MASTER THESIS

Quantifying Pond and Labor Productivity of Small-holder Aquaculture Farmers in the Central Dry-Zone of Myanmar

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Abstract

To date, aquaculture in developing countries is still largely based on unimproved fish species. As a result, indigenous fish species often show poor growth rate, high fish mortality, and may have high labor production costs. By introducing Genetic Improvement of Farmed Tilapia (GIFT) in Myanmar, WorldFish aims to increase pond and labor productivity such that smallholder farmers earn more from aquaculture from their scarce land, capital and labor resources. The case study presented below purposely selected fish farmers for a micro-economic and partially technical study on labor and pond productivity in aquaculture. Quantitative and qualitative research methods were used to obtain very detailed data allowing me to estimate pond and labor productivity under existing smallholder farmers conditions in Myanmar. The research region was the Central Dry Zone of Myanmar, an area close to those hatcheries which have been identified by World Fish and national research partners. The case study assesses the current productivity and income from pond aquaculture derived by smallholders and provides crucial baseline information for the planned study during 2020/21 to assess the food security, productivity, and income effects of introducing improved tilapia to these smallholder farmers. Information collected during the study regarding problems faced by smallholder aquaculture farmers in the Central Dry Zone will be useful to ensure better delivery of future projects and objectives. Investment scenarios included in the case study aim to provide a demonstration of how future changes to the practices of smallholder aquaculture farmers could impact their profitability. A more productive smallholder aquaculture sector in Myanmar could help to reduce the availability and prices for fish which is a major source of protein and micronutrients for the people of Myanmar.

I. List of Abbreviations

FCR – Feed Conversion Ratio

SSF – Small Scale Fisheries

CDZ – Central Dry Zone

DOF – Department of Fisheries

FAO – Food Aid Organization

GIFT – Genetic Improvement of Farmed Tilapia

JICA – Japan International Cooperation Agency

NRC – National Research Council

NSPAW - National Strategic Plan for the Advancement of Women

UN – United Nations

UNDP – United Nations Development Programme

WFP – World Food Programme

II. List of Tables

List of Figures

CHAPTER ONE - INTRODUCTION

1. INTRODUCTION

1.1. Background to the study

Aquaculture is important in the global context of development because of increasing demand for seafood protein driven by population growth, higher incomes, and urbanization (Naylor, 2016). Increasingly, as production of traditional capture fisheries fails to address growing consumer demands for fish protein, the development of sustainable aquaculture is critical to meet these shortfalls (FAO, 2012). Aquaculture continues to be the fastest growing food sector globally, with the sector growing at an average annual rate of 8 percent per year over the past 30 years, reaching a new high of 101.1 million tonnes in 2014 (FAO, 2014). Demand for fish is expected to increase substantially, at least in line with other animal-based foods, particularly in South and South-east Asia (FAO, 2014). The challenge of feeding current and future populations is made harder by the potentially negative impacts of climate change on agricultural production, the increasing competition for land, water and energy and the need to maintain regulatory environmental services (Edward, 2011).

Amongst the variety of food production systems, aquaculture is particularly important in developing countries as a tool to combat against malnutrition and poverty (Rohana, 2001). Inadequate nutrition is a global problem-30% of humanity suffers from malnutrition and food–related diseases (WFP, 2012). Presently, there are approximately 925 million chronically undernourished people within the developing world and over 6.6 million preventable child deaths every year related to malnutrition (FAO, 2011). Affecting roughly 2 of 7 people on the planet, more than two billion people suffer from dietary micronutrient deficiencies, including iron, iodine, vitamin A, and zinc (WFP, 2012). Incorporating fish into a diet is a good source of both macro- and micronutrients. Fish also provides essential minerals such as calcium, phosphorus, zinc, iron, selenium and iodine as well as vitamins A, D and B, thus helping to reduce the risks of both malnutrition and noncommunicable diseases (Alisson, et al., 2013).

Where fisheries or aquaculture are significant activities, contributions to poverty reduction are in the form of economic multipliers; for example many fisherfolk are landless and have daily cash incomes to spend in areas sometimes remote from markets, which helps sustain markets for agricultural produce, consumption goods and various services and ensures that the income from fishing stays in the local area (Thorpe, 2007). Other potential indirect impacts include employment, wage and income effects on other sectors, which could benefit the poor through production, consumption and other economic growth linkages (Haggblade 1991).

Myanmar, the second largest country in Southeast Asia after Indonesia, has a land area of 676,578 km^2 and a population of 52 million divided among 135 ethnic groups; it is prone to cyclones, landslides, earthquakes and drought. Despite abundant natural and human resources, Myanmar is less developed than many of its neighbors: it ranks 148th of 179 countries in the 2017 United Nations Development Programme (UNDP) human development index (UNDP, 2018). Annual per capita gross national income is US$250 with agriculture set as the backbone of the economy contributing to 43.7% of the GDP in 2007/08 while industry (manufacturing, mining/energy, and power) and services generated respectively 20% and 36.5% of the national GDP. Myanmar is ranked 12th (ahead of Thailand) among the world's major aquaculture countries. Freshwater fish account for close to 95% of Myanmar's reported aquaculture production (Belton, 2018) . Presently, aquaculture in Myanmar is rather limited in terms of the diversity of species farmed and based largely on semi-intensive production technology. In addition, Myanmar's aquaculture has not yet intensified (in terms of input use per hectare) as much as neighbors such as India, Thailand and Bangladesh. This information deficit is an outcome of the country's five decades of political and economic isolation, from which it began to emerge in 2011 (Belton, 2018).

A major bottleneck constraining the development of sustainable aquaculture in developing countries are unimproved fish strains (exhibiting slow growth rates and yielding lower economic potential) (Ponzoni et al., 2007). In the late 1980's, due to the importance of tilapia aquaculture in developing countries, Norway undertook the Genetic Improvement of Farmed Tilapia (GIFT). As a result, an improved tilapia strain with faster growth was created (Dey et al., 2000).

Hoping to expand on the economic success of previous GIFT dissemination programs (Egypt, Ghana), WorldFish intends to introduce GIFT strains to Myanmar. WorldFish, a part of Consultative Group on International Agricultural Research, aims to help poor producers and consumers strengthen their livelihoods and improve their food security by improving fisheries and aquaculture

(WorldFish, 2019). Presently, rohu production, a carp species, represents 70% of Myanmar aquaculture production. As such, aquaculture experts in Myanmar believe that that there is an overdependence on a single species leading to constraints to future growth in the aquaculture sector (Joffre et al, 2018). The introduction of GIFT to Myanmar can alleviate such dependency and create increased economic potential for small-holder farmers. The WorldFish project intends to disseminate GIFT to tilapia farmers in Myanmar. The dissemination of GIFT in Myanmar has many potential benefits for the farmers, including: employment generation through higher labor and pond productivity, income generation, improved food security, improved nutrition, and poverty alleviation. For example, previous studies have shown that fish farming in Myanmar generates significant employment--nearly double per acre as paddy farming. More so, fish is the leading purveyor of animal protein and the lead provider of micronutrients, critical for child development, to Myanmar consumers. (Belton et al, 2015). As such, for GIFT dissemination to succeed and benefit small-holder farmers, it is critical to understand the factors enabling and impeding aquaculture productivity of small-holder farmers in Myanmar.

1.2. Statement of the Research Problem

Ponds mainly use two types of scarce economic resources, land and capital. Land is needed for pond building, and it is likely to have a considerable opportunity cost. Capital is required for building the pond, and water pumps, and other technology and expenditures to use and maintain the pond. To increase the productivity of a given pond, more fish needs to be produced in a given time period. For example, understocking of fish or using inferior feed with indigenous, slowly growing fish will tend to lower pond productivity. This is important in Myanmar because sub-optimal pond management practices are widespread (Joffre et al, 2018). For example, presently, most fish feed is homemade feed, composed of locally available agricultural by-products, particularly rice bran and peanut oil cake. While cost-effective, using agricultural by-product as feed can be sub-optimal compared to improved feed technology. Similarly, limited use of fertilizer is identified as an area of improvement for pond management. Presently, the literature suggest that fish farmers do not maximize their productivity by enhancing the natural productivity of their ponds (Joffre et al, 2018). My research will aim to explore the role of cheaper inputs, feed quality, equipment, infrastructure, fingerling availability, as well as the role of pond fertilization on pond productivity.

Farm labor in aquaculture can be recruited on a temporary or permanent basis. Temporary labor is required mainly for harvesting fish, grading fingerlings, unloading feed delivered to the farm, and pond construction/repair (Belton et al, 2015). Aquaculture has an important role in supporting rural livelihoods by raising farm incomes and creating new non-farm employment opportunities (Belton et al, 2015). Aquaculture has been identified as a strong contributor to local economies in Myanmar, creating four times more labor demand per acre than crop farms (Jofree et al, 2018). As such, it is important to understand the specific labor demands of operating smallholder aquaculture in Myanmar. It is valuable to gain insights to the role of informal labor (family and friends), gendered labor (gender-based division of labor), labor seasonality, as well as, the role of hired labor, and labor availability. By combining knowledge gained of pond productivity and labor productivity, my aim is to better understand how the new GIFT Tilapia technology may or may not fit into the socio-economic and technological setting of smallholder aquaculture in Myanmar, and whether positive income contributions can be expected from introducing GIFT tilapia into these smallholder aquaculture systems. Positive income effects are expected to contribute to improved food and nutritional security, and to poverty alleviation. However, this causal chain of analysis from income to improved food and nutritional security is beyond the scope of my master thesis.

1.3. Significance of the study

The information gathered by this study will be useful for the baseline survey to be conducted by WorldFish sometime between 2019-2020. Problems identified in the study area can be used to improve future initiatives and increase visibility of certain issues. The investment scenarios analyzed in the study can be helpful in better understanding what kind of future initiatives can be beneficial to smallholder aquaculture farmers.

1.4. Research objectives

The objective of this study is to carry out an economic analysis of smallholder aquaculture farmers in the Central Dry Zone while the specific objectives are to:

1. To describe the socio-economic characteristics of the aquaculture farmers and the farms in the study area
2. To estimate the profitability of smallholder aquaculture production in the Central Dry Zone of Myanmar.
3. To estimate the impact of extension services and following best practice on profitability of fish farming in the Central Dry Zone of Myanmar.

4. To describe the challenges facing aquaculture farmers in the Central Dry Zone.
5. To better understand the role of labor for aquaculture in the Central Dry Zone.

1.5. Research questions

The pertinent questions in the study are:

1. Based on the current conditions of aquaculture in The Central Dry Zone of Myanmar, are the ponds of smallholder aquaculture farmers productive?
2. Which factors of pond productivity show the strongest correlation to economic profit for small-holder aquaculture farmers?
3. What challenges does an aquaculture farmer in The Central Dry Zone of Myanmar face and how do these challenges affect pond productivity and profitability?
4. Is labor a binding constraint for aquaculture small-holder farmers in the study region of Myanmar? what is the role of informal labor?
5. Assuming prevailing market conditions for aquaculture remain constant in the Central Dry Zone of Myanmar, is it economically profitable for new investors to start an aquaculture enterprise?

1.6. Hypothesis

The following null hypotheses will be tested:

H_{01} At the current environment for aquaculture production in the Central Dry Zone, access to improved feed and use of pond inputs (fertilizer, lime, and manure) is hypothesized to improve profitability for small-holder aquaculture farmers.

H_{02} At the current environment for aquaculture production in the Central Dry Zone, I expect access to labor, and high feed costs to be problematic for small-holder aquaculture farmers.

H_{03} At the current environment for aquaculture production in the Central Dry Zone, I expect informal labor to be widespread.

1.7. Scope of the research

To Leverage information from households regarding pond and labor productivity to alleviate existing problems and to present suggestions for future sector growth. To better understand the successes and pitfalls of small aquaculture in the central dry zone in order to better guide future initiatives regarding aquaculture in Myanmar. To provide crucial baseline information for the planned WorldFish study during 2020/21 to assess the food security, productivity, and income effects of introducing improved Tilapia to these smallholder farmers.

1.8. Content overview

The thesis is divided into five chapters each containing their own sections and subsections. The first chapter is the introduction and aims to provides the background of the study, introduces the research problem, states the research objectives, and describes the hypotheses to be tested. The second chapter is the literature review which aims to present the relevant information from existing studies and identify gaps in the literature. The third chapter will provide the methods of the study and discuss the study area in question. The fourth chapter will present and discuss the results of this study. The fifth chapter will summarize the results discussed in chapter four, present conclusions for the study, and provide study recommendations for future work.

CHAPTER TWO – LITERATURE REVIEW

2. LITERATURE REVIEW

The term "aquaculture" used in this review means activities related to extensive or semi-intensive aquaculture. Extensive aquaculture is defined as production systems where 'the aquatic animals must rely solely on available natural food, such as plankton, detritus and seston' (Coche 1982). Semi-intensive aquaculture involves "either fertilization to enhance the level of natural food in the systems and/or the use of supplementary feed (Hepher 1988). The review will cover the history of aquaculture in Myanmar, the present state of aquaculture in Myanmar, how aquaculture relates to food security, nutrition, gender and poverty alleviation, the factors affecting pond productivity, and the role of labor regarding aquaculture.

2.1. History of Aquaculture in Myanmar

The first private hatcheries focused on fingerling production were established in Myanmar around 1985, after which, aquaculture began to spread throughout the country (Belton, 2018). Following the end of socialist rule in 1988, and a removal of government restrictions on large-scale capitalist enterprise and on agricultural and fishery exports – followed a period of rapid increase in land value, and associated land speculation (Fujita, 2009). In response to this, the military controlled government employed widespread land confiscation, whereby military authorities seized public forests, seasonal freshwaters, and untitled agricultural land, and then leased or simply handed these properties over to close associates (SiuSue, 2017). Within Myanmar, this period symbolized by post-socialist nepotism is referred to as "crony capitalism" (Lee, 2014). The 1990's in Myanmar was a period during which large numbers of open auction fisheries were demarcated as tender lots and allocated to private individuals. Because of the monopoly rights given to private individuals, many small-scale farmers (SSF) were excluded from accessing fishing grounds. Government during this period neglected the livelihood concerns of local SSF communities and regarded the fishery sector as a mere source of revenue (Nyein, 2018).

According to Schedule II of the 2008 Myanmar constitution, sub-national (state and regional) levels of government have legislative powers and the responsibility of revenue management for the inland and freshwater fishery sector (Nyein, 2018). As such, the decentralization process has narrowed the distance between SSF and policymakers. Decentralization has facilitated the local engagement of

SSF by local policy actors. The democratization process in the 2000’s has provided SSF the opportunity to establish their own organizations and initiate campaigns to protect their fishing rights (Nyein, 2018). The 2010 Myanmar general elections saw a shift to quasi-civilian rule; unfortunately, the literature notes that dynamics of land confiscation, following the change in government, have intensified (Yukari, 2016). The removal of economic sanctions by the European Union in 2013 and the United States in 2016 has increased foreign investment and resulted in an increase of land values. Myanmar’s parliament has exacerbated the problem of land confiscation with its 2012 revision to the country’s Farmland Law, and the Vacant, Fallow and Virgin Lands Management Law, and through its repeal of the protective 1963 Peasant Law (Loewen, 2012). The combination of rising land values associated with economic liberalization and pro-industry government policy has resulted in a market environment which prioritizes industrial-scale agriculture and aquaculture for export to the detriment of small-scale farming and fishing (SiuSue, 2017). One author, writing for Japan’s Institute of Developing Economies, notes that as result of the previously mentioned actions there has been an “impressive” expansion of aquaculture in Myanmar since the 1990s (Soe, 2008). As of 2014, Belton et al. estimate that 260,300 acres of land had been converted into fishponds across the Ayeyarwady Delta (Belton, et al 2018). This conversion of agricultural land and seasonal fisheries into permanent fishponds has been praised and encouraged by international advisors and foreign economists due to the anticipated higher productivity and employment generation (Belton, et al 2018). The literature advocates for small-to-medium-sized commercially oriented aquaculture ponds due to the higher “income spillovers” that fish farms can generate for the local economy, as compared to equivalent areas of agricultural land (Belton, et al 2018). The World Bank has argued that an expansion of aquaculture “is needed to meet employment and food security targets in developing countries” (Randal, 2013).

2.2. Present State of Aquaculture in Myanmar

The Government of Myanmar identified self-sufficiency in food production and food security as key economic objectives (Colla, 2012) . Unfortunately, these economic objectives have been difficult to achieve due to unfavorable economic policies, extremes of weather, protection issues, poor social cohesion and the marginalization minority groups (Colla, 2012) . A 2009 survey estimated that 5 million people in Myanmar are food-insecure (FAO, 2018). Agricultural development is limited by low level of technology, lack of economic incentives to support rural producers, poor nutrition and health standards, and access to land (Colla, 2012). A low level of technology is linked to low use of fertilizers and poor quality of seeds and management; inadequate water availability means that most farmers are exposed to climatic variability; lack of credit and indebtedness limit the adoption of new technologies. Furthermore, research and extension services in Myanmar suffer from lack of equipment and inadequate training limiting their flexibility and ability to help farmers (Colla, 2012).

Fish is the cheapest form of animal protein in Myanmar, accounting for 50% of animal source food intakes. It occupies a share of food expenditure nearly as large as that of rice, the staple food of Myanmar's food security policy. (Belton, 2015). Aquaculture development in Myanmar creates rural growth linkages by generating demand for labor, goods (i.e. fish seed from nurseries) and services. Recent literature suggest that the average return of aquaculture is four times higher than those from crop farming (Belton et al, 2017) . It has been observed that smaller farms have a competitive advantage in the production of non-carp species, especially tilapia, pacu and freshwater prawn. The rapid growth rates and robustness of tilapia and pacu make them highly suitable culture species (Belton et al, 2017). Demand for fish in Myanmar has grown fast as a function of income increases, particularly in urban areas (Belton, et al 2015). As wild capture fish stock decline, aquaculture is expanding throughout Myanmar to meet the rising demand (IMR, 2014). Unfortunately, due to the high transaction costs of obtaining permission to construct ponds, has discouraged smallholder participation (Belton, et al 2015). Most farmed fish in Myanmar is sold as whole fresh fish in traditional wet markets. There is little value-added processing of farmed fish for export, largely because the carp species (rohu) that dominate farm production has limited international demand (DOF, 2014).

2.3. Food Security

Food security is defined by FAO as '… a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. This definition includes the nutritional aspect which is described as 'access to nutritious food to meet their dietary needs', however, this review uses the term 'food and nutrition security' to emphasize the access and appropriate utilization of micronutrient-rich foods, including the process through which they are cooked and absorbed in the body, and then used in physiologic functions at individual level (FAO, 1996). Amongst the variety of food production systems, aquaculture is particularly important in developing countries as a tool to combat against malnutrition and poverty (Rohana 2001). Compared with other animal proteins, farmed freshwater fish offer the rural poor a more cost-effective source of animal protein (Tacon, 1997). Aquaculture contributes to food security through a variety of pathways, including: increasing the availability of fish available for human consumption; by generating jobs and income, thereby improving ability to purchase food; and by facilitating access to better nutrition (FAO 2014).

Fish consumption patterns of the poor are often a result of staple food availability. When households lack food, fish produced by aquaculture or supplied by common-pool resources are used for cash, rather than as food for household consumption (Islam, 2007). For example, it has been observed in Bangladesh that poorer households sold more fish produced by their own ponds than better-off households (Karim, 2006). In these situations, fish is very important for food security since it can be exchanged for staple foods which are cheaper and higher in energy, preventing households from facing serious food insecurity (Kassam, 2014).

2.4 Nutrition

Inadequate nutrition is a global problem, it has been estimated that 30% of humanity suffers from malnutrition and food–related diseases (WFP, 2012). Presently, there are approximately 925 million chronically undernourished people within the developing world and over 6.6 million preventable child deaths every year related to malnutrition (FAO, 2011). Micronutrient deficiencies affect roughly 2 of 7 people on the planet, more than two billion people. Micronutrients are comprised of vitamins, minerals, trace elements, phytochemicals and antioxidants essential for health, whereas, macronutrients are the energy-giving caloric components such as starch, oil and structural proteins (Ratnayke, 2009). Common micronutrient deficiencies include deficiencies of iron, iodine, vitamin A, and zinc. Micronutrient deficiencies are especially concerning regarding pregnant women, lactating women, and young (WFP, 2012). Diet is directly linked to nutritional status. The typical diet of the poor is dominated by staple foods (rice, wheat, maize), with little food diversity. Diversifying a diet by adding animal-source foods, fruits and vegetables provides a variety of nutrients, contributing to improving nutritional status. Adequate dietary intake maintains the body's immunity and decreases the risk of diseases, contributing to minimizing extra costs and time for care and treatment, while optimizing labor productivity (Kawarazuka, 2010).

Incorporating fish into a diet is a good source of both macro- and micronutrients. Fish contains several amino acids essential for human health, such as lysine and methionine. Many fish (especially fatty fish) are a source of long-chain omega-3 fatty acids, which contribute to visual and cognitive human development, especially during the first 1000 days of a child's life (Roos, 2016). Fish also provides essential minerals such as calcium, phosphorus, zinc, iron, selenium and iodine as well as vitamins A, D and B, thus helping to reduce the risks of both malnutrition and noncommunicable diseases which may co-occur when high energy intake is combined with a lack of balanced nutrition (Allison, et al 2013). Nutritional content is especially high in small fish species consumed whole and in fish parts that are not usually consumed (such as heads, bones and skin) (HLPE, 2014).

