, cadmium, chromium, mercury and lead in their soil. Although the closed Sittaung Paper Factory was situated in these project areas, the soil test have never been done before. Farmers have no knowledge about these toxic elements and some farmers used a lot of pesticides five years ago.

One fourth of the farmers faced sea water intrusion in their field and they have no idea to manage saline soil because they do not know how to measure soil salinity and soil pH. A beneficiary farmer in Boyargyi village used salt-tolerant variety (Pyi Myanmar Sein) which is released by DAR and distributed by project to overcome this problem. Some farmers usually apply FYM when they found that the white salt patches on their soil surface. But most of both beneficiaries and non-beneficiaries did nothing special for this problem. In the areas with sloping land, most of farmers level the soil surface and destroy terraces by using the bulldozers without using soil conservation practices.

All farmers participated in FGDs cultivate rice only in the old field. They did not convert the forest into the paddy field most. Golden apple snails, one of the invasive species in rice production areas of Asia, have been introduced into the field of all farmers since 2017 monsoon rice season.

For seeds, most project farmers got good quality seeds from their village seed banks but these were only covered for one third of their land and they used their own seeds and bought seeds form neighbor farmers for the rest land. In case of non-beneficiaries, they usually keep their own seeds from the previous season and sometimes they buy from other farmers whose seeds seemed to be cleaned.

4.6.3 Water Use

Farmers in these selected villages usually practice rainfed rice production system and they have no irrigated field. Therefore, the main problem was difficulty in drainage during monsoon season. Within five years, the climate changes prominently and the entry of monsoon season was delayed and the duration also shortens. It was difficult to coincide crop establishment with the rainfall and there were repeated planting and loss of seeds. On the other hand, heavy rainfall and huge tidal bores lead to flooding and erosion and finally some field were destroyed with poor drainage system (Figure 12). Additionally, water shortage was suffered in some field without provision of rainwater harvesting for supplementary irrigation at critical stages of water requirements for rice. According to their discussion, it was found that governments support on building barriers for tidal bores are rare and poor farmers cannot afford to build these expensive barriers and also to maintain the drainage canals.

Figure 12 Rebuilding of expensive man-made barrier after heavy water flooding in a non-beneficiary farmer's field at Boyargyi village (September 2018)

Figure 13 Main water drainage tube near a beneficiary farmer field at Boyargyi village (September 2018)

4.6.4 Nutrient management

Half of the participated farmers practiced crop rotation (monsoon rice-green gram), two third of the rest grow both summer and monsoon rice and the one third left their field. Both beneficiaries and non-beneficiaries apply fertilizers by observing their plant situation. Both of them never test their soil fertility and they do not know where they can conduct soil analysis. No one in this project area can practice Site Specific Nutrient Management (SSNM). Some poor farmers use fertilizers depending on their financial situation. Urea is the fertilizer mostly used by both groups but the application rate is not more than 50 kg per acre. The project farmers told that balanced fertilizer application not only increases yield but also improves soil fertility and they tried to apply compound fertilizers. One fifth of the non-beneficiaries think that urea is better than the others because the rice plant grows quickly and they prefer it. Only one fifth of the farmers use triple super phosphate (T-super) and murate of potash. It was found that one third of the beneficiary and all non-beneficiaries are using the non-registered inorganic fertilizers that are imported from Thailand. The use of compost was low in their rice cultivation. All non-beneficiaries do not know what compost is and how to make compost. Although all of the beneficiaries know the compost and benefits of compost application, they cannot practice it because of the scarcity of raw materials and taking time.

4.6.5 Pest management

Most farmers do not use chemicals too much now. Only 5 of the beneficiaries and 10 of the non-beneficiaries used chemical pesticide to control the caterpillars. They do not know the application rate exactly because the labels and instruction are written in thai language and they used the instruction of neighbour farmers and the sellers. Most beneficiaries do not want to use chemicals as some farmers died and some suffers diseases in respiratory system in their villages due to careless use of pesticides. A farmer in MokeKaMaut village told that some farmers from his village used a kind of potash containing chemical to kill the wild duck and all the ducks were dead and they not only ate these ducks for their meal but also sold them at village market. This chemical is legally banned and cannot be bought by everyone but the shopkeeper sells the specific users at black market. All farmers usually control the snails by hand-picking. Rodent damage is mostly found at harvest time. Most of the project farmers use their traditional control method like hunting and trapping. One third of the non-project farmers use the registered rodenticides with over rate. To control damage of birds at the time of sowing and before harvesting, both groups of farmers used scare devices.