2.5 Poverty Alleviation

Direct poverty impacts are those which affect the welfare of households who adopt aquaculture; for example, through benefits such as increased regular income or fish consumption. Indirect poverty impacts affect the welfare of the poor through aquaculture adoption by both poor and nonpoor farmers, through a variety of potential impact pathways. For example, aquaculture development increases fish supplies, potentially increasing the availability and lowering the price of fish in local and urban markets. This may benefit poor consumers if production is not exported and if the poor consume the species produced by aquaculture. Aquaculture development can also increase employment of the poor on fish farms and can potentially increase the marginal productivity of labor, leading to higher rural wage rates (Kassam, 2014). It has been suggested that the extent to which aquaculture will realize its potential to contribute to rural development and poverty reduction is likely to be depend on the level of engagement by the poor, the scale of adoption, and the significance of indirect effects such as economic growth linkages (Kassam, 2014). Certain factors have previously been identified as enablers for poor household success. First, support from external agencies allows poor households to overcome investment constraints. Second, the substitution of natural capital for financial capital; for example, the availability of wild caught seed and feed inputs off-set the need for financial capital and allows poor fishing households with few financial resources to stock and feed their ponds. Lastly, the introduction of low-cost technology; such as cages or improved feed (Kassam, 2014).

2.5 Gender

Globally about 50% of people engaged in all sectors of fisheries and aquaculture are women. In 2014 there were more than 56.6 million fishers and fish farmers in the world, and overall, women account for more than 19 percent of all people directly engaged in the fisheries and aquaculture sector. Typically, women play many roles in small-scale fisheries including as paid or unpaid workers in pre- and post-harvest activities and processing plants, as family caregivers and stewards of social networks, as workers in non-fishery sectors to supplement the household income, and as members of fish worker movements and fishers' organizations (FAO, 2016a) . The political-economic context influences and is influenced by gender relations and gender dynamics in all communities, including fishing communities. Despite some positive changes regarding women's rights in Myanmar associated with the opening of political space and easing of the military's power (Asian Development Bank, 2016), negative gender stereotypes and systematic discrimination that inhibit women from achieving full equality remain entrenched (Angels et al, 2016; Gender Equality Network, 2015). The priority that Myanmar society places on women's childcare and household duties hinders women's political participation because these duties impose time constraints on women's ability to participate in activities outside the household (UNDP, 2015).

In Myanmar, the policy regime on gender and fisheries is rooted in the National Strategic Plan for the Advancement of Women (NSPAW) 2013-2022 and other instruments. In 2013, the government rolled out the 10-year NSPAW based on twelve priority areas of the Beijing Platform for Action and the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) (Myanmar National Committee for Women's Affairs, 2014). The ambitious plan includes practical recommendations for implementation, but women's rights groups, UN agencies and policy research groups have all observed little or weak implementation (Angels et al, 2016). In Myanmar rural women suffer disproportionately from poverty, lack of access to healthcare and education, and unemployment. Poverty is a primary concern for most rural women, who lack employment opportunities and education. Poverty has also led to mass migration as individuals often leave to find work in other states or countries. In other instances, poverty has forced families to take on high-interest debt (WOMEN'S LEAGUE OF BURMA 2016).

2.6 Feed

Feed cost is the largest operating cost of fish farming and often constitutes between 40-60% of the total cost of production in aquaculture in developing countries (El-Sayed, 2004). Good feed management is the result of good feed conversion, which is the result of adequate knowledge about energetic needs of the fish, adequate distribution of feed and good feeding techniques. Therefore, a feeding strategy that uses minimal amounts of feed for increasing economic returns has the potential to lower production cost by decreasing the quantity of feed used to produce a kilogram of fish (Marimuthu, et al 2010). The choice of feed input employed by a farmer depends upon a variety of factors and considerations: The feeding habit and market value of the target species; the culture system and intended stocking density of the target species; the market availability of existing commercially available feeds for the target species; the local market availability and cost of suitable feed ingredient sources; and, most importantly, the farmers ability to purchase feeds and allocate resources for feeding (Tacon and Metjan 2013). For successful aquaculture practices, it is essential to determine the minimum level of protein at which fish can attain maximum growth. Dietary protein, being the most expensive ingredient in fish feed, is also most important (NRC 2011). Low levels of protein in feed results in reduced growth, but excessively high levels of protein lead to increased production costs and extra nitrogenous wastes (Wu, et al 2014). Major feed ingredients used by farmers for preparation of feed in Southeast Asia are de-oiled rice bran, groundnut oil cake, cotton seed oil cake (CSOC), raw rice bran or rice polish, sorghum, wheat bran, soybean cake or meal (Kumar et al, 2018; Favre and Myint, 2009). In Myanmar rice bran is much cheaper than peanut oilcake. The two feeds cost $0.15-0.18/kg and $0.60-0.80/kg respectively. However, peanut oilcake has a much higher protein content than rice bran - 42% and 10-15% respectively – and is thus converted to fish biomass more efficiently, resulting in faster rates of growth than would be possible if feeding rice bran alone. A recent report estimates that 80% of aquaculture production in Myanmar is dependent on the use of agricultural byproducts and waste as feed, with the remainder using manufactured pellets (Belton et al, 2015). Only 15% of surveyed farms in the Ayeyarwady Delta and Yangon Region, where the most intensive aquaculture is found, currently use manufactured pellets (Belton et al, 2015). According to one trade source, Myanmar's total feed demand in 2018 is likely to increase by 15 percent from the previous year and could reach 3.9 Million Metric Tons in 2020 (Nelson, 2018).

2.7 Feeding Frequency

Optimum feeding frequency may provide maximum utilization of diet as feed cost is the largest operating cost of fish farming. The growth of fish at all stages is largely governed by the kind of food, ration, feeding frequency, food intake and its ability to absorb the nutrients. Among these, feeding frequency is an important aspect for the survival and growth of fish at the early stage (Mollah 1982). Over-feeding leads not only to reduction in feed conversion efficiency and increase in input cost, but also accumulation of wastes that adversely affects the water quality (Biswas 2006).

2.8 Stocking Density

Stocking density is an important parameter in fish culture operations, since it has direct effects on the growth and survival of fish. The growth rate of fishes increases as the stocking densities decreases and vice-versa. A smaller number of fish per unit area of pond have more space, food and dissolved oxygen (Hassan 2010). Large farms tend to stock at low density (0.11 fish/m^2), with a high feeding rate and a longer production cycle to target large-scale fish with high unit value and high total biomass. Small farms have more of a short-term strategy due to constraints in resource availability. They tend to stock large-sized fingerlings at higher density (0.47 fish/m^2), with relatively less feed, for a quick harvest (Belton et al., 2017a).

2.9 Water Quality

Water quality is a serious concern for aquaculture farmers. Insecticide and herbicide residues and accumulations from nearby agricultural operations may adversely affect fish health. Control of pond water levels is important in water quality maintenance and stock management. Water inlets and outlets must permit the controlled addition and removal of water (Molnar, 1996). Feeding rates, feeding frequency as well as the type of feed offered has been reported to influence the water quality (dissolved oxygen, alkalinity, turbidity, ammonia and nitrate) levels in the ponds especially with increase in dietary protein levels in the diet (Singh et al, 2004).

2.10 Fertilizer

Both organic fertilizers and commercial fertilizers can increase phytoplankton production and enhance aquaculture production in ponds (Boyd, 2018). Fertilization of aquaculture ponds increases productivity of phytoplankton which is the food base of zooplankton and benthic animals (Mischke, 2012). Fertilization of aquaculture ponds is analogous to fertilization of pastures to increase forage for livestock. Aquaculture fertilizers include livestock manure, plant crop residues, food processing wastes, fresh-cut or dry grass and certain chemical compounds (Hickling, 1962). Water quality also tends to deteriorate as nutrient input increases, and this stresses culture animals to increase the likelihood of disease. As a result, there are limits on the amount of production possible in fertilized ponds, and maximum production seldom is optimum production (Boyd, 1998). Excessive inputs of fertilizer should be avoided because they can result in dense phytoplankton blooms that cause dangerously low dissolved oxygen concentrations during the night, after certain weather events, and following phytoplankton die-offs. Excessive inputs of manure also can cause dissolved oxygen depletion as a result of oxygen demand to decompose the manure (Boyd, 1975).

2.11 Lime

The pH and mineral content of water are the result of interactions between the soil and water. Because ponds are commonly constructed of clay, an acidic soil, the effect on water quality can be significant. Alkalinity concentrations below 20 mg/L often lead to large swings in daily pH values, which stress aquatic animals (Wurts, 2004). The acidity of pond soils can be neutralized, and the productivity of the pond improved by liming. The process of liming refers to the application of various acid-neutralizing compounds of calcium or calcium and magnesium. Liming ponds can enhance the effect of fertilization; prevent wide fluctuations in pH; and add calcium and magnesium, which are important elements in animal physiology (Wurts, 2004).

2.12 Labor in Myanmar

Myanmar is characterized by high levels of landlessness and historically low wage rates. These factors mean that the availability of off-farm labor opportunities and the rates at which they are remunerated are crucial determinants of rural welfare. However, the ratio of land to labor is high, and as Myanmar's economic transition continues the value of real wages is likely to become an increasingly important factor in determining the economic viability of agriculture (Belton et al, 2015). Despite the emergence of significant numbers of small- and medium-scale commercial fish farms and SMEs, ownership in most value chain segments remains highly concentrated. For instance, very large farms (sized more than 100 acres, and operated primarily by absentee owners or companies) account for 60% of total pond area, and a single company retains a virtual monopoly on fish feed production (Belton et al, 2015). A moderately sized pond requires the fulltime labor of one to two people to manage it, plus additional temporary workers for grading and restocking fish during on-farm nursing and unloading and portering feed. It is likely that demand for labor created by aquaculture per unit area of land in Myanmar is considerably higher than that in paddy cultivation (Belton et al, 2015).

2.13 Productivity of Labor

There has been relatively little research about the productivity of labor of the aquaculture in Myanmar. However, a review of the literature presents some figures of neighboring countries of farm level productivity of aquaculture: 1.28 tons/worker in Vietnam; .41 tons/worker in Bangladesh; and 1.71 tons/worker in Indonesia (FAO, 2016b). In general Asia lags in productivity/worker compared to other regions of the world; 3.2 tons/worker in Asia, 5.1 tons/worker in Africa, 27.8 tons/worker in Europe, and 59.3 tons/worker in North America (Waite, 2014). Research indicates that fish farming in Myanmar is more labor intensive than cultivation of paddy, the main agricultural crop and the main agricultural policy focus in Myanmar and rest of region. Aquaculture requires casual labor for pond construction and repair, grading and stocking fingerlings, unloading deliveries of feed, and harvesting fish, and even a moderately sized pond requires the permanent labor of one to two people for feeding and guarding fish and performing day to day management (Belton et al, 2018) .

2.14 Gendered Labor

The gender division of labor refers to the division of tasks and responsibilities between men and

Women (Bertelsen, 2006). The aquaculture production-related roles of women are significant, but often under-recognized or ‘hidden’ in value chain analyses (Ndang, et al 2013). One factor in this is that women contribute to—but may not be the final decision makers regarding—pond management strategies and product uses and sales. Their role is similarly masked by ownership of ponds and land frequently being formally or informally held by male household-members. The literature suggests that the gender division of aquaculture production roles depends on the existing division of labor and gender norms, relating to what work is considered appropriate for men and women in a geographic location (Shirajee, et al 2010).

2.15 The Gaps in the Literature

As noted above, the productivity of labor for fish production needs continued research. It is important to better understand if the time invested in fish production provides good returns relative to other available alternatives. Likewise, it is important to better understand the factors which inhibit and promote labor productivity. Aquaculture in Southeast Asia is less productive relative to the rest of the world; as such, is important to understand what actions can be taken to improve labor efficiency and generate higher returns for aquaculture farmers. Best practices for feed type, feeding, frequency, stocking density, water quality, fertilizer and use of lime have been highlighted above; however, the literature notes that throughout Myanmar feed management and overall pond management techniques are sub-optimal, with large room for improvement (Joffre, 2018). As such, it is important to better understand the reasons behind poor pond management and low adoption of pond inputs. For WorldFish to successfully implement the distribution of a new species, the factors promoting or inhibiting adoption must be investigated. Hence, it is important to better understand the role of extension services for small holder aquaculture farmers in the Central Dry Zone.

CHAPTER THREE – MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. The Study Area

The Central Dry Zone (CDZ) of Myanmar covers an area of more than 54,000 km, encompassing 54 townships from lower Sagaing region (Figure 1). The CDZ is the most water stressed and one of the most food insecure regions in the country. The CDZ has a population of 10.1 million, of which approximately 43 % live below the poverty line and 40-50% are landless (Singh, 2017). Situated in the shadow of the Rakhine mountain range, the CDZ receives limited rains compared to country averages. The rainy season occurs from mid-May to October followed by a dry cool spell from mid-October to mid-February and a dry hot season from mid-February to mid-May. Average annual rainfall ranges from 500 to 1000 mm compared to 5000 mm in other parts of the country (Poe, 2011). Insufficient rainfall is not only the potential hazard but decreasing forest cover, heat stress, drought, and soil erosion place local communities at greater risk of localized flash floods during times of heavy rain (Poe, 2011).

The CDZ is characterized by high population density, with 34% of the population living on 13% of the land. It has a relatively high proportion of female headed households (18%), which is related to the outmigration of male family members (UNDP, 2015). A 2009 report found that 61% of sampled households in the CDZ have access to agricultural land (Poe, 2011). A 2010 report found that livelihoods in the CDZ are strongly dependent on agriculture with 58% coming from crop production, 25% from farm work, while the rest of 17% are based on livestock production, industrial work and regular employment for government, trading and remittances. (JICA, 2010). The CDZ is characterized by large crop diversity with more than 50% of all farming households growing three or more different types of crops. According to data from the Department of Agriculture, only 12.3% of total agricultural land is under irrigation, with the remaining 87.7% under rainfed conditions (CSO, 2011). The major economic activities in the Dry Zone are subsistence farming such as paddy, sesame and groundnut and small-scale livestock rearing. Agricultural productivity in the CDZ is low. The effects of dry spells, drought and erosion in the CDZ pushes many poor farmers into ecologically sensitive areas, where they apply unsustainable agricultural practices to survive; this, in turn, undermines long-term ecosystem resilience and ecosystem function (UNDP, 2014).

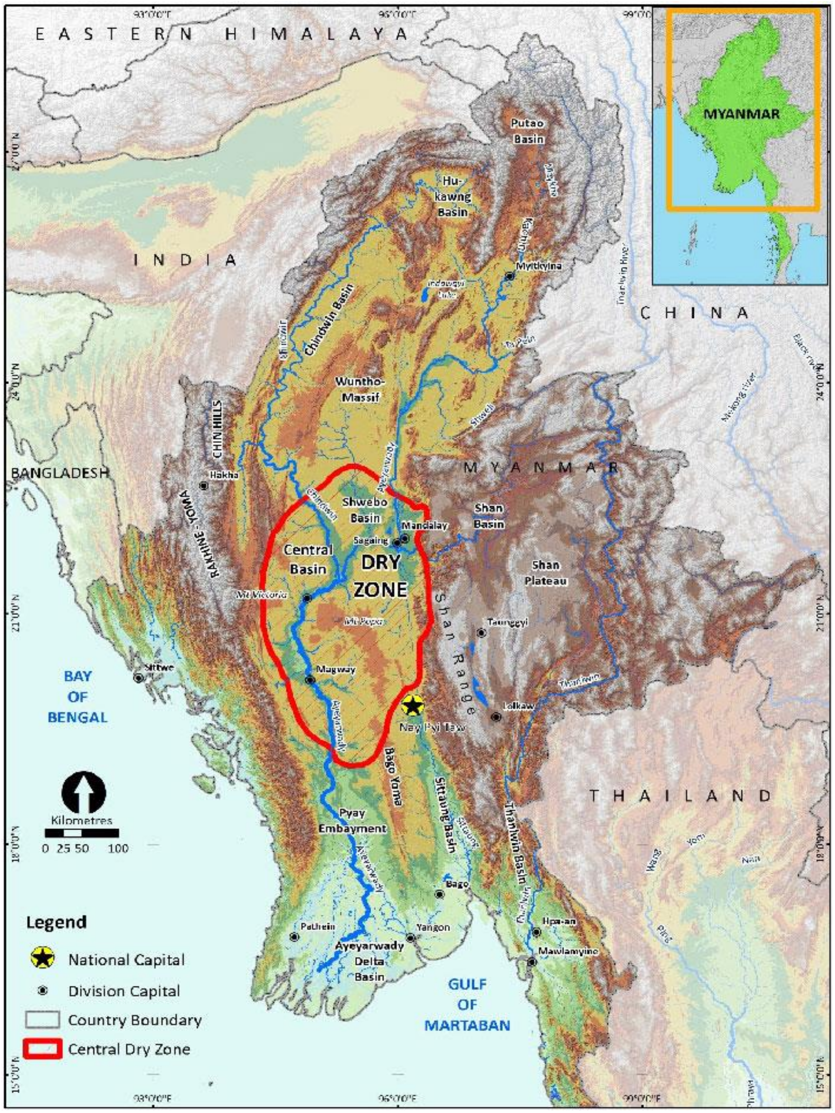

Figure 1: Map of the Central Dry Zone

Source: (The Australian Water Partnership, 2017)

3.2. The Study Region

The study was carried out in three villages in Shwebo Township of the Saigang Region. Shwebo Township is home to the study area of Shwebo City. The area is in the CDZ about 80 kilometers northwest of Mandalay City, Myanmar. Within the Sagaing Region, Shwebo District shares a southern border with Sagaing District, a southwest border with Monywa District and Yinmabi District, a western border with Kale District, and a northern border with Kanbalu District (Figure 3). Shwebo Township encompasses an area of 750 Km^2 with 10 wards containing 62 villages and correspond to 50,247 households (Ministry of Labour, 2017). Based on 2014 Census data, there are 108,955 males (46.3%) and 126,587 (53.7%) females. The mean household size is 4.5 persons, with a relatively high number of female headed households – 25.5%. Literacy rates are high at 95.5%. Labour force participation rate of 15-64 year olds is 85% for males and 62% for females. Tenure security is high, and landlessness is low, 89.2% own, 3.8% rent, and 7% other (Ministry of Labour, 2017). Shwebo District is one of the foremost areas in Sagaing Region for rice production; agriculture with a focus on grain production is popular, particularly its rice, "Shwebo Paw San" (Asian Development Bank, 2018).

The three villages surveyed in Shwebo Township are: Hta Naung Win Village, Chi Par Village, and Ward #10. Relative to Shwebo City, Hta Naung Win Village is located northwest, Chi Par Village is located southwest, and Ward #10 is located northeast (Figure 4).

Hta Naung Win Village was the first village surveyed. According to information provided by BRAC, Hta Naung Win Village has a population of 1956. The village is located approximately 5 kilometers northwest from Shwebo City. The village has 29 aquaculture farmers, of which 24 were interviewed. It has a rural population, with a relatively long history of aquaculture. The area is dominated by agriculture, with rice paddy production surrounding all sides of the village. The area sources its water from Mahar Nandar Lake (Figure 4), approximately 2 kilometers northeast of the village. In the village aquaculture is practiced in earthen ponds, typically adjacent to the household and near a water source. Dirt roads are the only way to access the village, water is provided via irrigation canals and streams, there is access to electricity, and there is a local school serving the community.

Chi Par Village was the second village surveyed. According to information provided by the village leader, Chi Par Village has a population of approximately 2700 inhabitants. The village is located approximately 8 kilometers southwest from Shwebo City (Figure 3). It has a rural population, with a relatively small presence of aquaculture. Presently, only 2 farmers are established in aquaculture practice. However, in the future, 16 farmers are in the process of starting aquaculture supported by BRAC. Aquaculture in the village is practiced in earthen ponds; however, the 2 farmers indicate using no inputs, including feed. Furthermore, both farmers indicate sourcing fish from water discharge of adjacent rice ponds. Chi Par Village is dominated by rice farming with a strong local textile sector focused around traditional loam production. The village is adjacent to a paved road, water is provided via irrigation canals and streams, there is access to electricity, and there is a local school serving the community.

Ward #10 was the third village surveyed. According to information provided by the village leader, Ward #10 has a population of approximately 1000 inhabitants in 150 households. The village is located approximately 2 kilometers northeast of Shwebo City (Figure 3). It has a semi-rural population, with a moderate presence of aquaculture. Ward #10 does not have much agriculture because of water scarcity issues. The area is known for dry hillsides and the department of irrigation prioritizes ares practicing agriculture, so the cost of water is higher. Ward #10 has recently started working with BRAC; previously, Ward #10 had five farmers practicing aquaculture, now, with BRAC's support, there are ten. The main income generating activities are small shops, non-agricultural wage labor, livestock, and aquaculture production. The village is adjacent to a paved road, water issues are a constraint, there is access to electricity, and there is a local school serving the community.