Figure 14 shows the comparison of the answers about use of chemical inputs, nutrient management and pest managements. It was found that beneficiary farmers have more knowledge about soil fertility management, crop nutrient management and pest management than non-beneficiary farmers and the beneficiary groups participated more active in focus group discussions (Figure 15).

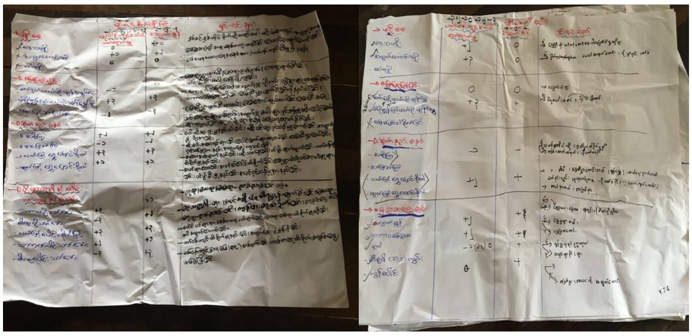

Figure 14 Discussions of beneficiary farmers and non-beneficiary farmers focus group discussions at GoePhyuGone village (October 2018)

Figure 15 Focus group discussion with non-beneficiary farmers at PaukTaw village (October 2018)

4.6.6 Harvest and postharvest

Although all farmers know the best time to harvest when the 85% of the grains turned into straw-coloured, it was not possible to harvest on time due to scarcity of labour and combine harvester. Most of the farmers harvest rice by hand and the rice stubble was grazed by livestock or plowed to improve the soil fertility. The harvested rice was placed on the bunds and dried for 3 to 4 days without covering it at night. After that, the rice was threshed and the brokers come and bought the rice. At that time, the price of rice was low but farmers had no other options besides selling rice at once. They have no enough space and place for storage and they need money to repay the bank loan. So, all farmers except some rich farmers sell all the rice to the brokers. 80% of the farmers in MokeKaMaut and KaYwel villages went to the other side of Sittaung river by boat or by car and sell at the rice miller in Waw township in Bago region. Therefore, the profit of the farmers are low with high production and transportation cost.

4.6.7 Health and safety

All farmers are responsible for their workers if there have accidents during their work time in the field. At the time pesticides application, almost all project farmers used protective clothing, masks, boots and gloves while two-third of the non-beneficiaries did not use these clothing. The pesticides are not applied by women and children below 18 years old in both groups. They always keep the chemicals pesticides out of reach of children. In case of disposal for pesticide containers, all project farmers and two-third of non-beneficiaries burned them or buried at the corners of their field. The rest of non-beneficiaries throw into the drainage canals and the streams. It may be seen that they think the disposal of chemicals containers is not dangerous for their health/

4.6.8 Labour rights

Children of project farmers are not engaged as permanent or seasonal workers. It was observed that a child of non-project farmers in Boyargyi village worked especially for driving machines during land preparation in the field. He (a 16 years old boy with black hat) also participated in focus group discussion (Figure 17). There were no discrimination among workers and farmers have to pay money in advance to get the enough labors. Sometimes, workers run away from the villages and farmer lost their prepaid money. The female wages (4,000-5,000 MMK per day) were lower than that of male (7,000 MMK per day) in both groups as they think that male has more strength to do heavy work than the female. Some children of farmers in study area are working in the rice field depending on the need of their parents.

Figure 16 Focus group discussion with project beneficiary farmers at KaYwel village (October 2018)

Figure 17 Focus group discussion with non-beneficiary farmers at Boyargyi village (October 2018)

4.7 Experts' point of view on situation of rice production and role of different institutions for development of rice production in Mon State, Myanmar

In our study, we interviewed 10 participants who are the experts, officers and staff from different organizations and institutes. Most of them are government staff and responsible for development of rice production in Myanmar. We studied how the government worked for development of rice production, situation of rice production in Myanmar, especially for Mon state and the relationships among rice farmers, extension agents, researchers and staff from different departments.

The main responsibility of DoA are seed production, training, research and development and human resources development. To fulfill these responsibilities, the staff of the DoA, especially the extension agents go to the field to impart new technology to the farmers and conduct demonstration plots with key farmers (2-5 farmers for each township) to show the effects of vermicompost and effective microbes. Although the extension agents want to visit 2-3 times per week, it is difficult to do this. They have no enough support from the office and their salary was low and they cannot afford to go to the village where these are very far (more than 30000 km) from their office with poor transportation. It takes long time to get there. Therefore, they generally visit the field 2 to 3 times per month and meet with the village officers and key farmers. The DoA usually gives the trainings concerning with rice production was usually two times a year just before monsoon rice cultivation season and summer rice cultivation season in large village tracts. These trainings last only one day and teach all about rice production from land preparation to post-harvest operations. Most of the trainers are high level staff officers and they teach their specific topics and the interest of farmers are very low. Most of the farmers do not want to attend these kinds of trainings because it takes time and they do not understand their teachings without practical work. On the other hands, farmers prefer to attend the trainings of the NGOs, INGOs and other private companies as they got money and presents form them. Therefore, their interest on training and their belief on staff are low. The field officer always apologize the familiar farmers to attend the trainings.