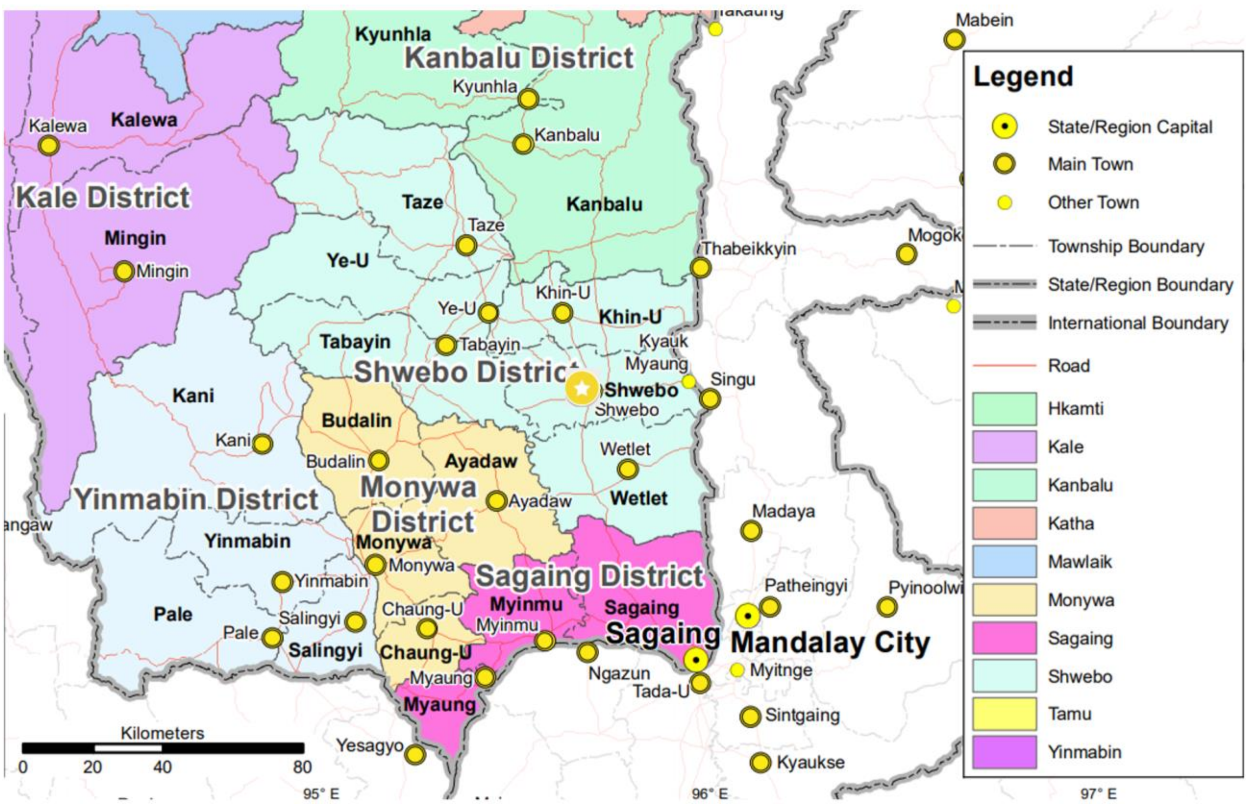

Figure 2:Map of Shwebo District

Source: Adapted from (ReliefWeb, 2017).

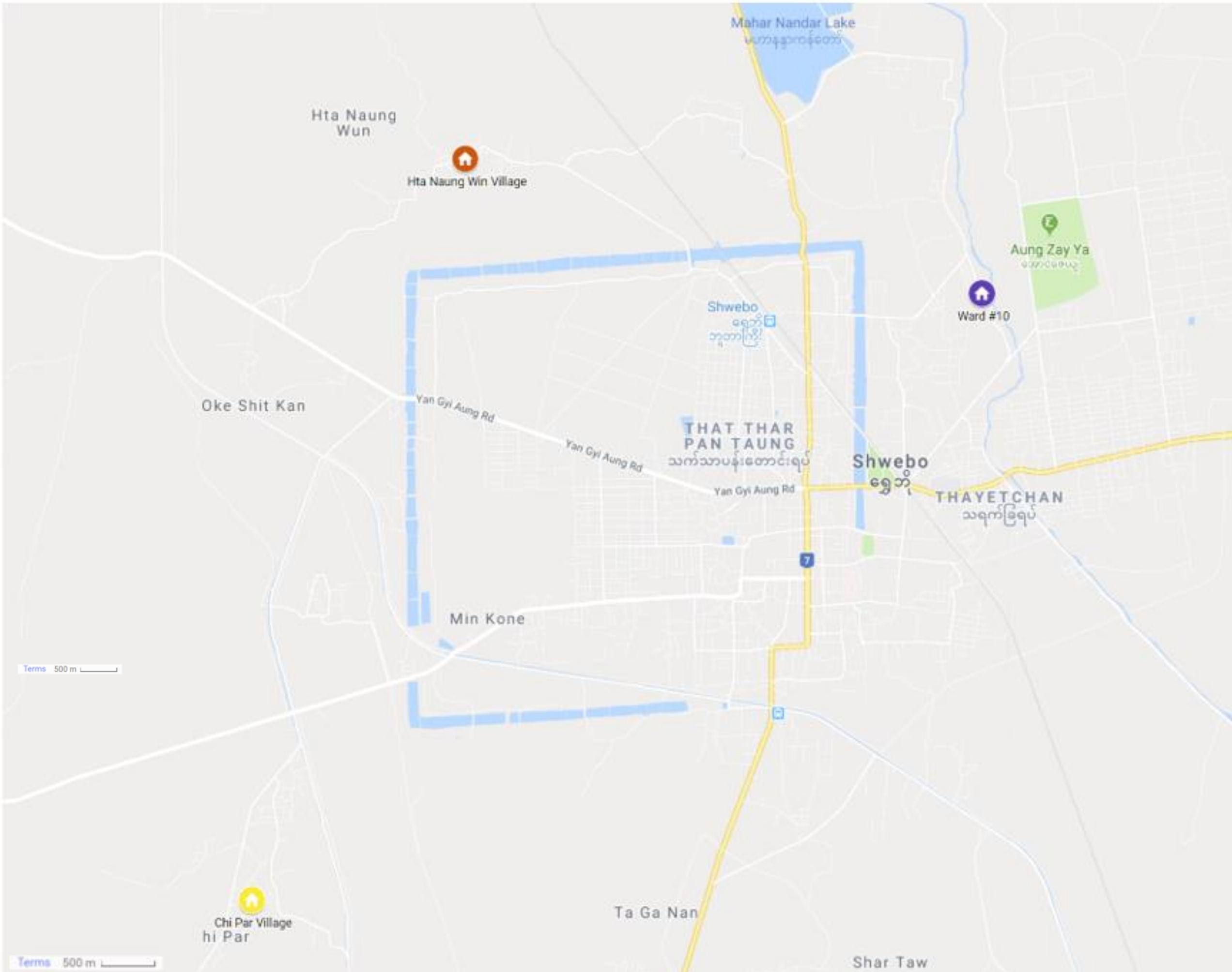

Figure 3: Map of Survey Area, Shwebo City, Shwebo District, Saigang Region, Myanmar

Source: Author's Work (2019)

3.3. Research Approach and Methods

The study uses both quantitative and quantitative methods. Qualitative methods are used to collect data on farmer's perceptions towards aquaculture, challenges practicing aquaculture, effectiveness of extension services, and importance of different fish farming activities. Denizen and Lincoln (2000) believe qualitative research involves an interpretive and naturalistic approach:

> "This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them" (p. 3)".

Quantitative methods are utilized to collect economic data pertaining to the fish farming enterprise. Babbie (2010) defines quantitative methods as:

> "Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon."

By testing the stated hypotheses (section 1.6) and making cause and effect deductions, this study seeks to analyze profitability of smallholder aquaculture farmers. Causal analysis is a simple tool to explore cause and effect relationships amongst variables; in which one phenomenon is the reason behind the other (Gaber, 2013). In this study, quantitative data is used to facilitate causal analysis. Altogether, the study follows the principles of grounded theory analysis, defined by Denizen and Lincoln (2000) as:

> "…a set of flexible analytic guidelines that enable researchers to focus their data collection and to build inductive middle-range theories through successive levels of data analysis and conceptual development…Grounded theory methods consist of simultaneous data collection and analysis, with each informing and focusing the other through the research process."(Denizen and Lincoln, 2000 p.108)

By utilizing both qualitative and quantitative tools, the study hopes to address the research questions.

3.4 Sampling Technique

3.4.1 Purposive Sampling

This study uses the technique of purposive sampling. Purposive sampling is a non-probability sampling method, relying on the judgement of the researcher to select elements for sampling. The aim of the method is to facilitate research through cost and time saving (Black, 2010). Prior to arriving in the study area, WorldFish and the University of Hohenheim worked together to select sites for surveying in the study area based on ease of access and presence of aquaculture. Initially, the project called for surveying of two villages: Hta Naung Win Village and Chi Par Village. However, as the survey progressed it became apparent that there were not enough respondents in Chi Par Village and, following a consultation with BRAC, a third village was added for survey

(Ward #10). Ward #10 met the criteria of ease of access and respondents with aquaculture practices. All three villages are located within 10km of Shwebo and are reachable within 45 minutes driving (Figure 4). 24 respondents were interviewed in Hta Naung Win Village, 2 respondents were interviewed in Chi Par Village, and 13 respondents were interviewed in Ward #10.

3.4.2 Theoretical Sampling

Theoretical sampling was used to facilitate the collection of qualitative data. In grounded theory studies, theoretical sampling occurs as the data collection progresses. After identifying the research topic and question, the researcher chooses a small handful of people to interview based on a set of criteria; the researcher pursues developing conceptual ideas rather than amassing general information (Charmaz, 1990). Throughout the study additional lines of questioning were added as certain topics required more attention. The Author reviewed field notes after each day and brainstormed new questions for the following interviews. Similarly, several additional informants were chosen based on provided information by respondents; including, a Department of Fisheries hatchery representative, a local bulk buyer, and three village leaders.

3.5 Data Collection

Table 1 details the data collection methods.

3.5.1 Structured Questionnaire

The study utilizes primary data. The primary data was collected through interviews facilitated with a structured questionnaire. The survey period was May 6th, 2019 to May 29th, 2019. The questionnaire is provided in Appendix A. Questions in the questionnaire focused on socioeconomic characteristics of the aquaculture farmers, the labor productivity of their practices, and the pond productivity of their practices. Additional questions were asked regarding the importance of various farm activities, challenges practicing aquaculture, and the changes of aquaculture practices over time.

3.5.2 Semi-structured Interview

Semi-structured interviews were conducted with 39 purposefully selected smallholder aquaculture farmers (Selection criteria in section 1.4.1). The semi-structured interviews with farmers based on predetermined research questions allowed for clarification of potentially interesting responses with follow-up questions based on the respondents provided information. A free range of questioning allowed for the identification of key concepts and the potential to acquire new and distinct knowledge. The interviews were conducted with the help of a translator. A translation of the questionnaire and several pre-determined questions was completed by the translator prior to survey start. Notes were taking in a field notebook throughout the semi-structured interviews. Photos were taken at each interview and documented the households, livelihood of respondents, pond sizes, and characteristics of the farms.

Table 1:Data Collection Methods

Applied Methods	Number of Respondents	Remark
Questionnaires	39 Farmers	3 Villages
Informant Interviews	5 Interviewees	1 DOF Representative 3 Village Leaders 1 Bulk Buyer

Source: Author's Work

3.6 Quantitative Analysis

3.6.1 Economic Analysis – Financial Analysis Approach

Economic analysis of attempts to relate the impact of an enterprise on the overall economic development of a country. Economic analysis considers the use of the nation's resources for the enterprise, and whether the use is justified. Conversely, financial analysis considers a single enterprise and does not consider macroeconomic factors (Gittinger, 1984). This study is based on the financial analysis approach because of is focus on microeconomic analysis. The study does not consider macroeconomic impacts.

3.6.2 Descriptive Analysis

Socioeconomic parameters such as age, gender, marital status, education, occupations, amongst others, were collected from respondents and subjected to descriptive statistics demonstrating frequency distribution, percentages, and cumulative percentages.

3.6.3 Enterprise Budget Analysis

The study performed an enterprise budget analysis in order to better understand the role of inputs on profitability and pond productivity. To do so, average costs and revenues were calculated based on information collected from respondents. Engle, et al (2005) discuss enterprise analysis in the context of aquaculture:

> “An enterprise budget provides a generalized snapshot of the costs and returns of a particular enterprise…for a particular period of time… Profits would be determined by finding whether or not revenues generated from the sale of tilapia were greater than the sum of all costs involved in tilapia production. Average or typical values would be used for all costs and prices in the analysis. …Costs are divided into the categories variable (those that vary with production; also called operating costs) and fixed (costs that will be incurred regardless of the level of production; also called ownership costs)”.

Gross income (gross revenue, gross receipts) determines all the cash and noncash revenue generated by the enterprise. It is determined by adding the total income generated by the enterprise.

$$\text{Gross Income (Revenue)} = Ix + Iy + Iz \ldots + I(n) \qquad (1)$$

Where:

I = Income

Revenue is defined as the total receipts from sales of a given quantity of goods or services. It is the total income of a business and is calculated by multiplying the quantity of goods sold by the price of the goods (OpenStax 2014).

$$\text{Revenue}(x, y, z) = \text{Quantity} \times \text{Price} \qquad (2)$$

Costs are divided into variable costs, which vary with production, and fixed costs, which are incurred regardless the level of production (Engle, 2005). Variable costs may include production, marketing, and selling expenses. Some variable costs depend on units sold; others depend on revenue (Farris, et al, 2010) :

$$VC = VC(X) + VC(Y) + VC(Z) + \cdots + VC(n) \qquad (3)$$

Where:

VC = Variable cost

Fixed costs, by definition, do not change with the number of units sold or produced (Farris, et al, 2010). The fixed costs used for the enterprise budget are the depreciated costs (see section 3.6.4) for all fixed assets.

$$FC = FC(X) + FC(Y) + \cdots + FC(n) \qquad (4)$$

Where:

FC = Fixed cost

Because some costs are fixed, total cost starts at a level above zero, even when no units are produced. This is because fixed costs include such expenses as factory rent and salaries for full-time employees, which must be paid regardless of whether any goods are produced and sold (Farris, et al, 2010) . Fixed costs include depreciation, interest on investment, taxes and insurance, and any other costs that are not related to the level of production of the business (Engel, 2010). The total cost of the enterprise budget on a farm is calculated by adding the total variable cost and the total fixed cost.

$$TC = TFC + TVC \qquad (5)$$

Where:

TC = Total cost

TFC = Total fixed cost

TVC = Total variable

3.6.4 Depreciation

Depreciation is an annual, noncash expense which accounts for the amount by which an asset loses value due to use, age, and obsolescence. It looks to spread the original cost over the asset's useful life. (Engle, 2010).

$$\text{Depreciation} = \frac{\text{Cost of Asset} - \text{Salvage Value}}{\text{useful life}} \qquad (6)$$

Engle states:

> "Depreciation must be calculated for all capital goods (goods with a useful life greater than a year). Capital goods such as buildings and equipment are necessary for aquaculture production. However, their use in aquaculture production results in their aging, obsolescence, and become worn out, losing value as a consequence. This loss in value is a business expense because it is related directly to the asset's use to produce revenue and profit. To be considered a depreciable asset, the capital good must have a useful life of more than 1 year and a useful life that can be quantified." (Engel 2010, p.120)

From the enterprise budget the net farm income (net profit), is defined by Engle (2010) as the difference between total revenue and total expenses, not including a gain or loss on the sale of certain capital assets.

$$\text{NFI} = \text{TR} - \text{TC} \qquad (7)$$

Where:

NFI = Net farm income

TR = Total revenue

TC = Total cost

The most important measure of profitability from the enterprise budget is net returns. Net returns are calculated by subtracting total costs from total revenue. An intermediate measure is to calculate income above variable costs (also known as gross margin) by subtracting total variable costs from gross revenue (Engle, 2010). This is indicated in the formula below:

$$\text{GM} = \text{TVC} - \text{GR} \qquad (8)$$

Where:

GM = Gross

TVC = Total variable cost

GR = Gross revenue

Breakeven price measures the cost of production of a single unit (fish) of the product. If the product can be sold for a price that is more than its cost of production, then a profit is generated. It indicates the selling price for which total income will just equal total costs for a given level of production and is calculated from the enterprise budget. It is calculated by dividing the total variable cost by the quantity produced (Engle, 2010).

$$\mathrm{BEP} = \frac{\mathrm{TVC}}{\mathrm{q}} \quad (9)$$

Where:

BEP = Break-even price

TVC = Total variable cost

Q = Quantity produced/yield

3.6.5 Investment analysis

It is necessary to perform an investment analysis to better understand the best use of financial capital for a limited number of resources. A manager equipped with sound financial information can make better investment decisions for the future. A payback period calculation is performed to understand how long of a time period is necessary for a recovery of initial investment. Based on average annual net returns, the payback period relates the initial cost of investment and the expected average annual net returns (Engle, 2010).

$$\mathrm{PP} = \frac{\mathrm{ICV}}{\mathrm{R}} \quad (10)$$

Where:

PP = Payback period

ICV = Initial cost of investment (total non-current asset)

R = Expected annual revenue (the revenue on an annual basis)

The simple rate of return expresses average annual net revenue as a percentage of the investment. Net revenue is found by subtracting the average annual depreciation from the average annual net cash revenue. The simple rate of return is an improvement over the payback period in terms of measuring profitability because it considers the earnings of an investment over the entire life of the investment. The RR is calculated by dividing the average net revenue by the expected annual revenue and multiplying the result by 100 (Engle, 2010).

$$RR = \left(\frac{ANR}{R}\right) * 100 \qquad (11)$$

Where:

RR = Rate of return

ANR = Average net revenue

R = Expected annual revenue

The average net revenue was calculated using a 20 years investment period, by adding the expected annual return each year (total net revenue). The initial amount invested was deducted from the total net revenue and then divided by the total years of investment.

$$ANR = \frac{TNR - CV}{Y} \qquad (12)$$

Where:

ANR = Average net revenue

TNR = Total net revenue

ICV = Initial cost of investment

Y = Number of years

Net present value (NPV) is the difference between present value of cash inflows and the present value of cash outflows over a given amount of time. The calculation is based around the notion that money in in the present is worth more than money in the future (discounting). A dollar earned in the future is not worth as much as the same dollar in the present because of alternative earnings that could be gained utilizing that money and inflation. Net present value was calculated using a 20-year investment period and the expected annual return for each year was discounted to obtain the present value of each year using (Engle, 2010):

$$PV = \frac{P_n}{(1+i)^n} \qquad (13)$$

Where:

PV = Present value

P_n = Cash flow for year n

I = Discount rate

N = Year n

The discount rate was calculated by the weighted average of the interest rate of loan obtained by the respondents and the opportunity cost of the capital used by the respondents for the investment. This opportunity cost was obtained by the bank interest rates on savings in Myanmar, which according to CB Bank (Myanmar's largest bank) - is 10 percent (CB Bank, 2019).

The net present value is calculated by adding all the present values and then deducting the initial cost of investment

$$NPV = \left(\frac{P_1}{(1+i)^1}\right) + \left(\frac{P_2}{(1+i)^2}\right) + \cdots + \left(\frac{P_n}{(1+i)^n}\right) - C \qquad (14)$$

Where:

NPV = Net present value

$P_{1, 2, n}$ = Cash flow for year 1, 2 to n

I = Discount rate

C = Initial Cost of Investment

The internal rate of return (IRR) is used to estimate profitability of a potential investment. Alternatively known as, marginal efficiency of capital, yield on investment, or discounted yield, the IRR is a discount rate that makes the NPV of all cash flows from a particular project equal to zero. (Engle, 2010).

$$0 = \frac{P_1}{(1+i)^1} + \frac{P_2}{(1+i)^2} + \cdots + \frac{P_n}{(1+i)^n} - C \qquad (15)$$

Net present value was set to zero

$P_{1, 2, n}$ = Cash flow for year 1, 2 to n

I = Discount rate

C = Initial cost of investment

The benefit-cost ratio gives the ratio of the present value of future net cash flows over the life of the project to the net investment (Curtis, 1993). It was calculated by dividing the NPV by the initial investment:

$$BCR = \frac{NPV}{INV} \quad (16)$$

Where:

BCR = Benefit cost ratio

NPV = Net present value

INV = Initial Investment

3.7 Opportunity cost

Opportunity cost is defined as the value of the next best alternative use of a resource (Hyman, 1997). To do this, one can compare the gross margin that would otherwise be earned if the land were used for other agricultural enterprise. The residual profit to land in aquaculture production was compared to the residual profit of other agricultural enterprises. The residual profit to land was obtained by deducting the labor cost of the enterprise and the capital cost of the enterprise from the gross margin of the enterprise.

$$RPLCP = GMCE - LCCE - CCCE \quad (17)$$

Where:

RPLCP = Residual profit to land for aquaculture production

GMCE = Gross margin of aquaculture enterprise

LCCE = Labor cost aquaculture enterprise

CCCE = Capital cost aquaculture enterprise

The enterprises that were used for comparison were paddy rice production, green gram, black gram, and chickpeas. The residual profit to land was calculated on an annual basis and the opportunity cost of using land for other agricultural purposes was calculated using:

$$OCLD = \frac{RPLCE}{RPLCP} \quad (18)$$

Where:

OCLD = Opportunity cost land

RPLCE = Residual profit to land of the compared enterprise

RPLCP = Residual profit to land of catfish production

This served as the opportunity cost of land for the farmer using his piece of land for other agricultural activities. Furthermore, the opportunity cost of labor for both the farm workers and the farmer was calculated. The average wage of the farm workers was compared to the national minimum wage in Myanmar and other wages for low skilled workers in Myanmar.

3.8 Qualitative analysis

The qualitative analysis was performed throughout the study at all points of data collection. The purpose was to use a semi-structured interview format to allow respondents to reveal insights into research areas. As concepts were identified throughout the interviews, additional lines of questioning were added to the survey. Notes transcribed during interviews were analyzed through the process of content analysis. Qualitative content analysis is defined as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns (Hsieh and Shannon, 2005). Qualitative content analysis goes beyond merely counting words to examining language intensely for the purpose of classifying large amounts of text into an efficient number of categories that represent similar meanings. Ultimately, the goal is to provide knowledge and understanding of the phenomenon under study (Hsieh and Shannon, 2005). Particularly insightful responses provided by respondents are discussed in greater detail in the discussion chapter.

3.9 Definition and measurement of variables

1. Age of respondents: the age of respondents was collected and further aggregated by age groupings.
2. Gender of respondents: the proportion of male to females was collected.
3. Marital status of respondents: the marital status of respondents was collected.
4. Educational level of respondents: the highest achieved level of education was collected from respondents.
5. Occupation of respondents: prior to field work, a literature review revealed which occupations are commons for the area; hence, a codified system was utilized for the various occupation types.
6. Years of aquaculture experience: respondents were asked to classify their experience based on the three categories: 0-5 years' experience, 5-10 years' experience, >10 years' experience.
7. Motivation for aquaculture: respondents were asked to rank the importance of their motivation for aquaculture, the options were profit, home consumption, and family/friends.
8. Types of pond construction: a visual inspection of the respondent's ponds was used to quantify the type of pond construction they utilized.
9. Number of ponds: respondents were asked the number of ponds they owned.
10. Size of ponds: respondents were asked to estimate the area of their ponds.
11. Land ownership: respondents were asked about their land ownership status (rent/own/lease).
12. Polyculture: respondents were asked if they practiced aquaculture, and if so, what fish did they typically stock.
13. Water sources: respondents were asked where they sourced the water for their ponds.
14. Distance to water sources: respondents were asked to estimate the distance to their water source.
15. Changes in fish production: respondents were asked if they had changed their aquaculture practices in the last 5 years. If yes, they were asked to detail changes in production, fish stocking, and technique.

16. Point of sale: respondents were asked about their recent point of sale.
17. Source of fingerlings: respondents were asked where they source their fingerlings.
18. Ranking importance of farm activities: respondents were asked to rank the importance of various farm activities to their livelihood. Activities were preselected from a literature review of aquaculture in Myanmar.
19. Ranking problems associated with aquaculture: respondents were asked if certain aspects of their aquaculture practice were problematic. Problems associated with aquaculture were preselected based on a literature review. An option was provided to add additional problems from respondents.

CHAPTER FOUR – RESULTS AND DISCUSSION

4. Results and Discussion

4.1 Introduction

39 respondents were surveyed from three different villages in Shwebo City. The following chapter presents the socioeconomic information gathered from the respondents, presents several enterprise budgets, and analyzes several investment scenarios. Certain questions and categories have less than 39 respondents; these differences are accounted for either due to errors in data collection or because questions were added after surveying had begun (as it became apparent additional questions were necessary). The data collected is compared to existing literature for aquaculture in Myanmar, as it is available.

4.2 Age of Respondents

The results presented in Table 2 show the ages of respondents are separated into 5 different age groupings. The ages vary from a minimum of 26 to a maximum of 70. The mean age closely matches the median age (48.7 vs 49). The distribution of the ages is relatively uniform, with a slight weighting towards the oldest category (60-70). Figure 4 displays the relative proportions of each age group. These ages are relatively higher than expectations, as previous aquaculture studies in Myanmar and neighboring countries have observed mean ages between 41-46 (Schneider, et al 2015; AquaFish, 2016). A previous study found that the age of freshwater aquaculture farmers had a negative and statistically significant impact on technical efficiency (Abdullahi, et al 2016). Consequently, the relatively high mean age could be problematic for the productivity of aquaculture in Shwebo District.

Table 2:Age Group of Respondents in the Study Area		
Age Groups	Frequency	Percentage
20-29	3	8%
30-39	8	21%
40-49	9	23%
50-59	6	15%
60-70	13	33%
Total	39	
Mean	48.7	
Median	49	
Minimum Age	26	
Maximum Age	70	
Source: (Field Survey 2019)		

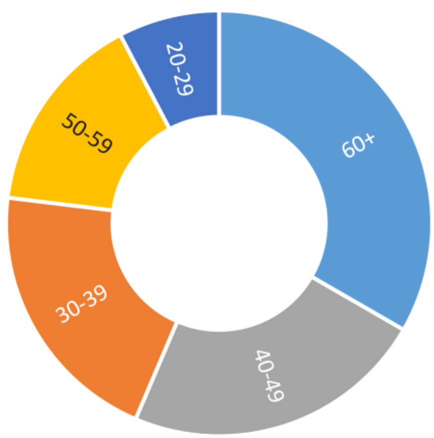

Figure 4: Age Groupings of Respondents in Study area

4.3 Gender Distribution of Respondents in Study Area

The results presented in Table 3 show the gender distribution of aquaculture farmers in study areas. There is small gender gap – with 59 % of respondents being male compared to 41 % female. This is relatively encouraging, as small-scale aquaculture sector has been shown to offer many benefits to women, including female empowerment and benefits to household income and food security (Aregu, et al 2017). A UNDP study had found that 21% of Myanmar households are women-led, indicating that the respondents surveyed showed a higher proportion of women-led households (UNDP, 2011).

Table 3:Gender distribution of Respondents in the Study Area

Gender	Frequency	Percentage
Male	23	59%
Female	16	41%
Total	39	

Source: (Field Survey 2019)

4.4 Marital Status of Respondents in Study Area

The results presented in Table 4 show the marital status of aquaculture farmers in the study areas. The large proportion of surveyed farmers are Married, 72% vs 28%. These results are in-line with a 2018 study which found the same percentages (72%/28%) at a fishing village at Inlay Lake, Myanmar (Win, 2018).

Table 4:Marital Status of Respondents in the Study Area

	Frequency	Percentage
Married	28	72%
Single	11	28%
Total	39	

Source: (Field Survey 2019)

4.5 Education Status of Respondents in Study Area

The results presented in Table 5 show the education level of aquaculture farmers in the study areas. There was a relatively even split of education level between farmers, with half receiving a primary education (49%) and the other half receiving a secondary education (46%). A small minority of farmers (2) had received higher education. A 2014 study found low level of education of fish farmers to be a constraint for the adoption of scientific aquaculture practices (Kumar, et al 2014). The Respondents level of education taken together with the fact that 100% of the respondents could read and write, indicates that farmers are well equipped to receive training, read instruction manuals, and use digital applications to improve their aquaculturally practices.

Conversations with respondents further demonstrated that their educational levels were sufficient to receive and utilize training. Farmers were eager to demonstrate their logbooks and study material provided by DOF and WorldFish, and spoke of utilizing the mobile phone application "Greenway" to improve their aquaculture practices.

Table 5:Education Status of Respondents in the Study Area

	Frequency	Percentage
Primary Education	19	49%
Secondary Education	18	46%
Higher Education	2	5%
Total	39	

Source: (Field Survey 2019)

4.6 Occupations of Respondents in Study Area

The results presented in Table 6 show the occupations of aquaculture farmers in the study area. Respondents could select more than one category, and many did so. 22 farmers had one or more occupations. Crop production was the second most common occupation for respondents; animal husbandry was third; and, mixed crop and livestock production was fourth. Surprisingly, relatively few respondents engaged in wage labor. A previous study found (FAO, 2018):

> "Faced with a low return from agriculture, farmers diversify their sources of income rather than farm more intensively. They engage in casual/seasonal work, which may include work in larger farms, rice mills and fish-processing units, and non-agricultural activities such as road construction, stone mining and grinding, weaving and small trade in local markets. Other sources of income include agroforestry (timber, bamboo, rattan, spices, medicinal plants, and honey) and small livestock such as chickens, goats and pigs. Some migrate in search of employment in cities or in neighbouring countries."

This observation is consistent with what is observed in Shwebo District. Most Farmers are diversified in their occupations and income generating activities. It is noteworthy to discuss the particularities of the respondents who indicated operating their own enterprise. Two types of enterprise are mentioned by multiple respondents, operating a loom business, and operating a small road-side shop, selling food items, toiletries and other essentials. Farmers surveyed indicated choosing additional occupations because of available time and their desires to supplement agriculture/aquaculture derived income. Section, 4.6.1, continues with a discussion of crop production in the study area. Similarly, section 4.6.2 discusses animal husbandry in the study area.

Table 6:Occupations of Respondents (39 Respondents, can have more than 1 occupation)

Occupation	Frequency	Percentage
Fish farmer	39	100%
Crop production	22	56%
Animal husbandry	19	49%
Mixed crop and livestock prod.	13	33%
Own enterprise	10	26%
Agricultural wage labor (crops)	3	8%
Livestock herder	1	3%
Non-agricultural wage labor	1	3%
Student/pupil	1	3%
Domestic work	0	0%
Government employee	0	0%
Private sector employee	0	0%
Trader	0	0%

Source: (Field Survey 2019)

4.6.1 Crop Production

The Dry Zone is predominantly a farm-based economy, but significant shares of inhabitants make a living by working off-farm. Only 31% of total income generated in the Dry Zone economy comes directly from farming (Myint, 2017). Crop production in the survey area is widespread (56 % of respondents) with rice production being by far the most frequently cited form of crop production. A 2009 report found 61% of sampled households in the Central Dry Zone have access to agricultural land (Poe, 2011). In Myanmar, a typical person is assumed to consume about 160 kg of white milled rice per annum. A high-grade variety of rice, Shwebo Pawsan, is specific to the region, and is in demand throughout the country (JICA, 2018). Several respondents indicated that in addition to rice production they have some vegetable production, however, such practice was not widespread and only relevant to a few households. Discussed later in greater detail in Table 16, crop production ranks as very important for a large proportion of households.

4.6.2 Livestock

Cattle are spread throughout smallholder farming systems but are found in high concentrations in the Dry Zone. Similarly, sheep and goats are concentrated in the Dry Zone. Cattle, sheep and goats are perfectly suited to the Dry Zone environment where the farmers essentially do not have to pay for any of the feed for them. According to recent study (FAO, 2018):

> "The Dry Zone is a very important area for livestock production, and arguably is the zone where livestock plays the most important role in farming systems. The zone is especially important for cattle, sheep and goat production"

Specific to the respondents and the study area, animal husbandry is slightly less widespread relative to crop production (56% vs 49%). 14 of the respondent households kept cows, 13 kept chickens, 6 kept pigs, and 3 kept water buffalos. Unlike, other parts of the dry zone, the study area did not have a prevalence of sheep and goats. The respondents with water buffalo indicated they kept the animals for working the fields.

4.7 Years of Aquaculture Experience

The results presented in Table 7 show the distribution of respondents based on their years of aquaculture experience. Nearly half (49%) of respondents have started their aquaculture practices in the last 5 years. The other half of respondents are relatively split between 5-10 years of experience and more than 10 years' experience. In several instances it was observed that aquaculture adoption occurred circumstantially. For example, one respondent indicated that when the department of Irrigation was digging canals, he had them dig out his pond. Another respondent indicated that he originally dug his ponds for water storage for his cattle but had repurposed following training. Later in the report, Table 26 and Table 27 will compare an enterprise budget between relatively new adopters (1-5 years) of aquaculture and older adopters (>5 years).

Table 7:Years of Aquaculture Experience		
Years of Experience	Frequency	Percentage
1-5 Years	19	49%
5-10 Years	8	21%
More Than 10 Years	12	31%
Total	39	
Source: (Field Survey 2019)		

4.8 Motivation for Aquaculture

When asked to “Rank the motivation for starting your aquaculture practice”, 88% of respondents indicated that their first motivation was for profit, compared to 12% who indicated that their first motivation was for home consumption. This information is rather indicative, as it seems that most respondents are food secure and hence can prioritize aquaculture for profit rather than home consumption. Further supporting this hypothesis, discussed in the section of Land ownership, all respondents are observed to be titled landowners. This indicates that the surveyed respondents are likely not the poorest demographic (landless) and are less likely to be food insecure.

Table 8:Motivation for Aquaculture		
Top Motivation	Frequency	Percentage
Profit	35	90%
Home Consumption	4	10%
Family & Friends	0	0%
Total	39	
Source: (Field Survey 2019)		

4.9 Types of Pond Construction

The results presented in Table 9 show that all respondents in the study area had Earthen Ponds. According to the Technical Guide for Tilapia farming, published by the Centre for the Development of Industry:

“Earthen ponds are more commonly used in tropical fish farming and represent the oldest fish farming facility. A good pond will show the following characteristics: a well designed water supply but also easy drainage; good impermeability of the pond as a whole and strength/integrity of the pond's walls and edges; access and possibility to work around the pond …"

There is not much literature available on Pond types in Myanmar, but one paper by Saw observed:

"Myanmar usually exports major carps to Bangladesh where they command a higher price…. The fish is normally cultured in earthen ponds and rarely in tanks. In terms of pond sizes, the smallest ponds are 0.1 ha, while the largest ponds are 10-20 ha."

This understanding is further reiterated by a FAO publication, which details Department of Fisheries (DOF) Protocol:

"These two problems were solved by Department of Fisheries through demonstration, showing that the common carps are to be cultured in earthen pond with clay soil deep enough to keep the water level at least one and half meter deep such that it does not reach embankment base."

As such, the surveyed respondents are in-line with advice propagated by the DOF protocols and construct earthen ponds.

Table 9:Pond Production Types

Pond Type	Frequency	Percentage
Earthen Pond	39	100%
Other	0	0%

Source: (Field Survey 2019)

4.10 Number of Ponds

The results presented in Table 10 shows the number of ponds maintained by respondents in the study area. There is some variability, but mostly respondents prefer 1 pond. As to be expected, the better performing households in terms of production and profitability are the ones with higher number of ponds. A 2017 report by Belton, et al, found the average number of ponds per growout farm is 3.1, rising from 1.5 for small farms to 6.1 for large farms (Belton, 2017). The mean number of ponds from survey respondents was 1.44 comparing well with the 1.5 mean observed by Belton for small farms.

Table 10:Number of Ponds		
# Ponds	Frequency	Percentage
1 Pond	28	72%
2 Ponds	6	15%
3 Ponds	4	10%
4 Ponds	1	3%
Total	39	
Number of Ponds	56	
Mean Number of Ponds	1.44	
Source: (Field Survey 2019)		

4.11 Size of Ponds

The results presented in Table 11 and Figure 5 show the size distribution and frequency of the ponds of respondents in the study area. There was significant variability in pond sizes, the minimum size was 84 m^2 compared to a maximum size of 6070 m^2. It should be reiterated that there is significant potential for error in observed pond sizes due to self-reporting by the farmers, and potential for significant under and overestimation. Respondents with multiple ponds tended to cluster the ponds together near their housing to facilitate ease of feeding and harvesting. In a few cases, the ponds were situated far away from the households, in which case, respondents reported feeding as problematic, this is further discussed in section 4.22.

Table 11:Size of Ponds			
Size	Frequency	Size (m²)	Percentage
0-1000 m²	20		36%
1000-2000m²	7		13%
2000-3000m²	14		25%
3000-4000 m²	5		9%
4000+ m²	9		16%
Total	55		
Mean Size		1957	
Minimum Size		84	
Maximum Size		6070	
Source: (Field Survey 2019)			

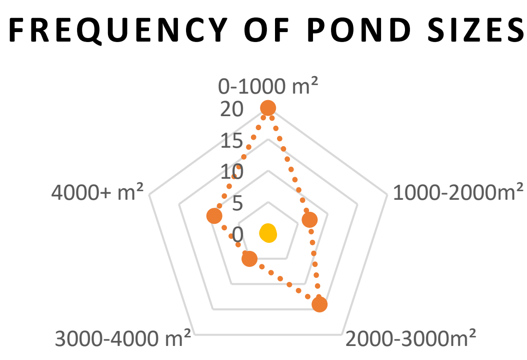

Figure 5: Pond Size Variability

4.12 Land Ownership

The Results presented in Table 12 and Figure 6 show land ownership based on three different groupings 1-5 acres (small), 5-10 acres (medium), 10+ acres (medium/large). All respondents surveyed are landholders, with 0 respondents reporting renting. Furthermore, most respondents surveyed are very small landholders with mean landholdings of 3.8 acres. A recent publication found that an all household average area of land owned (including households without agricultural land) is 4.2 acres, with a median of just 0.16 reflecting very high levels of landlessness. The mean acreage is in-line with Belton & Filipski's observations, however, the high level of landlessness observed in their study area is not found in Shwebo District. The low level of landlessness is reiterated by 2014 Myanmar Census data: "The Myanmar housing census of 2014 reveals that for Shwebo District the demographics of Shwebo District, tenure security is high and landlessness is low – 89.2% own; 3.8% rent; 7% other" (Ministry of Labour, 2017). Generally, most respondents surveyed indicated their land was used either for housing, livestock, aquaculture, or crop production. On several occasions the issue of land scarcity was brought up by the respondents, indicating that strict zoning regulations prohibit the conversion of agricultural land to aquaculture. This sentiment is highlighted in a recent report:

> "Inland aquaculture development has been constrained by restrictions that prevent the conversion of farmland to ponds despite evidence that fishponds in Myanmar can provide six times more revenue and four times more employment than the same area of rice paddy." (World Bank, 2019)

Section 4.13 expands on land ownership groupings.

Table 12:Land Ownership

Land Owned	Frequency	Size (Acres)	Percentage
1-5 acres	27	-	69%
5-10 acres	9	-	23%
10+ acres	3	-	8%
Total	39	-	
Mean		3.8	
Median		1.9	

Source: (Field Survey 2019)

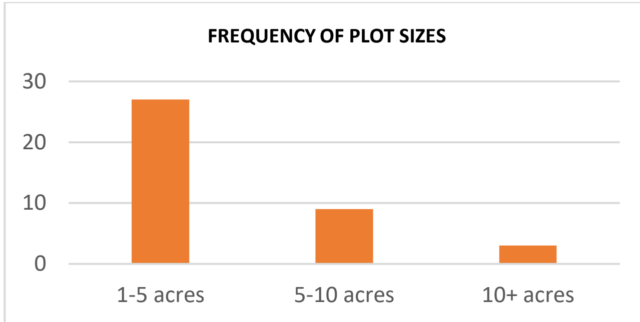

Figure 6: Land Ownership Variability

4.13 Categories of Farm Sizes

Table 13 presents 4 categories of subsistence to medium-scale aquaculture and is useful to compare the productivity of respondents based upon their respective category. For the sake of later comparison, 1-5 acres are quantified as small-scale aquaculture (Item 1), 5-10 acres are quantified as small-scale aquaculture (item 2), and 10+ acres are quantified as small/medium scale aquaculture (item 3). Because there were no large farm sizes there are no representatives for category 4.

Table 13:Categories of Farm Size

Farm Categories				
Item	1	2	3	4
Scale	Small (1-5 acres)	Small (5-10 Acres)	Small/Medium (10+)	Medium/Large
Market Orientation	Subsistence and/or Local	Local/district	District/urban	Urban/National
Investment	Low	Low/moderate	Moderate	Moderate/high
Ownership	Family owned & operated	Family owned & operated	Family owned & operated	Family owned & operated or absentee owner
Labor	Family	Family & possible occasional hired	Family & occasional hired	Permanent Labor
Organization	Minor activity in a portfolio of livelihoods options	One of a portfolio of livelihood options	Primary livelihood activity	Primary livelihood activity or entrepreneurial investment activity

Source: Adopted from (Bondad-Reantaso, 2010)

4.14 Polyculture

The results presented in Table 14 show whether the respondents practice Polyculture. As surveying began it became quickly apparent that polyculture was relatively widespread and that there was a diversity of fish rearing. Nearly half of the respondents indicated practicing polyculture. Amongst these there was many different combinations of preferred fish types. The importance of the fish was observed to be: Rohu > Tilapia > Ponfret > Tapian. Mostly, the observed polyculture practices were relatively simple and lacking consistent methodology. Surveyed respondents indicated that they would stock the fish as was convenient, and often by circumstance (gifting from friends and family, water discharge, and what was available in the local markets). There was a notably absent standardization of practices for those farmers who chose to practice aquaculture. The relative importance of farm activities is further discussed in section 4.14, Ranking Importance of Farm Activities.