In Thaton district, there have no government farm that provides seeds for rice production. The field officers always try to get seed from private farms and distribute to some farmers. The varieties that are mostly distributed to farmers are Paw San Yin and Yet-90. The amount of distributed seed is covered only 20 percent of rice production. Most farmers usually keep their own seeds from the previous season. There is no place to test seed quality and seed purity.

Likewise seed test, the field staff took soil samples from the farmers' fields and gave them to the head of officers two years ago and they do not see the results until now. They feel that farmers do not rely on government field workers and their follower farmers are not more than 5% of total farmers. In case of water management, farmers usually grow rainfed rice and drainage is the main problem for rice farmers. The department of irrigation and water utilization management department (IWUND) checked the drainage canals after monsoon season and estimated cost was proposed and repaired in summer season depending on the budget got from the government. As there are no collaborations among government departments and there were conflicts among farmers and government officers in maintenance of flood protection and drainage facilities. Therefore, it was found that there is no effective extension service that can help the rice farmers and know the needs of farmers.

Concerning with the chemicals used, most farmers in Mon State like to use the pesticides and fertilizers which are written in foreign languages because they think these are more effective. Not only farmers but also the field officers do not know what chemicals are registered or not. Typically, farmers usually get the information about pesticides and fertilizers application from the other farmers. They do not know exactly which kind of chemicals is suitable for their plant situation. Farmers have no knowledge about pest management and soil fertility management. Although there are qualified field officers and extension workers who attended the trainings given by INGOs and the government organizations, their participation in rural development and extension is less due to lack of sufficient facilities and support to them. In practical field, farmers have no one to give the information and technologies. Farmers apply chemicals without safe use and dispose of the containers wherever they want. The non-registered pesticides and fertilizers can be bought easily at black market and the inspectors for chemicals usually check the small retailers but they never go to the large wholesalers. Therefore, strict laws are needed to punish the lawless sale.

The farmers in Mon State generally harvest the rice by using sickles and labour availability is the most influencing factor to harvest the rice timely. Many of the qualified agricultural labours go to the Thailand and Malaysia as permanent workers. There are only 3 combine harvesters in the department of agricultural mechanization in Bilin Township. Therefore, it is relatively low compared with the area of rice cultivations. Farmers are also weak in post-harvesting and they placed the harvested rice in the field and dried for 5 days without storing in the covered place at night. Some farmers lost rice by rodents and rice quality is degraded due to improper drying technique. It is still needed to promote the post-harvest techniques in rice production.

After harvest, most of the farmers sell to the local brokers who define the rice price. Farmers have no chance to define price and have to sell their rice with the lowest price at the harvest time. Some rich farmers have storage place and they sell their rice when the price becomes high.

According to the focus group discussions and key informant interviews, it was found that farmers really need support of extension workers, but the extension agents did not receive enough facilities from the government. Moreover, there is a gap between extension agents and researcher. These are the big barriers to improve the knowledge of farmes.

5 Conclusions

This study was an attempt to to explore current situation of rice production and socio-economic characteristics of project beneficiary and non-beneficiary households and to assess the rice cultivation practices, constraints faced in rice production, rice yield, profit of project beneficiary and non-beneficiary households in Kyaikhto, Bilin and Thahton Townships. In addition, this study investigated the influencing factors on rice productivity and profit of rice production.

It was found that there were no significant differences in average age and experience in rice production of household heads between beneficiary and non-beneficiary households. Most of the household heads finished primary education level but 12% of beneficiary household heads and 32% of non-beneficiary household heads were illiterates. About 55% of their income comes from rice production, 32% from non-agricultural activities including selling goods, government or company staff, labour income, motorcar, motorbike driver and handicraft, other home based work and remittance, 12% from livestock and other crops production.