Table 14:Polyculture

Response	Frequency	Percentage
Yes	18	49%
No	19	51%
Total	37	

Source: (Field Survey 2019)

4.15 Water Sources for Aquaculture

The results presented in Table 15 show the source of water for the respondents in the survey area. Overwhelmingly, respondents indicated sourcing water from nearby ponds/reservoirs/canals, facilitated by the Myanmar Department of Irrigation. As the survey progressed water scarcity was often cited as a serious problem for respondents (further discussed in the problems section). Typically, respondents far from the irrigation canals or streams (managed by the department of Irrigation) would utilize pumps to source water for their aquaculture practices. Alternatively, those closer to the irrigation canals or streams could often divert water as was necessary and/or utilize water from adjacent rice paddies. A line of questioning revealed that farmers utilizing water from rice paddies were not considering the potential effects of pesticides, insecticides, and herbicides utilized for the rice production on their aquaculture practices. This practice could potentially have negative health effects and should be handled with caution. FAO has published guidelines for rice fish culture, which indicate:

> "The wide scale of rice-fish is still constrained by continued application of pesticides in rice-based farming. The use of pesticide is not recommended in rice-fish farming. In

> rice-fish culture, there are ways of controlling rice pests that do not need pesticide…" (FAO, 2001).

Surprisingly, two farmers indicated relying on rainwater for their aquaculture production. This practice is high risk and leaves farmers vulnerable to climatic shocks. Boyd, et al. discuss the relevance of agrometeorology to aquaculture:

> "Watershed and excavated ponds rarely receive inflow from wells, streams or other external bodies of water. Fisheries production in such ponds often is referred to as "rainfed" aquaculture. Rainfall, overland flow, evaporation and seepage are critical factors regulating the amount of water available for rainfed aquaculture. Small, rainfed ponds are the most common aquaculture systems used by poor, rural people in tropical nations." (Boyd, 2010).

Later, Boyd, et al stated regarding climatic shocks (drought):

> "Drought can be particularly devastating in watershed ponds. Where groundwater is not available for refilling ponds, water levels may decrease drastically, causing overcrowding of fish." (Boyd, 2010).

Taken more generally, A paper presented by Subasinghe, et al. from a FAO Global Conference on Aquaculture in 2010 states:

> "Water stress due to decreased precipitation and/or increased evaporation may limit aquaculture in some areas. This may take the form of increased risks associated with a reduced water supply on a continual basis, or by reducing the length of a routine growing season. Increased variation in precipitation patterns and droughts may increase the risk and costs of aquaculture in some areas as provision for these extremes has to be made" (Subasinghe, et al 2010).

Section 1.13.1 Continues with a discussion of distance from water source.

Table 15:Source of Water for Aquaculture (can be more than 1)		
Water Source	Frequency	Percentage
Pond/Reservoir/Canal	37	95%
Rainwater	2	5%
Ricefield	1	3%
Total	40	
Source: (Field Survey 2019)		

4.16 Distance to Water Source

The results presented in Table 16 show the distance to water sources for respondents in the survey area. Three of the responses were unusable. Mostly, respondents indicated that water was sourced nearby, often less than 5 meters away from their ponds, as reflected by the median value of 0 meters shown in Table 16. It should be mentioned that the villages surveyed were separated by large distance, and, as such, had correspondingly different problems and water conditions. Specifically, Ward #10 had severe issues with water access. Farmers from Ward #10 reported that the area is drought prone and the local department of Irrigation gives priority to rice production for water access, hence leaving them with insufficient water access to optimally manage their aquaculture practices. One farmer reported having to pump water nearly 1km to supply his pond. These kinds of sentiments are shared by a 2010 report:

> "Water is becoming increasingly scarce in some parts of the world. Most of the freshwater used by humans goes to irrigation. There will be increasing pressure to use that water for human and industrial uses. Moreover, some groundwater aquifers are being overdrawn, calling into question the long-term sustainability of current levels of irrigation. Water scarcity may thus either restrict production or increase its cost. Aquaculture will have to compete with agriculture as well as industrial and domestic users for a limited water supply which may often be supporting a growing population." (Subasinghe, et al 2010).

Water access was frequently cited as problematic by farmers and will be further discussed in section 4.21.

Table 16:Distance to Water Source			
Distance	Frequency	Distance (m)	Percentage
0-50 meters	27		69%
50-150 meters	5		13%
150+ meters	4		10%
Total	36		
Mean		77.3	
Median		0	
Source: (Field Survey 2019)			

4.17 Changes in Fish Production

The results presented in table 17 show the number of respondents in the survey area who have changed their aquaculture practices in the last 5 years. The changes corresponding to a Yes answer were determined to be changes in fish stocking practice, changes in pond dimensions or pond number, and/or changes in management techniques. Initially, prior to the survey, the expectation was that the number of survey respondents indicating recent changes would be high – corresponding to recent trainings respondents had received from BRAC and WorldFish. However, the data collected demonstrates that not all respondents have changed their practices corresponding to training (38%). It is possible that some respondents did not need to change their practices following training because they were already successful in their aquaculture practices, however, it is rather unlikely. A line of questioning regarding resisting changes revealed several common reasons for aquaculture farmers to maintain their old management techniques, including; insufficient time for changes, lack of knowledge, lack of financial resources, and being content with their current practice. It was observed that farmers whom resisted change chose which fish they stocked and how they managed their ponds based on their personal preferences and experience. These farmers preferred to continue growing the fish they had grown before because they knew they could do so with relatively little risk and relatively high certainty. A recent review regarding factors driving aquaculture technology adoption notes:

> "Farmers' perceptions of aquaculture technology is a key precondition for its

adoption. Technologies that provide greater relative advantage in terms of productivity and costs were found to be favored by producers. The capital- and management-intensive nature of aquaculture seldom allows farmers to switch all their land to a new technology. Hence, technology components should be divisible and their results visible…Availability of high-skilled labor, education, and extension support reduces the complexities associated with aquaculture technology and were found to be critical factors enhancing technology learning. However, sociological factors such as age and experience were found to have a mixed effect on aquaculture adoption" (Kumar et al, 2018).

In this context, it appears that the perception of some of the respondents towards changes in aquaculture technology is inhibiting their adoption of the technologies, potentially because of their age and/or previous aquaculture experience.

Table 17:Has Your Fish Production Changed in the Last 5 Years

Answer	Frequency	Percentage
Yes	24	62%
No	15	38%
Total	39	

Source: (Field Survey 2019)

4.18 Point of Sale

The results presented in Table 18 show the distribution of respondents in the survey area based upon their preferred selling methods. 44% of respondents indicated selling in their local village. Likewise, 44% of respondents indicated preferring to deal with bulk buyers. The remaining 13% indicated they do not sell fish, corresponding to problems with fish production or preference for home consumption. Frequently cited reasons for preferring bulk buyers included: less labor requirements, flexibility, and competitive prices. However, not all respondents shared these sentiments; some indicated that they had dealt with bulk buyers previously but chose to end the arrangement because of their perception that they can make more profit through individual sales. They cited bad price rates from the bulk buyers as the primary problem. A meeting with BRAC at the end of the survey period revealed that BRAC recommends: "…If the farmers have a high harvest rate, they should use bulk buyers". Such recommendations could be interpreted to mean that the smallest farmers (category 1&2), whom have relatively small harvests, should avoid bulk buyers. Recent results presented by Belton, et al (2017) indicate that amongst Myanmar's aquaculture farms, the main buyer of harvested fish was overwhelmingly a fish trader (bulk buyer) (96%). It appears that respondents in the survey area have a relatively low acceptance of bulk buyers, relative to what is to be expected. In the author's opinion, there are many possible explanations for such a discrepancy, but a likely contributing factor could be the relatively small size of the aquaculture sector in Shwebo District, compared to other parts of Myanmar. DOF hatchery production numbers (2013-2014) give a rough proxy of the size of the aquaculture sector: Shwe Bo Township produced 6.59 million fingerlings; as a whole, the Saigang region produced 21.69 million fingerlings; by comparison, Yangon region produced 141.58 million, Mandalay region produced 186.45 million, and Ayeyarwaddy region produced 79.28 million (FAO, 2016). A relatively small aquaculture sector in Shwebo District could mean an underdeveloped value-chain, and correspondingly, less bulk buyers.

In addition, to the 43 surveyed respondents, a loosely structured interview was conducted with a Bulk Buyer along with a visit to Shwebo's largest fish market (facilitated by DOF staff). Section 4.18.1, Bulk Buyers, will present the results from an interview with the largest Bulk Buyer in Shwebo District.

Table 18:Point of Sale

Sale Point	Frequency	Percentage
Village	17	44%
Bulk Buyer	17	44%
Don't Sell	5	13%
Total	39	

Source: (Field Survey 2019)

4.18.1 Bulk Buyers

Due to the learned importance of bulk buyers in Shwebo District, the Author chose to conduct an interview with a bulk buyer in Shwebo district. The interview was facilitated by DOF and was conducted in one afternoon over a span of 30 minutes. The bulk buyer interviewed is the largest bulk buyer in Shwebo, with his own stocking ponds and 150 employees. The buyer reflected that he typically works with 10-15 neighboring villages, frequently employing local people from the villages to facilitate the harvests. These arrangements were always informal, and this suited him and the employees. He stated that he was in no way involved with training activities provided by DOF, WorldFish, or BRAC. Furthermore, when asked about district-wide problems, he stated that there is insufficient supply from local hatchery production, and that he would like to see the capacity improved. In his opinion, there is much room for sectoral growth of aquaculture in Shwebo District. When asked to reflect on market trends, the buyer stated that Rohu is the most popular followed by pomfret, tapian, and tilapia.

4.19 Distance to Point of Sale

The results presented in Table 19 show the distance to the point of sale for the respondents in the survey area. A large majority of respondents (92%) indicated that they sold their fish close to home. For the purpose of survey responses, bulk buyers were counted as 0km. The data indicates that when respondents chose to sell on their own, they preferred to do so in their own village. The few respondents who indicated that they preferred to sell outside of their village did so because they believed they could command a higher price elsewhere. A study from Cambodia found:

> "Rural markets, despite being little developed, are more numerous, spatially diffuse and located at a shorter distance to the farm gate, thus reducing the transportation time and transaction costs. They also require relatively less volume of aquaculture produce, which in turn reduces the dependence on tied relations between producers, traders, distributors and retailers. Thus, aquaculture has the potential of initially increasing rural food self-sufficiency and to provide farm income diversification through rural market development" (Bracket et al, 2011).

Farm income diversification is of importance to the respondents surveyed in Shwebo district. As shown in Table 6, most respondents have multiple occupations and derive income from many different sources, hence, having a nearby point of sale is advantageous for respondents.

Table 19:Distance to Point of Sale		
Distance	Frequency	Percentage
0-5 km	36	92%
5-15km	1	3%
15+ km	2	5%
Total	39	
Source: (Field Survey 2019)		

4.20 Source of Fingerlings

The results presented in Table 20 show the sources of fingerlings used to stock ponds of respondents in the survey area. There was a surprisingly diverse number of sources for fingerlings. BRAC was the most frequently cited source for fingerlings. This is not surprising as villages for surveying were selected based on the criteria that they received BRAC training and support. It was observed that respondents chose to supplement fingerlings based on their personal preferences and availability. Eight respondents cited getting fish from nearby water discharge (stream/irrigation canals). Such practices have been observed in other areas of Myanmar (Oo and Mackay 2018):

> "Recent work in Bago Region, Myanmar, has uncovered a widely practiced system of local/indigenous aquaculture. This system is similar to rice field fisheries in nearby Asian countries where fish spawn and feed in the flooded rice fields during the monsoons then move to ponds as flooding declines, where they are harvested".

Surprisingly, the DOF was not cited as a frequent source of fingerlings. However, it should be noted that BRAC works alongside DOF to receive its fingerlings, so, ultimately, most fingerlings are produced by DOF. The author was invited for a demonstration of the DOF hatchery and practices, the results are described in section 4.20.1

Table 20:Source of Fingerlings (can have more than 1 source)		
Fingerling Source	Frequency	Percentage
BRAC	29	74%
Bought	9	23%
Streams/Canal	8	21%
Friends/Family	5	13%
Department of Fisheries	3	8%
Source: (Field Survey 2019)		

4.20.1 DOF Hatcheries

Fingerling production is underdeveloped in Myanmar, with a small number of hatcheries operating at a limited technological level. As of 2016, there were 26 active government hatcheries, producing about 644 million fish fingerlings. DOF hatcheries mostly produce Rohu (68%) and are concentrated in the Yangon and Mandalay Regions, however, most of the production is used to stock natural waterbodies (DOF, 2017). A meeting with the DOF hatchery manager provided interesting insight into the particularities of Shwebo district. The region has 1 DOF hatchery and 6 private hatcheries, however, there is no formal arrangement between DOF and the private hatcheries. The manager revealed that the DOF hatchery strives to increase production every year and currently has an 8 million fingerling stocking density. He reiterated that land scarcity is a problem for Shwebo district, and that repurposing of agricultural land for aquaculture is strictly controlled and/or prohibited. When asked about best practices for aquaculture, the manager ranked technique as most important (stocking density, feeding, inputs), followed by water quality, and, lastly, feeding quantity. He provided valuable information regarding local prices for Rice bran, Feed Pellets, Cottonseed, and Peanut Cake, shown below in Table 21.

Table 21:Local Feed Prices		
Type of Feed	Protein Content	Price / 1 Viss
Rice Bran	10-14%	500
Pellet	15-25%	700-800
Cottonseed	35%	700
Peanut Cake	46%	1200
Source: (Field Survey 2019)		

Additionally, the hatchery manager stated that a good feed to yield ratio for rice bran is 3:1, whereas, for pellets a good feed to yield ratio is 2:1. For comparison, a recent report found that the feed conversion ratio (FCR) of rice bran was widely reported by farmers as 3.4, whereas the FCR of peanut oilcake was reported as 2 (Belton et al, 2015). The DOF representative stated that he believes improved feed would be hugely advantageous if adopted by smallholder farmers, and revealed that for his own personal aquaculture practice, his yields and profits have grown substantially since utilizing feeds with higher protein content.

4.21 Importance of Farm Activities

The results presented in Table 22 rank the importance of farm activities for respondents in the survey area. The most frequency cited as very important was rohu, followed by crop production and tilapia. This is in line with expectations for Myanmar, Belton et al, found that rohu production accounts for 70% of all farmed fish production in Myanmar. Regarding aquaculture, the questionnaire, only asked about the importance of rohu and tilapia, so there is no data available for pomfret or tapian. Figure 8 compares the importance of Rohu vs Tilapia for the surveyed respondents. Rohu had 29 responses in the highest 2 importance categories compared to 8 for tilapia, conversely, rohu had only 5 responses in the lowest 2 importance categories compared to 24 for tilapia. It is clear, that respondents perceive rohu to be of significantly higher importance than tilapia. Figure 7 provides valuable insight into relative importance of different farm activities. It is clear, for respondents in Shwebo District, that goat, sheep, and ducks are of little to no importance. Water buffalo have slight-moderate importance in the context of facilitating field work for rice production. Poultry and eggs had slightly important-moderate importance, 13 of 39 respondents indicated having poultry, however, none of the respondents indicated that the poultry was very important. Similarly, pigs were slightly important for respondents, with 6 of 39 keeping them. As mentioned previously, cows are of importance in the central dry zone (FAO, 2018). The rankings provided by respondent's support this finding, 14 of 39 respondents indicating owning cows with 8 indicating that cows are very important-important and 6 indicating that cows are moderately important-slightly important. It was observed that several respondents derived extra utility from their ponds by utilizing them as a water source for their cows. In one instance, a respondent in Ward 10 indicated that he had dug ponds previously as a method to store water, since water access was problematic in this region, and had only recently repurposed them for aquaculture. Interestingly, the respondent chose not to utilize inputs for his pond; he indicated he was aware that he could potentially improve his aquaculture production by utilizing more inputs, but was hesitant to do so, because of his concern that the water quality might adversely affect his cows. As expected, crop production was consistently ranked as very important. However, it was surprising to see so many respondents not involved in crop production. According to recent data, 37.8% of Myanmar's GDP is contributed by value added of agriculture, providing 70% of total employment (FAO, 2018). According to 2014 census data, Shwebo district has 76% males and 76.7% females working in "agriculture, forestry and fishing" (Myanmar Census, 2014). Unfortunately, this data is not disaggregated between agriculture and fishing, so it is hard to elicit what proportion of these percentages is attributed to aquaculture. Based on this relatively small sample size, it appears that in Shwebo district, specific to the survey area, some farmers practicing aquaculture can support themselves without reliance on crop production. Such findings are supported by work from Belton, et al (2018) who notes:

> "…fish farming in Myanmar generates much higher returns per acre to the farmer than agriculture…" (Belton et al, 2018).

This higher income potential from aquaculture is discussed in greater detail in section 4.24.

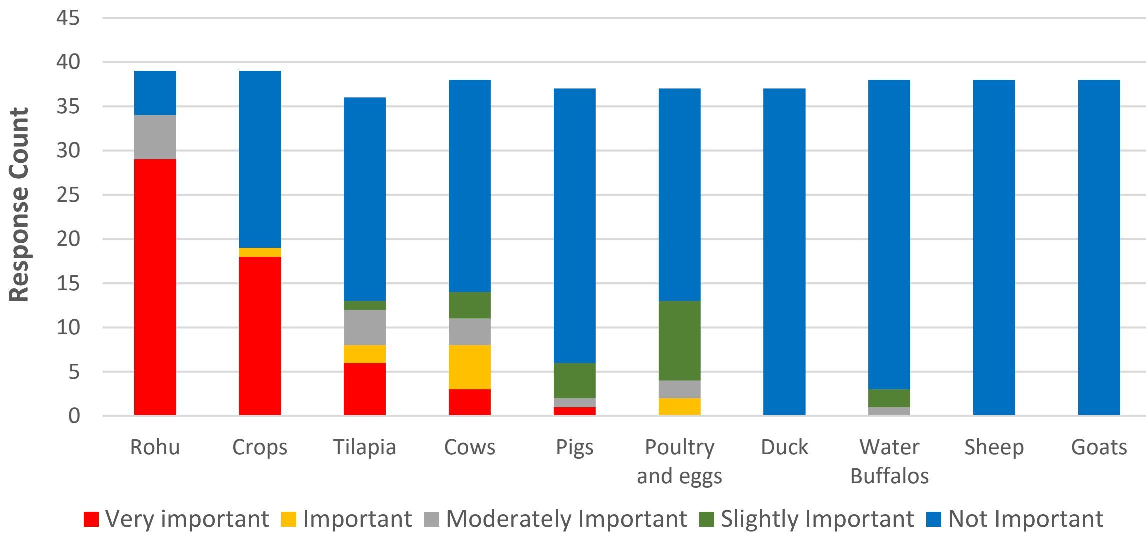

Figure 7:Importance of Farm Activities

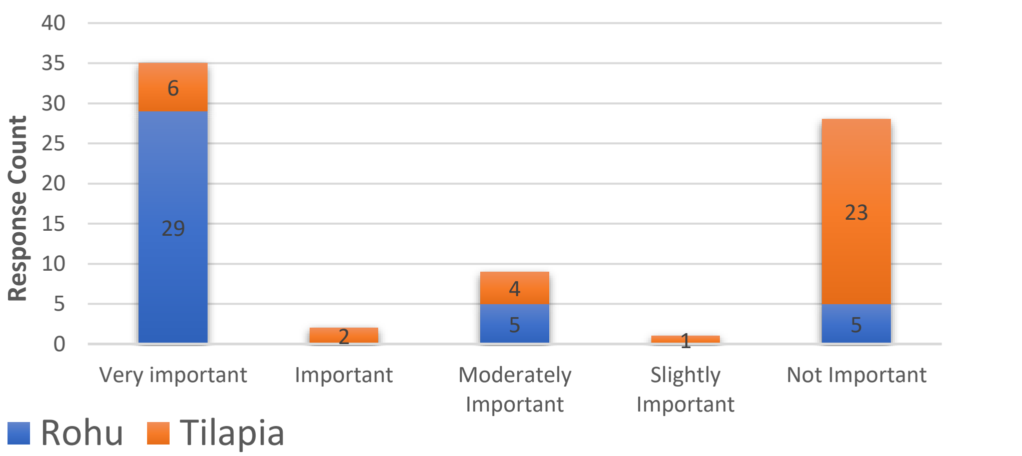

Figure 8:Importance of Rohu vs Tilapia

Table 22:Ranking Importance of Farm Activities
Corresponds to Count of Responses

	Very important	Important	Moderately Important	Slightly Important	Not Important
Rohu	29	0	5	0	5
Crops	18	1	0	0	20
Tilapia	6	2	4	1	23
Cows	3	5	3	3	24
Pigs	1	0	1	4	31
Poultry and eggs	0	2	2	9	24
Duck	0	0	0	0	37
Water Buffalos	0	0	1	2	35
Sheep	0	0	0	0	38
Goats	0	0	0	0	38

Source: (Field Survey 2019)

4.22 Problems with Aquaculture Related Activities

The results presented in Table 23 show the rankings of aquaculture activities based on how problematic they are for the respondents in the study area. Initially the questionnaire was designed with 13 different problem categories, however, as the survey progressed it became clear that water access was a major problem for many of the respondents, as such, it was added to the questionnaire and reflects a lower response count than the other aquaculture related activities. Altogether, the results collected demonstrate that, Shwebo district has several specific problems areas for aquaculture farmers. For the sake of clarity, and completeness, the 4 identified problem areas (water access, pond construction, fish feeding, and access to credit) have been designated their own sub-sections below.