The average farm size of interviewed households was 17 acres and the average rice sown area of sampled households was 16 acres. Beneficiary and non-beneficiary households used twenty six monsoon rice varieties. The varieties mostly cultivated by beneficiary households were Nagayar (32%), Taungpyan (27%) and Kyarpyan (25%). About 30% of beneficiary households cultivated Taungpyan and 28% of non-beneficiary households cultivated Kamarkyi variety. The average seed rate was 1.5 baskets per acre. About 80% of households applied mineral fertilizers (mainly urea) in rice cultivation. Moreover, about 14% of the sampled households used organic fertilizer (compost and farmyard manure). About 25% of the non-beneficiary households used herbicides and the number of herbicides used beneficiaries was relatively lower than that of non-beneficiaries. In this study, the average productivity of the sample households was 39 baskets per acre with the average profit of 143,000 kyats per acre. One-fourth of the sample households keep rice for their own consumption. Of these, two-third of the households keeps enough to cover their consumption.

Both beneficiary and non-beneficiary households have several constraints concerning with rice production in the study area. Among them, seed quality problem was mostly found in non- beneficiary households. Only a few beneficiary households faced this problem. For asking about compost making, two-third of the beneficiary households think that it takes time and they have no enough time to make compost. About most of non-beneficiary households do not know how to make compost. The other general problems faced by the interviewed households are labour scarcity, climate change, drainage problems and no enough finance.

According to results from the regression analysis, the rice productivity of the selected fields of sampled households was significantly influenced by being project non-beneficiary households, number of land preparation (tillage). The average monsoon rice yield obtained by beneficiary households was higher than that of non-beneficiary households. The more land preparations done in the field, the less rice yield would be. There was no significant influence of establishment methods, use of herbicide and seed rate on rice productivity. In case of profit, land preparation cost and rice selling price influenced significantly and highly on the profit of rice production of selected households. The higher the rice selling price, the more profit would obtain from rice production. Moreover, the costs of land preparation was lower, the profit would be higher. The other significant influence factor on profit is herbicide use and the average profit obtained from the fields where the herbicides used was higher than that of the fields with no herbicides use. However, being project non-beneficiaries, selling place and varieties has no significant influence on profit.

The result of focus group discussions has shown that both project beneficiary and non-beneficiary farmers need to keep record books to predict the production cost and recognize the climate change in recent years because only 22% of project beneficiaries have log books and all non-beneficiary households have no record books.

Although project farmers have much knowledge about sustainable production than non-beneficiary farmers, both groups used chemical fertilizers depending on their financial situation and they have never done soil test. On the other hand there are so many important aspects to be considered such as black markets of chemicals and food safety of local people. It was observed that the selected households' practices were not leading to sustainable rice production. Although project beneficiary households obtained more yield than non-beneficiary households, they were also using some fertilizers and pesticides that are not registered.

Based on focus group discussions and key informant interviews, it can be assumed that the support of government plays a very important role to improve the rice production of this region. The support of government organizations seems to be weak because of these reasons: first, the extension services are not effective to impart the technology and knowledge to the farmers; second, the extension agents have no enough funds to keep contact with the farmers and check the fields; third, there is no effective collaboration among government organizations. As a result, researchers do not know what the farmers require exactly and most of the farmers have no knowledge about agricultural inputs and cultivation practices.

From this study, it can be recommended that maintenance of drainage canals is currently needed to do and government should give enough facilities to the extension agents and force the different departments concerned with rice production to build up the effective collaboration. On the other hand, the government should define the stable rice price to solve the problem of lowest selling price at the time of harvest. Moreover, the government should lay down more strict laws to inspect the fertilizers and pesticides wholesale and retail markets regularly. In addition, many farmers faced many problems including quality seeds, fertilizers and other chemicals, drainage and financial problems and government should try to work with the international and local companies and organizations to ensure the quality of inputs and financial support for rice production. In recent years, less interest on rice production due to low profitability and the loss of rice farm due to impacts of climate change are leading to labour scarcity in rice production. Government should take the insurance programme into consideration to improve rice production.

This study indicates that the need of further studies on current situation of rice production in different regions of Myanmar and institutional analysis on departments concerning with Myanmar rice production.

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Annex 1: Project definition

Student's name and contact details	**No No Aung** **nono.aung@students.bfh.ch**
Principal advisor[1]	Dr. Alessandra Giuliani, HAFL
Co-advisor's name and contact details[2]	Prof. Dr. Urs Scheidegger, HAFL Jos van der Zandenor and Tun Zaw Htay, HELVETAS Myanmar and GoMP Project Management team
Working Title of the master's thesis	**Crop management practices and their impacts on farm productivity and farm income in the Gulf of Mottama Region, Myanmar**
Background[3] and state of knowledge	This Master Thesis will be carried in the framework of HELVETAS Myanmar under the the Gulf of Mottama Project. The project overall goal is that the unique biodiversity of the GoM is conserved and sustainably developed to benefit human communities that depend on it. This project has the following outcomes. Outcome 1: Livelihoods are secured and diversified to build resilience in communities. Outcome 2: Coastal natural resources use is sustainable and well-managed, and biodiversity is conserved. Outcome 3: Coastal natural resources governance is coordinated and effective, and awareness on the GoM values is raised. Under outcome1, the expected outputs are (1) improved and/or diversified fisheries and on-farm livelihoods through skills and market system development (2) developed off-farm options through skills and market system development and (3) supported communities for disaster risk management, planning and adaptation. (Source: www.helvetas.org/myanmar) In Myanmar, farming is the major employment in rural areas and a greater portion of rural communities' income is derived from agriculture. However, average crop production per hectare is still low due to poor soil, inadequate water supply, improper application of fertilizers, infestation by the pests, and lack of technical know-how on crop production. Therefore, farmers' income is very low and farmers face limitations, such as timely and appropriate field operations and the input like quality inputs such as seeds, labor, pesticides and fertilizer. On the other hand, irregular rainfall patterns, poor natural resources management, and increased rural population are creating land degradation and fragile biophysical environment resulting in a decrease of crop yield. Hence, it is of crucial importance to work towards a sustainable crop production system in Myanmar. This study is contributing to the Gulf of Mottama Project and will focus on the Gulf of Mottama Region (Bago Region and Mon State) for assessing the impact

1 This must be a member of the academic staff within the specialisation programme, either a senior lecturer or a research associate with a PhD or an MSc with a minimum of three years' research experience.2 If the thesis is carried out in collaboration with a partner organisation, a substantial part of the content supervision may be delegated to a scientist at the partner organisation (co-advisor). Also, research associates involved in the specialisation programme or working at BFH-HAFL may act as a co-advisor. The co-advisor will not necessarily be the expert for the oral examination. It is not mandatory to define a co-advisor.

2 If the thesis is carried out in collaboration with a partner organisation, a substantial part of the content supervision may be delegated to a scientist at the partner organisation (co-advisor). Also, research associates involved in the specialisation programme or working at BFH-HAFL may act as a co-advisor. The co-advisor will not necessarily be the expert for the oral examination. It is not mandatory to define a co-advisor.

3 If necessary include a description of the project in which the thesis is embedded in an annex

	of current cultivation practices on the farm productivity and income. This will be done by analyzing the farmers' income logbooks distributed by project and to compare with the current farmers' cultivation practices. These books contain their production records, expenses for their productions and income from production. The research will be done between July 2018 and November 2018 in the project target area.
Objective of the thesis	The objective of this thesis is to investigate the impact of crop management practices on farm productivity, and farm income by analyzing farmers' income logbooks and farmer's practices. In doing so, the thesis provides a contribution to output 1 under outcome 1 of the GoMP (improved and/or diversified fisheries and on-farm livelihoods through skills and market system development).
Expected outcomes[4]	The thesis wants to achieve the following: Output 1: The **existing socio-economics and situation** of farmers in the selected areas is assessed. Output 2: **Farming productivity and farmers' income** of the selected farmers in the projected area are compared. Output 3: **Cultivation practices** that give highest profitability and sustainable production to farmers are identified.
Research questions or hypotheses	What are the socio-economic characteristics of farmers in the research site? What are the constraints and challenges faced by farmers in crop production? What are the income generating activities derived from agricultural activities of farmers in these areas? What are the most profitable ones? What are the factors affecting the household income of farmers in the project area? What are the crop management practices used in these selected areas? Which cultivation practices can provide the highest profitability and sustainable production to farmers?
Approach and methodology	- Literature review (on cultivation practices, farm income analysis, farmers' logbooks, sustainable production etc.) - Quantitative and qualitative Analysis the farmers' log books distributed by project (records from July-December 2017) – 10-15 farmers in 8 villages, in particular looking at 1. Main Livelihood Activities 2. Ownership Record 3. Crop Production Record 4. Marketing of Farm Products Record 5. Summary of Cost and Benefit Record 6. Soil Conservation Record 7. Compost Producing Record, and comparing the analysis with the current cultivation practices, - Field observation and survey using structured questionnaire on soil/water management and cultivation practices of a total of at least 60 farmers randomly selected from the same villages where farmers are using logbooks (August 2018) Data analysis with SPSS -> Descriptive analysis, the Comparative Mean analysis and the Regression analysis (September – November 2018)
Place(s) of research	The fieldwork will be conducted in the project target area of the GoM region, Myanmar.