Table 23:Problems with Aquaculture Related Activities					
	Not Problematic	Slightly Problematic	Moderately Problematic	Problematic	Very Problematic
Water access	7	0	4	0	23
Pond Construction	23	2	0	1	11
Fish Feeding	18	6	5	4	6
Access to Credit	32	0	4	2	1
Fish Stocking	39	0	0	0	0
Fish Harvesting	39	0	0	0	0
Access to Materials and Tools	38	0	1	0	0
Access to Training	34	2	1	1	0
Access to Labor	38	0	0	0	0
Cost of Labor	39	0	0	0	0
Water Quality	39	0	0	0	0
Marketing Your Fish	39	0	0	0	0
Robbery/Security	39	0	0	0	0
Transportation of Fish	38	0	0	0	0
Source: (Field Survey 2019)					

4.22.1 Water Access

The results presented in Table 23 show that water access is regarded as very problematic by 23/34 surveyed respondents. There are 5 less respondents than expected because water access was identified as a problem after surveying had begun and was added after the second day of surveying. As previously mentioned, some of the issues with water access are the result of policymaking decisions. Based on information provided by respondents and DOF staff, Myanmar legislation is decisively pro-crop production regarding land use and associated water allocation. In practice, this translates to limited water rights for aquaculture producers. This was particularly evident in Ward #10, where relatively less farmers practiced agriculture, and, as a result, had problems with water access. The water access issues are compounded by the dry nature of the central dry zone and implications of climate change. At the time of surveying (May-June 2019) temperatures were consistently above 43 degrees and respondents indicated that the monsoon rains were late to arrive. A paper by Tin Yi observes:

> "…annual rainfall quantity in the Central Dry Zone is project to decrease by 45 percent within the twenty-first century. Whereas the temperature in Myanmar is projected to increase on average about 0.5°C, it will probably rise by 0.7 to 1.2 °C in the Dry Zone area" (Yi, 2011)

To adapt to inadequate water access, some respondents went to extreme lengths; notably, one respondent pumping water 1 kilometer to his ponds. At the time of surveying, many of the ponds visited in Ward #10 were dry. When pressed about climate change and its impact on their livelihoods the respondents had several observations; several respondents indicated that extreme weather has become more frequent in recent years. All respondents asked about climate change indicated that there had been a higher frequency of flooding in recent years. These observations are supported by a recent study, which found:

> "The Central Dry Zone is susceptible to limited water availability and quality, since the seasonal and dry climate are aggravated by rising temperatures and increasing rainfall variability…A shorter monsoon season results in water shortages for agriculture, drinking water and livestock; and higher temperatures result in faster evaporation, lowering agricultural yields and impacting nutrient cycling. Severe heat affects livestock health and agricultural productivity" (Fee et al, 2017)

Environmental changes in the CDZ coupled with a notably pro-crop production water policy, could be problematic for future aquaculture in Shwebo district.

4.22.2 Pond Construction

The results presented in Table 23 show that pond construction is very problematic for 11/37 surveyed respondents in the study area. Information from 2 respondents was not collected in this regard. When asked to elaborate, several respondents indicated problems relating to pond erosion as a result of flooding events. Labor shortage was not indicated as a problem relating to pond construction. High capital cost was cited as a constraint for pond construction. In the study area, most respondents hired labor to dig out their ponds. On several occasions, respondents indicated that the family used their free time to dig out their ponds, saving on hired labor costs. Several respondents indicated choosing to hire machinery for digging out their ponds, choosing to do so because of perceived cost savings associated with less time requirements and higher work efficiency. A previous study by Stewart regarding small-holder fish farming in Africa found:

> "The results of station based trials and the performance of similar systems elsewhere suggests that under certain circumstances aquaculture systems can return significant benefits to land and labor invested in the operation…Based on gross margins, the cost (or notional cost) of labor invested in pond construction is paid back in the first or second year of operation"

Even though pond construction is perceived as problematic, the potential for returns can offset the pond construction costs. A gross margin analysis is presented later in the paper.

4.22.3 Fish Feeding

The results presented in Table 23 show that fish feeding is very problematic for 6/39 of the respondents in the survey area. Respondents indicated that problems with feeding are associated with distance of the ponds from their homes, and feed costs. The cost of fish feed in the Central Dry zone as a constraint has been previously documented by Seng Lat et al. (2014), whom observed that more than 80% of small-scale fish farmers and 33% of medium-scale fish farmers in Shwebo report fish feeding as problematic. All respondents in the survey area indicated that they use rice bran as their feed of choice. From information gathered from BRAC, respondents, and DOF, it is clear that rice bran is the feed of choice because of cost constraints. Respondents indicated choosing rice bran because of its cost effectiveness. Seng Lat et al, found that the cost of manufactured pellet is 10% to 30% higher in the Myanmar compared to other countries in the region, due to a lack of competition in the sector. As previously discussed in the DOF hatchery section, even though rice bran is the least cost-intensive that does not mean it is the most cost-effective. Feed to yield ratio should be considered when deciding which feed source to utilize. A recent study indicated:

> "Fisheries and aquaculture value chains are underperforming. This is apparent in areas

including very limited value-added processing postharvest, limited diversity of available fish seed, and low levels of adoption of pelleted feeds in aquaculture…" (World Bank, 2019).

Belton et al (2015), observed:

> "Only 15 percent of owner-operated farms use any manufactured pelleted feeds. This is considerably lower than in other Asian countries (for example, 38 percent of farms in Bangladesh, 90 percent in China)"

As such, there is clearly much room for improvement in the CDZ. Promoting improved feed should a priority given its very low rate of adoption in the CDZ.

4.22.4 Access to Credit

The results presented in Table 23 show that access to credit is moderately problematic for respondents in the study area. Seven of thirty-nine surveyed respondents indicated that access to credit was moderately problematic or worse. In a discussion with a village leader of Ward #10 it was revealed that informal lending between villagers with high interest rates is rates is commonplace. Respondents indicated frequently receiving loans from family and friends in their village. A recent study of aquaculture loans in Myanmar by Lu Min Lwin et al, found:

> "Credit for aquaculture was accessed by a similar proportion of growout farms (44%) and nurseries (37%). The three most important sources of credit for aquaculture were relatives and friends (44%), private moneylenders (28%), and fish traders (13%)"(Lwin and Htun, 2016).

Access to formalized credit channels was recognized as a constraint by several respondents. Previous work had found that:

> "The uneven adoption of technologies capable of delivering higher yields may reflect difficulties in accessing sufficient capital, in a context where access to formal sources of credit has historically been extremely constrained" (Turnell, 2010).

As such, it is possible that the insufficient access to credit indicated by respondents might be limiting their adoption of improved technologies and suppressing their potential yields.

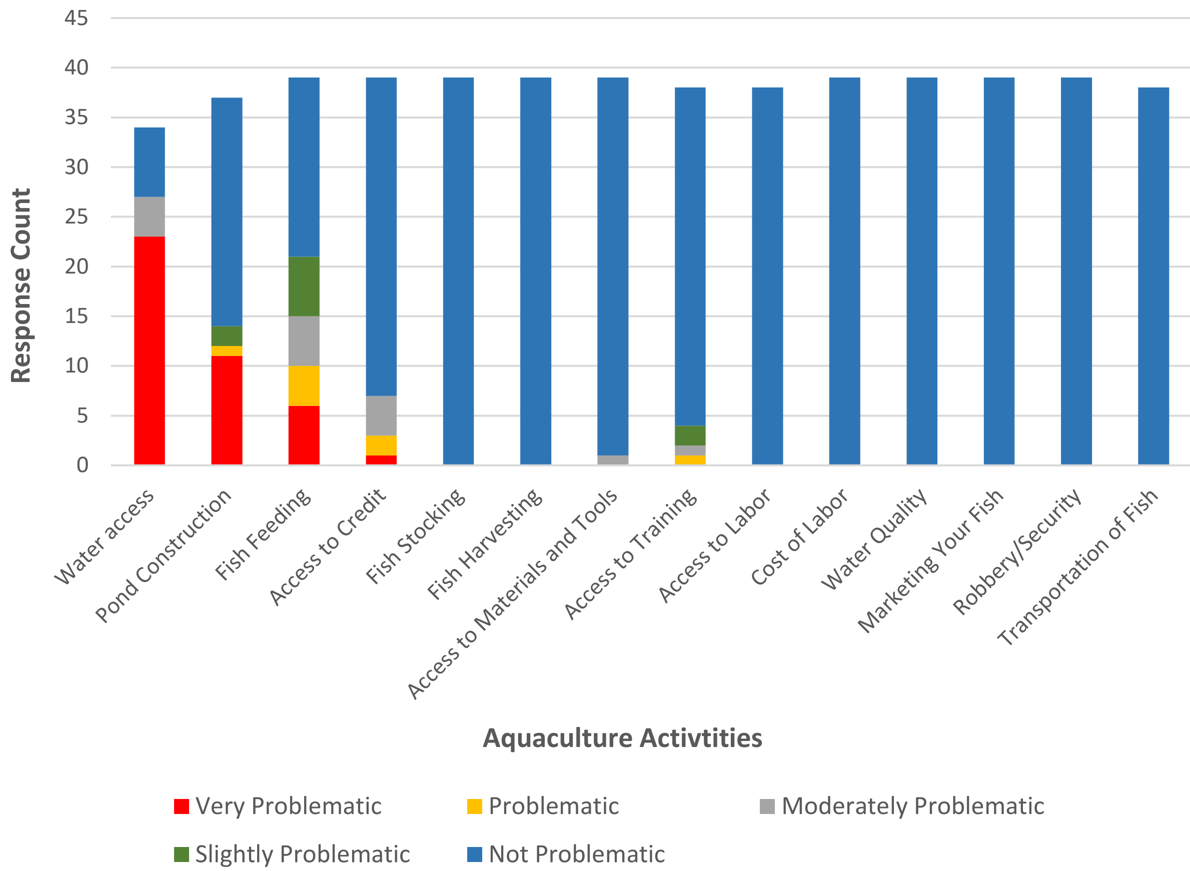

Figure 9: Ranking Problems of Farm Activities

4.23 Hired Labor

The results presented in Table 24 show the demand for hired labor for respondents in the survey area. 38% of respondents indicated that they hired labor in the past 12 months. 62% of respondents indicated not requiring hired labor for their aquaculture practice. The average prevailing wage rate for aquaculture labor was 1875 kyat/hour. Those respondents who hired labor hired approximately 26 hours/year, slightly more than 3 person/days/year. Family labor was typical throughout the survey area. Most households practicing aquaculture divided labor amongst the family, relatively evenly between males and females (discussed in greater detail in section 4.25). The main tasks necessitating hired labor were pond maintenance, pond construction, and harvesting. No respondents indicated a hired labor shortage. Hired labor was typically relatives or family friends and almost always someone from the village.

Table 24:Hired Labor (Last 12 months)		
Answer	Frequency	Percentage
Yes	15	38%
No	24	62%
Total	39	
Average Wage Paid: 1875 Kyat/hour Average Yearly Hired Labor: 26.33 hours Average Yearly Labor Costs: 49366.7 Kyat		
Source: (Field Survey 2019)		

4.24 Labor Seasonality

The results presented in Table 25 and Figure 10 show the seasonality of labor for respondents in the study area. The average number of hours worked, and average wage paid was calculated for respondents who indicated hiring labor (N=15). Results indicate that labor is seasonal. For respondents in the study area, labor demand is higher from January to May. These results likely correspond to the period when most aquaculture farmers harvest their fish. June to October correspond to the driest periods and the rainy season, when demand for hired labor is the lowest. Interestingly, the wage rate appears to be highest in May (~2000 kyat/hour) compared to a relatively low wage rate during January (~1100 kyat/hour). One potential explanation for such large differences in wage rates is the relatively high demand for wage labor in May corresponding to harvesting of fish and preparations for the dry season.

Table 25:Labor Demand by Month

	May	June	July	August	September	October	November	December	January	February	March	April
Average Number of Seasonal Employees	0.7	0.6	0.3	0.1	0.4	0.0	0.9	0.0	1.9	0.5	0.3	1.3
Average Hours Worked	5.3	0.9	0.4	0.0	0.1	0.0	1.1	0.0	9.6	4.3	1.6	3.0
Average Wage Paid (Kyat)	10666.7	1166.7	600.0	0.0	1400.0	0.0	3000.0	0.0	10733.3	6400.0	7500.0	7900.0

Source: (Field Survey 2019)

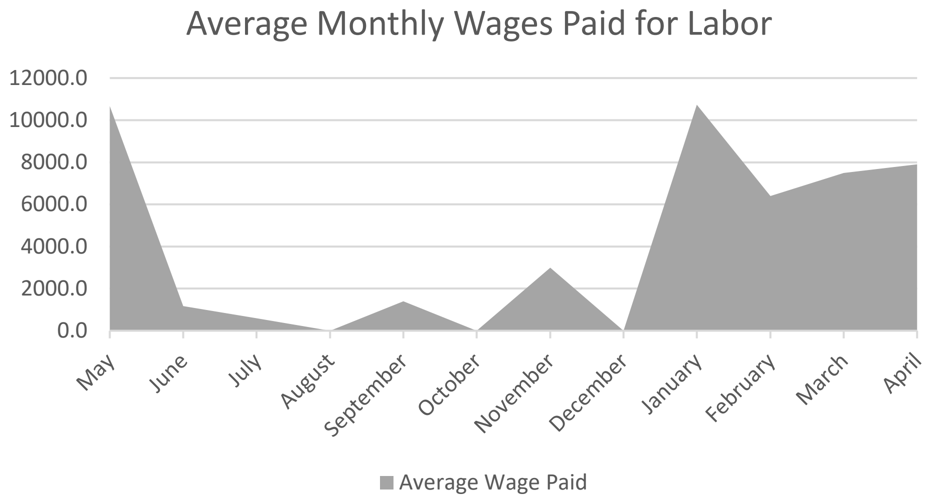

Figure 10: Average Monthly Wages Paid for Labor

4.25 Family Labor

The results presented in Table 26 show the division of family labor between the two most time intensive aquaculture activities, feeding and harvesting. These activities are presented because respondents indicated spending little time on other aquaculture activities (pond construction, stocking, weeding, and fertilizer input). The total average family labor for all respondent households equaled 26.75 Person/days/year. A 2017 report found that family labor for aquaculture farms in Myanmar with less than 10 acres averaged 70 family labor days/year (Belton, 2017). As such, it appears that respondents in the study area utilize less family than expected. One possible explanation for this observed difference is the fact that very few respondents have large ponds, with a mean pond size of ~2000m^2. Table 26 disaggregates the two most time-intensive aquaculture related family labor activities by gender. Overall, the most labor-intensive aquaculture related family labor was feeding. The division of labor was evenly split between males and females for feeding, both working approximately the same person/days/year, 17 for male respondents compared with 19 for females. The second most labor-intensive activity necessitating family labor was harvesting. Harvesting was predominantly done by males and usually necessitated approximately 5 person/days/year.

Table 26: Family Time Spent on Farm Activities / Year				
Feeding	# of Respondents	Avg Hours Worked/Year	Avg P-days Worked/Year	Total P-days Worked/Year
Female	N=26	154	19.0	495
Male	N=27	138	17.3	467
Harvesting	# of Respondents	Avg Hours Worked/Year	Avg P-days Worked/Year	Total P-days Worked/Year
Female	N=1	60	7.5	7.5
Male	N=6	41	5.2	31.1
Source: (Field Survey 2019)				

4.26 Introduction to Enterprise Budget and Investment Analysis:

The following section of Chapter 4 will present the enterprise budget and an investment analysis based upon the data presented in the enterprise budget. As previously discussed, the respondents are divided into two main categories, grow-out fish farmers and fingerling farmers. Unless otherwise stated, the tables will present information for grow-out fish farmers. This is intentionally decided because most surveyed respondents (31 of 39) are grow-out fish farmers. Finally, the chapter will conclude with 3 future investment scenarios representing different possible future outcomes for respondents in the survey area.

4.26.1 Enterprise Budget: Grow out Farmers vs Fingerling Farmers

This discussion will compare two enterprise budgets (Table 27 and Table 28) between grow-out fish farmers and fingerling fish farmers in the study area. For this study, grow-out fish farmers are defined as those farmers who grow only large fish from bought fingerlings. Fingerling fish farmers are defined as those who only grow fingerlings and do not produce large grow-out fish. For respondents in the study area there were 31 grow-out fish farmers who sold their fish (4 only had fish for home consumption), and four fish farmers who only produced fingerlings. It became evident early in the survey that grow-out fish farmers and fingerling producers represented two different farming practices and different levels of profitability; as such, it was decided to compare the two and better understand the revenue and profitability associated with the different farming practices. The Average revenue for grow-out fish farmers is 726582 kyat compared to 2401875 kyat for fingerling producers (3.3x difference). The Average total variable cost for grow-out fish farmers is 477071 kyat compared to 772755 kyat for fingerling producers (1.6x difference). The

Average total cost for grow-out fish farmers is 612342 kyat compared to 970356 (1.6x difference) kyat for fingerling producers. The Average profit for grow-out fish farmers is 114240 kyat compared to 1431519 kyat for fingerling producers (12.5x difference). Even though fingerling producers total cost reflects a difference of only 1.6x that of grow-out fish farmers, their profit is a remarkable 12.5x times larger when compared to grow-out farmers. For grow-out fish farmers a break-even price is calculated to be 1539 kyat per viss and a break-even yield of 204 viss (1.63kg/viss). This reflects that a 1539 kyat output price and a 204 viss yield is required to cover all costs of the enterprise. For fingerling producers, a break-even price is calculated to be 16.89 kyat/fish corresponding to break-even yield of 14719 fish. This reflects that a 16.89 kyat outprice, and a 14719 fish yield is required to cover all costs of the enterprise. Overall, fingerling farmers are substantially more profitable in the study area compared to grow-out fish farmers. Even though the results might suggest that more farmers consider fingerling production, there are limits to how many can do so. Fingerling producers rely on grow-out fish farmers as customers for their fingerlings. If all grow-out fish farmers decided to change their production methods to fingerling production, then there would be no buyers for fingerlings, and conversely an excess of fingerling producers. However, as noted in previous sections, both a DOF representative and a bulk buyer agreed that the aquaculture sector has room for growth in Shwebo District. In order to sustain growth of the aquaculture sector in Shwebo District there will be a demand for more fingerling producers; consequently, it is reasonable to promote more farmers to consider fingerling production.

Table 27:Enterprise Budget for Aquaculture Farms Selling Growout Fish Where Qs>0 in Shwebo District (Number= 31)

Item	Description	Unit	Quantity (Qs)	Price/Unit(K)	Total (K)
Revenue		Kyat			
Grown Out Fish Sold	Average Q/P	Viss	310	2344	726582
Gross Income		Kyat			**726582**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			340903
Routine repairs, constructions	Empirical Avg.	Kyat			49839
Fuel	Empirical Avg.	Kyat			26955
Cost of Fingerlings	Empirical Avg.	Kyat			25903
Workers' Wages	Empirical Avg.	Kyat			20339
Pumping rental	Empirical Avg.	Kyat			5645
Manure	Empirical Avg.	Kyat			3097
Lime	Empirical Avg.	Kyat			2906
Transportation	Empirical Avg.	Kyat			1065
Fertilizer	Empirical Avg.	Kyat			258
Equipment & Tools	Empirical Avg.	Kyat			161
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**477071**
Gross Margin					**249511**
Fixed Costs					
Pump**	Empirical Avg.	Kyat			33387
Netting**	Empirical Avg.	Kyat			13565
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			1344
Piping**	Empirical Avg.	Kyat			14425
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg.	Kyat			39078
Land*	Opportunity Cost	Kyat			33472
Total Cost					612342
Profit (Net Returns to Management)					**114240**
Breakeven Price		Kyat			1539.2
Breakeven Yield		Viss			204

Source: (Field Survey 2019)

* Opportunity Cost of Land

** Annual Depreciated Cost

Table 28:Enterprise Budget for Aquaculture Farms Selling Fingerlings Where Qs>0in Shwebo District (Number = 4)

Item	Description	Unit	Quantity	Price/Unit(K)	Total (K)
Revenue		Kyat			
Fingerlings Sold	Avg.Q/P	N	45750	52.5	2401875
Gross Income		Kyat			**2401875**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			388855
Cost of Fingerlings	Empirical Avg.	Kyat			272500
Fuel	Empirical Avg.	Kyat			39500
Workers' Wages	Empirical Avg.	Kyat			27500
Routine repairs, constructions	Empirical Avg.	Kyat			25000
Lime	Empirical Avg.	Kyat			11900
Fertilizer	Empirical Avg.	Kyat			2500
Equipment & Tools	Empirical Avg.	Kyat			2500
Pumping rental	Empirical Avg.	Kyat			2500
Manure	Empirical Avg.	Kyat			0
Transportation	Empirical Avg.	Kyat			0
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**772755**
Gross Margin	Empirical Avg.	Kyat			**1629120**
Pump**	Empirical Avg.	Kyat			27083
Netting**	Empirical Avg.	Kyat			8125
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			0
Piping**	Empirical Avg.	Kyat			9167
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg	Kyat			114286
Land	Opportunity Cost				38940
Total Cost					970356
Profit (Net Returns to Management)					**1431519**
Breakeven Price		Kyat			16.89
Breakeven Yield		Quantity			14719

Source: (Field Survey 2019)

* Opportunity Cost of Land

** Annual Depreciated Cost

4.26.2 Enterprise Budget: Inexperienced Grow Out Farmers vs Experienced Grow Out Farmers

This discuss will compare two enterprise budgets (Table 29 and Table 30) between experienced grow out farmers in the study area and inexperienced grow out farmers in the study area. Experienced farmers are defined to be those with more than 5 years' experience; conversely, inexperienced farmers are defined as those with less than 5 years' experience. It was chosen to compare the enterprise budgets of grow-out farmers as opposed to fingerling producers because they represent most respondent households. 17 respondents in the study area are classified as inexperienced grow-out farmers compared to 18 respondents in the study area whom are considered experienced grow-out farmers. The Average revenue for inexperienced grow-out farmers is observed to be 279257 kyat compared to 1075230 kyat for experienced farmers (3.8x difference). The Average total variable cost for grow-out farmers is observed to be 355129 kyat compared to 612722 kyat for experienced farmers (1.7x difference). The total cost for inexperienced grow-out farmers is observed to be 517681 kyat compared to 746087 kyat for experienced farmers (1.44x difference). The Average profit for inexperienced grow-out farmers is observed to be -238424 kyat compared to 329143 kyat for experienced farmers. Experienced farmers have substantially higher revenues (3.8x) than inexperienced farmers even though they have relatively similar costs (1.44x). For inexperienced grow-out fish farmers a break-even price is calculated to be 3052 kyat per viss and a break-even yield of 148 viss (1.63kg/viss). This reflects that a 3052 kyat output price and a 148 viss yield is required to cover all costs of the enterprise. For experienced grow-out farmers, a break-even price is calculated to be 1334 kyat per viss corresponding to break-even yield of 262 voss. This reflects that a 1334 kyat outprice, and a 262 viss yield is required to cover all costs of the enterprise. Not surprisingly experience is instrumental in generating a profit for aquaculture farmers in the study area. Experienced farmers were observed to have larger operations and a higher willingness to spend on variable costs. Relatively similar total costs observed between experienced and inexperienced farmers corresponding to a large difference in observed revenues suggests that perhaps management practices, techniques, and knowledge are instrumental in achieving a relatively higher revenue. This analysis led to the selection criteria of the final enterprise budget comparison: experienced grow-out fish farmers with high input use vs experienced grow-out fish farmers with low input use.

Table 29:Enterprise Budget for Aquaculture Farms Selling Grow-out Fish with Experience <5 years and Where Qs>0 in Shwebo District (Number = 17)

Item	Description	Unit	Quantity (Qs)	Price/Unit(K)	Total (K)
Revenue		Kyat			
Grown Out Fish Sold	Avg.Q/P	Viss	116	2400	279257
Gross Income		Kyat			**279257**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			177471
Routine repairs, constructions	Empirical Avg.	Kyat			120588
Workers Wage	Empirical Avg.	Kyat			21529
Fuel	Empirical Avg.	Kyat			14800
Cost of Fingerlings	Empirical Avg.	Kyat			7588
Manure	Empirical Avg.	Kyat			5176
Pumping rental	Empirical Avg.	Kyat			3824
Lime	Empirical Avg.	Kyat			1771
Transportation	Empirical Avg.	Kyat			1706
Fertilizer	Empirical Avg.	Kyat			382
Equipment & Tools	Empirical Avg.	Kyat			294
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**355129**
Gross Margin					**-75872**
Fixed Costs					
Pump**	Empirical Avg.	Kyat			29216
Netting**	Empirical Avg.	Kyat			13824
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			0
Piping**	Empirical Avg.	Kyat			12284
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg.	Kyat			84874
Land	Opportunity Cost	Kyat			22354
Total Cost					517681
Profit (Net Returns to Management)					**-238424**
Breakeven Price		Kyat			3052.1
Breakeven Yield		Viss			148

Source: (Field Survey 2019)

* Opportunity Cost of Land

** Annual Depreciated Cost

Table 30: Enterprise Budget for Aquaculture Farms Selling Grow-out Fish with Experience >5 years and Where Qs>0 in Shwebo District (Number = 18)

Item	Description	Unit	Quantity (Qs)	Price/Unit(K)	Total (K)
Revenue		Kyat			
Grown Out Fish Sold	Avg.Q/P	Viss	460	2340	1075230
Gross Income		Kyat			**1075230**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			432222
Fuel	Empirical Avg.	Kyat			65778
Routine repairs, constructions	Empirical Avg.	Kyat			57444
Cost of Fingerlings	Empirical Avg.	Kyat			30278
Workers Wage	Empirical Avg.	Kyat			14694
Lime	Empirical Avg.	Kyat			6111
Equipment & Tools	Empirical Avg.	Kyat			5417
Fertilizer	Empirical Avg.	Kyat			444
Pumping rental	Empirical Avg.	Kyat			222
Manure	Empirical Avg.	Kyat			111
Transportation	Empirical Avg.	Kyat			0
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**612722**
Gross Margin					**462508**
Pump**	Empirical Avg.	Kyat			34537
Netting**	Empirical Avg.	Kyat			12250
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			2315
Piping**	Empirical Avg.	Kyat			22500
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg.	Kyat			18095
Land	Opportunity Cost	Kyat			43668
Total Cost					746087
Profit (Net Returns to Management)					**329143**
Breakeven Price		Kyat			1333.5
Breakeven Yield		Viss			262
Cost of Production (per fish)		Kyat			

Source: (Field Survey 2019)

* Opportunity Cost of Land

** Annual Depreciated Cost

4.26.3 Enterprise Budget: Experienced Grow Out Farmers with High Input Use vs Experienced Grow Out Farmers with Low Input Use

This discussion will compare the enterprise budgets (Table 31 and Table 32) between experienced grow-out farmers with high-input use and grow-out farmers with low-input use. High input farming households are defined to be as those that utilize one or more of lime, manure, fertilizer, antibiotics, and pesticide. Conversely, low input farming households are defined as those that do not utilize any of the above inputs (only commercial feed). The motivation to compare input usage for households in the study area stems from the motivation to understand the utility of aquaculture inputs in relation to profit generation. It was important to compare only experienced households in order to try and control for the effect that experience has on profitability. The enterprise budget of four experienced high-input households are presented in Table 31, and the enterprise budget of three experienced low-input households are presented in Table 32. The average revenue for experienced low-input grow-out farmers is observed to be 354431 kyat compared to 515209 kyat for experienced high-input grow-out farmers (1.5x difference). The average total variable cost for experienced low-input grow-out farmers is observed to be 236500 kyat compared to 329333 kyat for experienced high-input grow-out farmers (1.4x difference). The total cost for experienced low-input grow-out farmers is observed to be 323455 kyat compared to 425675 kyat for experienced high-input grow-out farmers (1.31x difference). The average profit for experienced grow-out farmers is observed to be 30975 kyat compared to 89534 kyat for experienced high-input grow-out farmers (2.89x difference). For experienced low-input grow-out fish farmers a break-even price is calculated to be 1679 kyat per viss and a break-even yield of 94 viss. This reflects that a 1679 kyat output price and a 94 viss yield is required to cover all costs of the enterprise. For experienced high-input grow-out farmers, a break-even price is calculated to be 1275 kyat per viss corresponding to break-even yield of 165 voss. This reflects that a 1275 kyat outprice, and a 165 viss yield is required to cover all costs of the enterprise. Taking the profits observed for farmers and dividing by their respective quantities harvested corresponds to a 220 kyat profit/viss harvested for low-input experienced grow-out households vs 347 kyat profit/viss harvested for high-input experienced grow-out households (1.57x difference). High input households generate more profit per viss sold. Interestingly, although low-input households commanded a higher selling price, high-input households still achieved a higher profit/viss harvested with a markedly lower selling price.

The average pond area of the four low-input households is calculated to be 3137 m^2 compared to 2076 m^2 for the high-input households; meaning that, even though the high input households have substantially less pond area, and accept a lower market price for their fish, they are still more profitable than the low-input households. The average costs for observed inputs are small when compared to other average variable costs, but results presented above suggest that the use of inputs can correspond to improvements to profitability for households willing to utilize them. These results suggest that the usage of inputs should be prioritized amongst the package of extension services due to their potentially large benefits for relatively low costs.

Table 31: Enterprise Budget for Aquaculture Farms with More Than 5 Years' Experience Selling Grow-out Fish with Low Inputs (only feed) in Shwebo District (Number = 4)

Item	Description	Unit	Quantity (Qs)	Price/Unit(K)	Total (K)
Revenue		Kyat			
Grown Out Fish Sold	Avg. Q/P	Viss	141	2517	354431
Gross Income		Kyat			**354431**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			205000
Cost of Fingerlings	Empirical Avg.	Kyat			20000
Fuel	Empirical Avg.	Kyat			6500
Pumping rental	Empirical Avg.	Kyat			5000
Routine repairs, constructions	Empirical Avg.	Kyat			0
Workers Wage	Empirical Avg.	Kyat			0
Manure	Empirical Avg.	Kyat			0
Lime	Empirical Avg.	Kyat			0
Transportation	Empirical Avg.	Kyat			0
Fertilizer	Empirical Avg.	Kyat			0
Equipment & Tools	Empirical Avg.	Kyat			0
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**236500**
Gross Margin					**117931**
Fixed Costs					
Pump**	Empirical Avg.	Kyat			24167
Netting**	Empirical Avg.	Kyat			6250
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			0
Piping**	Empirical Avg.	Kyat			2083
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg.	Kyat			17857
Land	Opportunity Cost	Kyat			36598
Total Cost					323455
Profit (Net Returns to Management)					**30975**
Breakeven Price		Kyat			1679.3
Breakeven Yield		Viss			94

Table 32: Enterprise Budget for Aquaculture Farms with More Than 5 Years Experience Selling Growout Fish with Many Inputs (Lime + fertilizer/manure) in Shwebo District (Number = 3)

Item	Description	Unit	Quantity (Qs)	Price/Unit(K)	Total (K)
Revenue		Kyat			
Grown Out Fish Sold	Average Q/P	Viss	258	1995	515209
Gross Income		Kyat			**515209**
Variable Costs					
Feed Cost	Empirical Avg.	Kyat			253333
Routine repairs, constructions	Empirical Avg.	Kyat			3333
Workers Wage	Empirical Avg.	Kyat			14000
Fuel	Empirical Avg.	Kyat			24000
Cost of Fingerlings	Empirical Avg.	Kyat			26667
Manure	Empirical Avg.	Kyat			1333
Pumping rental	Empirical Avg.	Kyat			0
Lime	Empirical Avg.	Kyat			6000
Transportation	Empirical Avg.	Kyat			0
Fertilizer	Empirical Avg.	Kyat			667
Equipment & Tools	Empirical Avg.	Kyat			0
Drugs and water treatment	Empirical Avg.	Kyat			0
Taxes and Insurance	Empirical Avg.	Kyat			0
Security	Empirical Avg.	Kyat			0
Maintenance of fences	Empirical Avg.	Kyat			0
Gasoline/Oil	Empirical Avg.	Kyat			0
Total Variable Cost					**329333**
Gross Margin					**185875**
Fixed Costs					
Pump**	Empirical Avg.	Kyat			25000
Netting**	Empirical Avg.	Kyat			13333
Vehicle**	Empirical Avg.	Kyat			0
Containers/Storage**	Empirical Avg.	Kyat			0
Refrigerator**	Empirical Avg.	Kyat			0
Piping**	Empirical Avg.	Kyat			8333
Tools**	Empirical Avg.	Kyat			0
Pond Construction**	Empirical Avg.	Kyat			13333
Land	Opportunity Cost	Kyat			36342
Total Cost					425675
Profit (Net Returns to Management)					**89534**
Breakeven Price		Kyat			1275.3
Breakeven Yield		Viss			165

Source: (Field Survey 2019)

* Opportunity Cost of Land

** Annual Depreciated Cost

4.27 Opportunity Cost of Land

The opportunity cost of pond production is discussed in table 33. The table compares profitability of land per hectare of different agricultural enterprises in Myanmar. In the case of Myanmar, that land would likely be utilized for paddy rice production, green gram, black gram, or chickpeas. To calculate the kyat/hectare/year, Average farmer profit/year was divided by the average farmer pond size, see section 4.10. Overall, even for relatively low-earning aquaculture farmers (grow-out farmers) their $/hectare was observed to be substantially higher than likely alternatives. Grow-out farmers in the study area Averaged less than what previous studies have observed for aquaculture farmers (Oo and McKay (2018), Belton et al, (2017)). Fingerling producers averaged substantially more $/hectare than what is typical for smallholder aquaculture. The higher returns per hectare for both grow-out farmers and fingerling farmers demonstrates that, given the low profitability of the alternatives, aquaculture is an efficient allocation of land resources and is likely to produce higher profits compared to likely alternative land uses in the Central Dry Zone of Myanmar.

Table 33:Opportunity Cost of Land

Enterprise	Kyat/hectare/year	$/hectare/year	Opportunity Cost
Growout aquaculture from study*	597490	389	1
Fingerling aquaculture from study*	6433793	4191	10.8
Smallholder aquac. literature**	3501335	2281	5.9
Smallholder aquac. literature***	2449860	1596	4.1
Green gram****	891835	581	1.5
Black gram****	409845	267	0.68
Chickpeas****	216435	141	0.36
Paddy rice production****	175000	114	0.29

* From Author's Study (2019)

** Oo and McKay (2018)

*** Belton et al, (2017) .

**** World Bank (2016)

4.28 Opportunity Cost of Labor

The opportunity cost of labor is discussed in Table 34. The table compares the wage rates of respondents in the study region with other employment opportunities likely available to the respondents. Based on their socioeconomic characteristics, the respondents would likely fall into the low skilled category and/or agriculture category. As discussed previously, the author collected data on time spent on aquaculture related activities. This data along with the profitability of farmers, was used to calculate the kyat/labor day of respondents. For grow-out farmers (N=31), their kyat/labor day of 3789 compared well with previous observation by Gopal et al (2014) of 5060. For fingerling farmers, their kyat/labor day of 156279 was unexpectedly high. The author believes that this number reflects the fact that all surveyed fingerling farmers utilized bulk buyers and only spent time on feeding. Even if fingerling wage earnings/labor day are an overestimate, they give an idea that fingerling production in the Central Dry Zone is an extremely cost-efficient utilization of ones times. Data collected from both groups of respondents shows that aquaculture is a good utilization of time for respondents compared to expected alternatives (low skilled labor, and agriculture). Notably, calculated wage earnings for aquaculture farmers are higher than both the Myanmar minimum wage rate, and the national average wage rate and compare well with industry wages and service industry wages observed by the World Bank (2018).

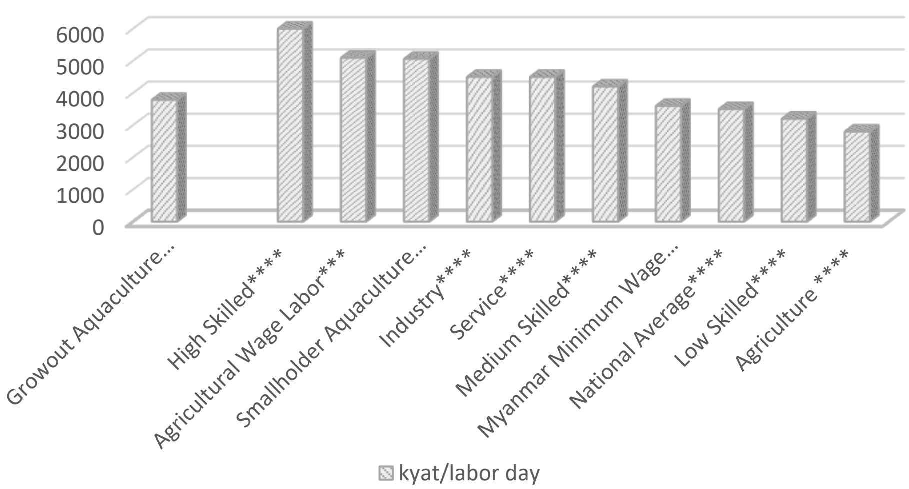

Figure 11:Comparisons of Aquaculture Wage Earnings vs Alternatives

Table 34:Comparison of Aquaculture Wage Earnings vs Other Employment Opportunities			
Enterprise	kyat/Labor Day	$/Labor Day	Opportunity Cost
Growout Aquaculture from Study*	3789	2.5	1.0
Fingerling Aquaculture from Study*	156279	101.8	40.72
Smallholder Aquac. from Literature**	5060	3.3	1.32
Agricultural Wage Labor***	5096	3.3	1.32
Myanmar Minimum Wage Rate****	3600	2.3	0.92
National Avg.****	3500	2.3	0.92
High Skilled****	6000	3.9	1.56
Medium Skilled****	4200	2.7	1.08
Low Skilled****	3200	2.1	0.84
Agriculture ****	2800	1.8	0.72
Industry****	4500	2.9	1.16
Service****	4500	2.9	1.16

Source:

* From Author's Study (2019)

** Gopal, et al (2014), mean earnings, 2014 kyat

*** World Bank (2018), median daily earnings, 2015 kyat

**** Belton, et al (2017), mean earnings, 2017 kyat.

4.29 Depreciation Schedule

The results presented in table 35 show the depreciation of fixed assets for 31 of the respondents (grow-out farmers) in the study area. The Average total cost of fixed assets was 869161 kyat and the annual depreciation paid on the assets was 101799 kyat. There was no salvage value for any of the recorded fixed assets. The assets were observed to have a useful life of 2-14 years.

Table 35:Depreciation Schedule for Depreciable Fixed Assets (N=31)				
Items	Cost (Kyat)	Salvage Value (Kyat)	Useful Life	Depreciation (Kyat)
Pump	200323	-	6	33387
Netting	27129	-	2	13565
Vehicle	0	-	0	0
Containers/Storage	0	-	0	0
Refrigerator	8065	-	6	1344
Piping	86548	-	6	14425
Tools	0	-	0	0
Pond Construction	547097	-	14	39078
Total	869161			101799
Source (Field Survey 2019)				

4.30 Variable Cost as a Percentage of Total Cost

The information presented in table 30 shows the itemized variable cost as a percentage of total cost for the grow-out fish farmers surveyed in the study area. As previously discussed, feed cost is expected to be the largest percentage of variable cost (Section 2.6). The results collected from respondents match this expectation with feed cost accounting for 56% of total costs.

Table 36: Variable Cost as a Percentage of Total Cost (N=31)

Variable Cost	Percentage of Total Cost
Feed Cost	56%
Repairs, construction	8%
Fuel	4%
Cost of Fingerlings	4%
Workers Wage	3%
Pumping rental	1%
Manure	1%
Lime	0%
Transportation	0%
Fertilizer	0%
Equipment & Tools	0%
Water treatment	0%
Taxes and Insurance	0%
Security	0%
Maintenance of fences	0%
Gasoline/Oil	0%

Source (Field Survey 2019)

4.31 Expected Annual Returns and Payback Period

The expected annual returns based on the information presented in Table 37 is 114240 kyat. The total amount of average capital investment was found to be 869161. The payback period for non-current assets was found to be 7.6 years for grow-out farmers. Since all surveyed respondents had lived in the area for a long time and were landowners, the cost of land was is not included in the investment costs of non-current assets. There was no found literature on payback periods for aquaculture in Myanmar; but, a previous study on small-scale aquaculture in Mozambique found a similar payback period of 8 years (Salia and Alda 2008). Overall, eight years seems like a long period of time to recoup initial investment costs considering the relatively small profit collected per year (114240 kyat).

Table 37:Investment Costs of Non-current Assets		
Non-current Assets		Value
Pump	Kyat	200323
Netting	Kyat	27129
Vehicle	Kyat	0
Containers/Storage	Kyat	0
Refrigerator	Kyat	8065
Piping	Kyat	86548
Tools	Kyat	0
Pond Construction	Kyat	547097
Total		869161
Expected Annual Return		114240
Payback Period	7.61	Years
Source (Field Survey 2019)		

4.32 Net Cash Revenue

Table 38 presents a simple net cash revenue for growout farmers in the study area over a 20-year period. The profit presented in the enterprise budget of growout farmers, section 4.26.1, is used as the annual net cash revenue. The initial investment costs reflect the average capital investment for growout farmers. For a 20-year period, the total cash revenue was calculated to be 1415639 kyat. Net cash revenue for a 20-year period corresponds to 546478 kyat, corresponding to an average net revenue/year of 27300 kyat and a rate of returns of 3%. Given the large initial investment cost, and low observed rate of returns, and given current productivity information for smallholder growout aquaculture farmers, it would not be recommended for investors to pursue small-holder aquaculture in the survey area. However, modest improvements to fish yield and the use of improved feeds could correspond to large gains in profit, this will be analyzed in greater detail in scenario 1, 2, and 3.