Date of master's thesis colloquium	8th February 2018
Language of the master's thesis	☒ English ☐ German ☐ French ☐ Spanish ☐ Italian
Confidential master's thesis	☒ no ☐ yes ⇨ ☐ agreement[5] has been signed

4 Break down the objective into several partial objectives (expected outcomes or expected results or expected outputs)

Assessment matrix	☑ standard HAFL	☐ other (see annex)
Extensive application of a social-scientific method (especially surveys, interviews)	☐ no ☑ yes	
Semester in which the thesis will be submitted[6]	☐ Spring Semester, year ☑ Autumn Semester, year 2018 This will be the third study semester of the student.	
Comments		

Date, place:

Principal advisor's signature: Student's signature:

………………………………………………. ………………………………………..

⇨ *Please send to the Head of Specialisation for approval. Deadline is at most two months after the colloquium.*

⇨ *The student is hereby reminded that the "Guidelines for Master's Theses" govern the writing of the thesis. The effective «Guidelines for Master's Theses» and the «Guide to Writing a Master's Thesis» as well as the templates and different forms can be found in the Intranet: Studium/Masterstudium/Master's Thesis.*

5 Student Work Agreement - Confidentiality Agreement between BFH-HAFL and student

6 The semester in which the master's thesis will be submitted is binding. The student is obliged to submit the thesis in one of two slots during this semester. Postponing the date to a later semester requires an application with due justification to the Head of Teaching.

Annex 2: Household Survey on Rice Production

Form No. ______Village: _____________ Village Tract: ____________Township: ___________ Date: ____

1. Demographic Information of Respondents

1. Name:...........................Ph No.-------------	6. Experiences:	( )Yrs
2. Sex: ☐ Male ☐ Female	7. Major occupation:	
3. Age:	8.Minor occupation:	
4.*Marital Status:	9. Farm size : Own	Le( ) Ya( ) Kaing( ) acres
5. Education Level:	: Rent	

*Single=1, Married=2, Divorced=3

2. Household background information

Head & Members	*Sex	Age	Educational status		Type of occupation		Seasonal farm income	Source of Income	
			Schooling years	School enrolment in this year	Major	Minor		On Farm	Off Farm
1. Head									
2. Spouse									
3. Son									
4. Daughter									
5. Relative									
6. Others									

*F=Female, M= Male

3.Do your family member have work from your village?

☐ Seasonal ☐ Permanent (Local) ☐ Permanent (Abroad)

If yes, how many people? _____________

4. Household Assets

Kind	Y/N	No.	Kind	Y/N	No.	Kind	Y/N	No.	Kind	Y/N	No.
Cattle			Cart			Generator					
Dairy Cow			Tractor			Well					
Calf			Bicycle			Water pump					
Pig			Motorcycle			Sprayer					
Goat			Car/Trailer			Phone					

5. Average working days & wage rates of household members

Members	Major employ-ment working days/month	Wage rate of major employ-ment/day	Minor employ-ment working days/month	Wage rate of minor employ-ment/day	Total income/ month
Head					
Spouse					
Son					

6. Sources of income (for Head and all household members)

	Types	Name of Crop	Average Income/Season
Crop production	- Crop 1		
	- Crop 2		
	- Crop 3		
Animal husbandry	-Cattle		
	-Pig		
	-Poultry		
	-Fishery		
	-Others		
Non-farm activities (own investment)	-Petty trade		
	-Self-employed		
	-Home based work		
	-Others		
Farm (Rent-out)	-All crops		
Wage labor:	Agriculture/ Non-agriculture		
Pension			
Remittance			
Transfers from relatives or others			
Others			

7. Household consumption/expenditure

Types of expenditure	Expenditure MMK/ Month/Season	Types of expenditure	Expenditure MMK/ Month /Season
I. Food items		**-Kitchenware**	
-Rice		**-Furniture**	
-Oil		**-Durable goods**	
II. Non-food items		**-House maintenance**	
- Education		**-Clothing**	
-Transportation		**-Services**	
-Fuel oil		-Social activities	
-Health		-Religious activities	
-Electricity		-Others	
-Candle		III. Total expenditure of food & non-food items	

.

8. Monsoon Rice Production (2017)

Variety	Cultivated area	*Establishment	Seed rate	Seed price per basket	Type (1=own, 2=buy)	**Type of Land Ownership (payment)	Total production (basket)	Home consumption amount (basket)	Amount of seed for growing and donation (basket)	Selling amount	Price/unit	Revenue

*Transplanting (T) or Direct seeding (D)

**Owned (O) or Hired (H)

Where did you get the seeds?

(a) Village Seed Bank (b) brokers/wholesalers (c) DoA (d) own seeds (e) other farmers

Do you feel the quality of seed from Seed Bank or DoA is different from other sources?

(i) Yes (ii) No

Did you practice organic composting?

(a) Yes (b) No

If yes did you follow the instruction from GoMP or others' recommendation?

(a) Yes (b) No

Did you apply farm-yard manure?

(a) Yes (b) No

Types of fertilizers you used previously?

…………………………………………………………………………………..

Did you try to mitigate the soil saline problems?

(a) Yes (b) No

If yes, what kind of practice did you do?

………………………………………………………………………………….

Did you attend to the trainings provided by GoMP project?

(a) Yes (b) No

If yes, do you feel, those training are affective for your on-farm activities.

(a) Yes (b) No (c) Hard to say

If yes, please mentioned one of the most effective things which you adopt?

……………………………………………………………………………………………….

<table>
<tr><th rowspan="2">Activities</th><th rowspan="2">Duration</th><th colspan="2">By animal or machine</th><th colspan="2">Hired labor</th><th colspan="2">Family labor</th><th rowspan="2">Total Cost (MMK)</th><th rowspan="2">Remark</th></tr>
<tr><th>Quantity</th><th>Price</th><th>Quantity</th><th>Price</th><th>Quantity</th><th>Price</th></tr>
<tr><td>Banding</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Ploughing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Harrowing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Levelling</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rotatory</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Others</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Seed bed preparation</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Transplanting (by hand)</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Transplanting (by machine)</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Transplanting (by fork)</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Direct seeding (broadcasting)</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Direct seeding (by machine)</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>others</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Plant Caring</td><td colspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Harvesting</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Threshing</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Drying</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Transportation</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Fertilizer Application

<table>
<tr><th rowspan="2">Type of Fertiliz-er</th><th rowspan="2">Time of Applica-tion (Which time?)</th><th colspan="2">Times of Applica-tion per cropping season (How many times?)</th><th rowspan="2">Type (1=own, 2=buy)</th><th rowspan="2">Method of Applica-tion*</th><th colspan="2">Family Labor</th><th colspan="2">Hired labor</th><th rowspan="2">Total cost</th></tr>
<tr><th>Quantity</th><th>Price</th><th>Quantity</th><th>Price</th><th>Quantity</th><th>Price</th></tr>
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</table>

* Basal =1, Top Dressing = 2, Broadcasting= 3, Other = 4

Do you have any knowledge for fertilizer application? Yes/ No.

If yes, from which source?

Describe your opinion on the type of Fertilizer you used for rice production?

Water management

Type of Activity	Time (Which time?)	Amount (water level)	Method	Family Labor		Hired labor		Total cost
				Quantity	Price	Quantity	Price	
Drainage								
others								

Crop Health

Did you use chemical or/and organic pesticides? Yes or No

If yes,

Type of pesticides	Type (1=own, 2=buy)	Time (Which time?)	Applied		Times of Application per cropping season (How many times?)	Family Labor		Hired labor		Total cost
			Quantity	Price		Quantity	Price	Quantity	Price	

Weed control

Did you control weed in your field? Yes or No

If yes,

Activities	Type (1=own, 2=buy)	Times of Application per cropping season (How many times?)	Family Labor		Hired labor		Total cost	Remark
			Quantity	Price	Quantity	Price		

Constraints

Quality of Seeds

(a) Not a problem (because of seed bank)
(b) Bad quality
(c) Difficult to get
(d) Etc…

Access to quality seeds

(a) Not a problem (because of seed bank)
(b) Transportation is bad
(c) Lack of information
(d) Don't know where to get
(e) Bad quality seeds from neighboring farms
(f) Etc…

Land preparation

(a) Labor scarcity
(b) Lack of cattle drawn harrow
(c) Difficult to hire a machine
(d) Etc…

Compost making

(a) Time consuming
(b) Labor consuming
(c) Hard to get raw materials
(d) Lack of technologies/ Difficulties in technologies availability
(e) Cost consuming
(f) Etc…

Do you have any other difficulties about rice cultivation practices?

The most important first

Annex 3: Key Informant Interview

Form No.___Name____________Position_____________Address___________Date_________

1) How long have you been affiliated with GoMP? Or how many years have you worked at DoA?

2) What and how familiar are you with GoMP's impact and outcomes (results of the project)? Or DoA visions?

3) What are the GoMP's supports (financial and technical) to farmers? Or what are the DoA's supports to farmers?

4) How much training (cultural practices for rice production) did the GoMP or DoA give in a year? And what are those? Who are the trainers? How long did it take?

No.	Training	Trainers	Trainee (farmers)	Duration (hr/day)	How to choose the trainee?
1	Farm management				
2	Land preparation				
3	Water Management				
4	Nutrient Management				
5	Pest Management				
6	Food safety				
7	Postharvest operations (crop residue management)				
8	Health and safety				
9	Human rights				
10	Gender issues				

5) How do you feel about the response of farmers, their technical knowledge and apply in the field?

6) Is there any soil analysis by project or by DoA or by themselves?

7) Which varieties are mainly used by farmers?

No.	Name	Variety		Remark

8) What are the local production systems?

9) What do they practice irrigation and drainage systems?

10) What are the nutrients and soil fertility management? (recommended rate)

11) If they use chemical fertilizers, where did they buy?

12) What are the pest, disease and weed management?

13) Where did they buy chemicals and how did they apply?

14) How do they harvest their rice and practice post-harvest technology?

15) What are the lowest wages for agricultural workers? Is there any discrimination between male and female? Also child labor?

16) Where do they sell their rice?

17) What is the average yield per acre?

No.	Variety	yield	price

Annex 4 : Outputs from regression analysis of rice productivity

```
lm(formula = sqrt(Yield.10) ~ Membership + Variety.rec + Landpreparation +
   establishment + seedrate + herbicideuse, data = analysis)
Residuals:
     Min       1Q   Median       3Q      Max
-3.00804 -0.76397 -0.00208  0.60550  3.11976
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                6.65122    0.48885  13.606  < 2e-16 ***
Membershipnon-beneficiary -0.43054    0.15474  -2.782  0.00596 **
Variety.recPSV            -0.55456    0.22036  -2.517  0.01271 *
Variety.recBTV            -0.06763    0.27477  -0.246  0.80585
Variety.recKPV            -0.15171    0.20556  -0.738  0.46145
Variety.recMNV            -0.49769    0.49803  -0.999  0.31896
Variety.recNGY             0.20957    0.26123   0.802  0.42345
Landpreparation           -0.26332    0.13247  -1.988  0.04833 *
establishmentttfork        0.42936    0.37297   1.151  0.25116
establishmentdirect       -0.47131    0.36501  -1.291  0.19825
seedrate                   0.24509    0.14828   1.653  0.10006
herbicideuseuse            0.42193    0.22207   1.900  0.05901 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.016 on 183 degrees of freedom
  (17 observations deleted due to missingness)
Multiple R-squared:  0.2156,  Adjusted R-squared:  0.1684
F-statistic: 4.572 on 11 and 183 DF, p-value: 3.965e-06
```

Annex 5 : Outputs from regression analysis of profit from rice production

```
lm(formula = sqrt(profit) ~ Membership + Variety.rec + landpreparationcost +
    herbicideuse + transportationuse + priceperbsk, data = analysis)

Residuals:
    Min      1Q  Median      3Q     Max 
-314.90  -56.90   12.50   61.42  267.14 

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)    
(Intercept)              328.742535  34.957279   9.404  < 2e-16 ***
Membershipnon-beneficiary -18.881952  14.973988  -1.261  0.20881    
Variety.recPSV           -39.933391  23.562444  -1.695  0.09170 .  
Variety.recBTV             4.379678  26.327708   0.166  0.86805    
Variety.recKPV            -4.050418  22.513016  -0.180  0.85741    
Variety.recMNV           -40.118380  43.396729  -0.924  0.35639    
Variety.recNGY            35.041025  26.706276   1.312  0.19102    
landpreparationcost       -0.001181   0.000401  -2.944  0.00363 ** 
herbicideuseuse           55.869979  23.554361   2.372  0.01866 *  
transportationuseuse     -38.490614  26.389027  -1.459  0.14628    
priceperbsk                0.030091   0.004588   6.559 4.72e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 102.3 on 196 degrees of freedom
  (5 observations deleted due to missingness)
Multiple R-squared:  0.3061,  Adjusted R-squared:  0.2707 
F-statistic: 8.647 on 10 and 196 DF,  p-value: 1.144e-11
```

Digital Annex

1. Data sheets
   Aung_NoNo_digital annex_all data 2018_20190222
   Aung_NoNo_digital annex_data for regression_20190222

2. R codes
   Aung_NoNo_digital annex_code_20190222.R
   Aung_NoNo_digital annex_yield_20190222.R
   Aung_NoNo_digital annex_profit_20190222.R

3. Reference book for focus group discussion
   Aung_NoNo_digital annex_SRP Standard for Sustainable Rice Cultivation v 1.0_20190222