Table 38: Net Cash Revenue of Growout Farmers (N=31), 20 years	
Year	Net Cash Flow (kyat)
0	-869161
1	114240
2	114240
3	114240
4	114240
5	114240
6	114240
7	114240
8	114240
9	114240
10	114240
11	114240
12	114240
13	114240
14	114240
15	114240
16	114240
17	114240
18	114240
19	114240
20	114240
Total cash revenue	1415639
Less Initial investment cost	-869161
Net cash revenue	546478
Average net revenue/year	27323.9
Rate of returns	3%
Source: Hypothesized Scenario from Field Survey Data 2019	

4.32 Net Present Value

Table 39 presents a net present value analysis for respondents in the study area for a 20-year investment period. A net present value analysis provides a more realistic investment analysis than net cash revenue by discounting present earnings against future earnings (Engle, 2010). Because there was no data collected on loan characteristics, and all respondents surveyed are landowners, the discount rate used for the net present value calculations only accounts for the opportunity cost of capital, taken to be the average interest rate provided by the largest bank in Myanmar (10%).

Given a 20-year investment period, an initial investment cost of 869161 kyat, a constant average yearly profit of 114240 kyat, and a 10% discount rate, the NPV of the investment is 103429 kyat with a calculated internal rate of return corresponding to 11.7% and a benefit-cost ratio of 0.12. Although, the NPV analysis demonstrates that with future discounting included the investment makes a profit, the profit is relatively small given the large initial investment (demonstrate by the low benefit-cost ratio). Typically, a BCR greater than 1.0 demonstrates that the project can be pursued and is economically advantageous (Kharaman, et al 2002). As such, given observed profits for growout farmers in the study area, it cannot be recommended for new farmers to pursue aquaculture in the study area. However, as discussed previously, modest gains in productivity will be shown to have significant impacts on profit margins of smallholder farmers.

Table 39:Net Present Value, Internal Rate of Return and Cost-Benefit Analysis for a 20-year Investment with a 10% discount rate

Year	Net Cash Flow (Kyat)	Present Value Factor	Present Value
0	-869161		
1	114240	0.909	103855
2	114240	0.826	94413
3	114240	0.751	85830
4	114240	0.683	78027
5	114240	0.621	70934
6	114240	0.564	64486
7	114240	0.513	58623
8	114240	0.467	53294
9	114240	0.424	48449
10	114240	0.386	44044
11	114240	0.350	40040
12	114240	0.319	36400
13	114240	0.290	33091
14	114240	0.263	30083
15	114240	0.239	27348
16	114240	0.218	24862
17	114240	0.198	22602
18	114240	0.180	20547
19	114240	0.164	18679
20	114240	0.149	16981
		Total	972590
		Investment Costs	-869161
		NPV	103429
		IRR	11.7%
		Benefit-Cost Ratio	1.12

Source: Hypothesized Scenario from Field Survey Data 2019

4.33 Effects of Interest Rates on NPV Analysis

Table 40 demonstrates the impacts of different discounting rates on the net present value of 20 year investment for smallholder growout farmers. A 10% discount rate is relatively high, so analyzing a lower future discount rate is important when considering future investments. As such, even with a relatively lower 6% discount rate, the BCR ratio still does not get above 1.0. Typically, a BCR greater than 1.0 demonstrates that the project can be pursued and is economically advantageous (Kharaman, et al 2002).

Table 40:NPV Sensitivity Analysis for a 20-year Investment

Discount Rate	NPV (kyat)	BCR
6%	441163	1.51
7%	341100	1.39
8%	252466	1.29
9%	173687	1.20
10%	103429	1.12
11%	40574	1.05
12%	-15847	0.98
13%	-66647	0.92
14%	-112528	0.87

Source: Hypothesized Scenario from Field Survey Data 2019

4.34 NPV Analysis Scenario 1

The previous discussions showed how experienced farmers are more profitable than inexperienced farmers. As such, it is interesting to see the role of learning and experience on profitability. Scenario 1 shows a net present value analysis with considerations for improving profitability. For simplicity, farmer learning in scenario 1 will be represented by a modest 3% improvement in net cash flow each year (compounded yearly) while maintaining the same costs. The discounting rate will remain unchanged (10%) over the investment period. Even with a modest 3% improvement year-to-year, the NPV for a 20-year investment in Scenario 1 is 3.15x that of the NPV with constant net cash flow (no learning, no changes in quantity sold, and no changes in costs). Scenario 1 generates an IRR of 14.6% compared to 11.7% in the baseline scenario. This scenario does not account for changes in quantity sold or in costs, as such it is arguably too simplistic, but the scenario does give an idea that modest yearly improvements can have significant impact on the investment scenario in the study area.

Table 41:Scenario 1 - 3% Yearly Improvements to Gross Profit

Year	Net Cash Flow	Present Value Factor	Present Value
0	-869161		
1	114240	0.909	103855
2	117667	0.826	97246
3	121197	0.751	91057
4	124833	0.683	85263
5	128578	0.621	79837
6	132435	0.564	74756
7	136409	0.513	69999
8	140501	0.467	65545
9	144716	0.424	61374
10	149057	0.386	57468
11	153529	0.350	53811
12	158135	0.319	50387
13	162879	0.290	47180
14	167765	0.263	44178
15	172798	0.239	41367
16	177982	0.218	38734
17	183322	0.198	36269
18	188821	0.180	33961
19	194486	0.164	31800
20	200321	0.149	29776
		Total	1193862
		Investment Costs	-869161
		NPV	324701
		IRR	14.6%
		Benefit Cost Ratio	1.37

Source: Hypothesized Scenario from Field Survey Data 2019

4.35 NPV Analysis Scenario 2

Scenario 2 examines a scenario where the farmer improves his or her practice leading to immediate increases in quantity sold. This scenario is meant to replicate the adoption of best practices, hence changing quantity harvested and quantity sold. The scenario analyzes improvements of 5%, 10%, and 25% and their effects on the net present value given a 20-year investment period. The scenario sees the adoption of best practices as a onetime gain and does not include yearly improvements to the farmers aquaculture practices and their quantity of fish sold. The increases shown in this scenario offer a more realistic depiction of what farmers could expect if they are able to able to adopt certain improved practices. For example, GIFT tilapia adoption by smallholder farmers in the Philippines has been observed to increase harvests by up to 55% (World Fish, 2019). As such, modest gains of 5%-25% offer a more realistic investment scenario when compared to Scenario 1. Modest improvements of 5%,10%, and 25% correspond to calculated NPV of 423802 kyat, 723165 kyat, and 1661172 kyat. The 5% and 10% improvements in quantity sold correspond to low BCR's of 1.49 and 1.83. However, a 25% improvement over current quantity sold for growout farmers in the study area results in a BCR of 2.91 for a 20-year investment period and represents a substantially more profitable investment scenario. This scenario illustrates that modest gains to productivity for aquaculture in the CDZ can impact whether one can or cannot recommend to potential investors to take up aquaculture.

Table 42:Scenario 2 – Improvements to Quantity Sold with no Cost Increases

			Quantity (Qs)	Price/Unit (Kyat)	Total (Kyat)
Scenario 2: 5 % increase in Qs, No Changes					
		Revenue	326	2344	
Total	1292963	**Gross Income**			764213
Less Cost	-869161	**Total Variable Cost**			477071
NPV	423802	**Gross Margin**			287142
IRR	16.7%	**Profit (Net Returns to Management)**			151871
BCR	1.49				

			Quantity (Qs)	Price/Unit (Kyat)	Total (Kyat)
Scenario 2: 10 % increase in Qs, No changes					
		Revenue	341	2344	
		Gross Income			799376
Total	1592326	**Total Variable Cost**			477071
Less Cost	-869161	**Gross Margin**			322305
NPV	723165	**Profit (Net Returns to Management)**			187034
IRR	21.1%				
BCR	1.83				

			Quantity (Qs)	Price/Unit (Kyat)	Total (K)
Scenario 2: 25 % increase in Qs, No changes					
		Revenue	387.5	2344	
		Gross Income			909554
Total	2530333	**Total Variable Cost**			477071
Less Cost	-869161	**Gross Margin**			432483
NPV	1661172	**Profit (Net Returns to Management)**			297212
IRR	34.0%				
BCR	2.91				

Source: Hypothesized Scenarios From Field Survey Data 2019

4.36 NPV Analysis Scenario 3

Scenario 3, presented in Table 43, represents an idealized situation where a new technology, such as the GIFT tilapia strain, is adopted in combination with an improved feed. The scenario reflects a significantly higher quantity sold (50%) corresponding to a significantly higher quantity harvested and a significant increase in total feed cost (35-50%). All other costs stay constant throughout the investment period relative to the baseline NPV. The 35% higher feed cost corresponds to section 4.18.1, and Table 21, and the adoption of pelleted feed. Pelleted feed corresponds to an improved feed to yield ratio relative to rice bran, but costs approximately 35-50% percent more. As such, two different situations are analyzed within scenario 3, a 50% higher quantity sold with a 35% higher feed cost (representing the lower bound of feed costs) and a 50% higher quantity sold with a 50% higher feed cost (representing the higher bound of feed costs). The 50% higher Qs and 35% higher feed costs correspond to an NPV of 2182100 kyat, an IRR of 41% and a BCR of 3.51. Given this scenario, farming GIFT tilapia and relatively cheap pelleted feed, it would be recommended that new investors consider aquaculture farming due to a relatively high expected return. The 50% higher Qs and 50% higher feed costs correspond to an NPV of 1746751 kyat, an IRR of 35.1%, and a BCR of 3.0. Similarly, even with significantly higher feed costs (representing the highest expected feed costs), it can be recommended for a new investor to pursue aquaculture with GIFT tilapia. Such a scenario demonstrates that profit for smallholder aquaculture farmers in the study area is more sensitive to quantity sold than to feed costs.

Table 43:Scenario 3 – Improvements to Quantity Sold with higher Costs

Scenario 3: 50% higher Qs, 35% feed costs					
	20 Year investment		Quantity (Qs)	Price/Unit(Kyat)	Total (Kyat)
		Revenue	465	2344	
		Gross Income			1090058
Total Revenue	3051261	**Total Variable Cost**			596387
Investment Cost	-869161	**Gross Margin**			493671
NPV	2182100	**Profit (Net Returns to Management)**			358400
IRR	41.0%				
BCR	3.51				
Scenario 3: 50% higher Qs, 50% feed costs					
	20 Year investment				
			Quantity (Qs)	Price/Unit(Kyat)	Total (Kyat)
		Revenue	465	2344	
Total Revenue	3051261	**Gross Income**			1090058
Investment Cost	-869161	**Total Variable Cost**			647523
NPV	1746751	**Gross Margin**			442535
IRR	35.1%	**Profit (Net Returns to Management)**			307264
BCR	3.0				
Source (Field Survey 2019)					

CHAPTER FIVE – CONCLUSIONS AND RECOMMENDATIONS

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study aimed to describe the socio-economic characteristics of the aquaculture farmers in the study area, to estimate the profitability of smallholder aquaculture production in the Central Dry Zone of Myanmar, to estimate the impact of extension services and following best practice on profitability of fish farming in the Central Dry Zone of Myanmar, to describe the challenges facing aquaculture farmers in the Central Dry Zone, and to better understand the role of labor for aquaculture in the Central Dry Zone. To do so, 39 respondents were interviewed providing both qualitative and quantitative information. This information was then analyzed in a socio-economic analysis, an enterprise budget analysis, and an investment financial analysis.

The typical respondent tended to be older, male, married, and involved in crop production in addition to aquaculture. Typical respondents had started aquaculture in the last five years, motivated mainly by profit, and typically kept one pond. All respondents owned their land and could be categorized as small aquaculture farmers, oriented towards local and community markets. A typical respondent sold fish either in the village or to a bulk buyer, but rarely far outside of the village. For a typical respondent, rohu was the most important farm activity, followed by crop production and tilapia. Typical respondents experienced the most problems with water access, followed by pond construction, and fish feeding. For a typical respondent, there was no problems hiring labor, typically labor was hired on a short-term basis for help with harvesting and/or pond construction and pond maintenance and tended to be hired near the end of the aquaculture season between January and May. A typical household utilized family labor, with feeding and harvesting being the two most time-consuming activities. The total average family labor for respondents equaled approximately 27 person/days/year.

The first enterprise budget analysis showed a division between the earning potential of growout fish farmers, who bought fingerlings and grew them, and fingerling producers, who sold fingerlings to growout farmers. The average fingerling producer spent 1.6 times more than an average growout farmer but generated a profit of 12.5 times more than an average growout farmer. The analysis concluded, that if the aquaculture sector in Shwebo is to expand, as was discussed previously in the report, it can be recommended that smallholder farmers consider becoming fingerling producers, as it is more profitable than growout fish farming. There are limitations to this recommendation, as not everyone can be a fingerling producer because of their dependent nature on growout fish producers.

The second enterprise budget analysis compared experienced aquaculture farmers (>5 years' experience) against inexperienced farmers (<5 years' experience). An average experienced growout aquaculture farmer spent 1.44 times more than an average inexperienced aquaculture farmer, all while earning an average of 329143 kyat of profit per year compared to an average loss of 238424 kyat per year for inexperienced growout farmers. Experience is important for generating profit in the study area for growout farmers, suggesting that perhaps management practices, techniques, and knowledge are instrumental in achieving a relatively higher revenue for respondents in the study area.

The final enterprise budget analysis compared experienced growout aquaculture farmers who utilized feed and two or more inputs (lime, manure, fertilizer) against experienced growout aquaculture farmers who utilize no inputs (only feed). High input experienced growout farmers typically spent 1.31 times more than low-input experienced growout farmers, while generating 2.89 times more profit. Even more impressive, high-input households were able to produce more fish with substantially less pond area (3137 m^2 average pond area for low-input households, compared to 2076 m^2 average pond area for high-input households). As such, this report finds that input utilization should be prioritized for its strong potential to increase yield/unit area.

The opportunity cost of land was calculated for growout farmers. It was found that using the land for aquaculture production has more earning potential than the likely alternative of paddy rice production. Similarly, the opportunity cost of labor was calculated for growout farmers. It was found that growout farmers in the study area earn approximately $2.5/labor day based on their time spent on aquaculture. Compared to the likely alternatives of low skilled labor and agriculture, growout aquaculture production has more earning potential per time worked. However, it is noted that observed earnings per labor day are lower when compared to a previous aquaculture study in Myanmar (Gopal , et al 2014).

Several investment financial analyses were performed for growout fish farmers. First, a net present value analysis for a 20-year period with a constant 10% discount rate, based on current productivity figures and profit for growout farmers, found that an investment would have a positive NPV of 103429 kyat, but a low BCR of 1.12; as such, investment in aquaculture would have low potential long-term gains. A sensitivity analysis for the discount rate revealed that up to an 11% discount rate could be applied and still return a BCR >1. Second, scenario 1 analyzed an alternative where growout farmers made modest improvements to profitability year-to-year (3% improvement) with a constant 10% discount rate over a 20-year period. Scenario 1 produced a substantially higher NPV of 324701 kyat, but still a relatively low BCR of 1.37. Scenario 1 concluded that even with constant modest profitability gains, growout farming can be a worthwhile investment. Third, scenario 2 analyzed scenarios where productivity was improved (5%, 10%, and 25%) corresponding to more fish sold, but without increases in costs. This scenario was meant to replicate a scenario where farmers adopt best practices and improve their techniques leading to a sustained improvement in returns. Scenario 2 found that a 5% increase in quantity sold corresponded to a NPV of 423802 kyat and a BCR of 1.49, a 10% increase in quantity sold corresponded to a NPV of 723165 kyat and a BCR of 1.834, and a 25% increase in quantity sold corresponded to a NPV of 1661172 kyat and a BCR of 2.91. As such, scenario 2 concluded that modest improvements to current quantities produced can make investing in growout aquaculture a worthwhile investment (with the assumption of minimal incurred costs). Lastly, scenario 3 analyzed two situations where productivity was substantially improved (50%) but at a substantial cost. This scenario was meant to simulate the adoption of improved fish varieties (GIFT tilapia) and improved feed, corresponding to significantly higher growth rates and harvest potential, but at significantly higher costs. A situation with 50% higher quantity sold corresponding to a 35% higher feed cost (lowest expected price of pelleted feed) found a NPV of 2182100 and a BCR of 3.51; whereas, a situation with 50% higher quantity sold and a 50% higher feed cost found a NPV of 1746751 and a BCR of 3.0. Scenario 3 concluded that profit for smallholder aquaculture farmers is more sensitive to quantity sold than to feed costs.

The first null-hypothesis predicted that access to improved feed and use of pond inputs (fertilizer, lime, and manure) is hypothesized to improve profitability for small-holder aquaculture farmers. Based on the analysis of experienced growout farmers with low input use against experienced growout farmers with high input use, this study finds that for respondents in the study area the use of pond inputs improves profitability. The second null hypothesis predicted that access to labor and high feed costs would be problematic for respondents in the study area. Based on collected information, access to labor is not problematic, and high feed costs are moderately problematic, but not the most problematic. Water access and pond construction are observed to more problematic in the study area for respondents. The third null hypothesis predicted that informal labor would be widespread in the study area. Based on collected labor data, this hypothesis is true. Average households spend approximately 27 labor days/year of family labor on aquaculture, compared to just 3 labor days/year of hired labor on aquaculture.

5.2 Limitations of the Study

Several aspects of data collection were problematic and as such are noteworthy. First, farmers often kept poor records of their production, as such; productivity data was largely based on the recall abilities of the farmer. In several cases, it had been several months since harvest, and the farmers had difficulties recalling exact harvest amounts. Second, distances and area were frequently estimated by the farmer and translator for the author, as such, it is likely there was errors introduced based on this data collection method. To attempt to minimize this effect, the author had first collected data in local measurement units, which were later converted to m^2. Lastly, a representative of the department of fisheries accompanied the author alongside all interviews, as such, there is potential that respondents modified their responses based on the presence of the DOF representative. It was stressed by the author through the translator and the help of local village leaders that the study was academic and did not seek to collect official data for the DOF, but there is a likelihood that respondents were hesitant to fully disclose all information for fear of potential negative impacts from DOF.

5.3 Recommendations

The study has the following recommendations:

1. Aquaculture farmers should be encouraged to come together and share information and help each other. Most farmers said they would be happy to help their neighbors and

friends in the village to improve their aquaculture practices, but none of the villages had a formalized aquaculture group which met regularly to help one another.

2. The use of inputs should be prioritized. Most farmers had attended several trainings and received training and information regarding input use; however, many farmers either ignored this training or did not implement what they had learned.
3. The use of improved feed should be encouraged in the study area. None of the households used improved feed. Even though, several households had the financial means to invest in better feed, they chose not to do so.
4. Water access needs to be prioritized and given more attention by local administrators and organizations. Respondents indicated that the Department of Irrigation prioritizes agriculture, and often ignores the water scarcity issues of aquaculture farmers. Water access issues were most problematic for respondents in the study area.
5. Training and information regarding pond construction should be improved. Many respondents indicated their interest in expanding their pond production. However, pond construction was observed to be problematic in the study area. Manual labor was commonly used to dig ponds, which could be substituted with machinery.
6. Value-added processing of fish should be encouraged in the study area. None of the respondents indicated any value-added processing of their fish. Doing so could be advantageous for farmers, as it would allow them to generate additional income, and potentially sell their fish when market demand is higher corresponding to higher prices.
7. Fingerling production should be encouraged. It was observed that fingerling producers generate substantially more profit than growout farmers. Several sources indicated that the aquaculture sector in Shwebo district has much potential for future growth; as such, encouraging small-holder aquaculture farmers to become fingerling producers makes sense given the potential future demand for more fingerling production.

5.4 Future Research

The study found that modest improvements to the productivity of smallholder aquaculture in the Central Dry Zone of Myanmar can have large impacts on the profitability of aquaculture farmers. Input use is relatively low and can be improved. Similarly, none of the respondents used improved feeds. Future studies should focus on the factors limiting input use adoption, and improved feed adoption, as well as factors which enable input use and improve feed utilization.

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Appendix A: Questionnaire

Section 1: Household Roster

	1	2	3	4	5	6	7	8	9	10
	Name	Sex	What is the relationship of [NAME] to the head of the household? 1=Head 2=Spouse 3=Son/daughter 4= Grandchild 5=Parent 6=Sister/Brother 7=Nephew/Niece 8=Other relatives 9=Non-relative 10=Other (specify)	How many months of the past 12 months has [NAME] lived with the household?	How old is [NAME]?	Marital status 1..SINGLE 2…MARRIED 3…DIVORCED 4…WIDOWED	Can [NAME] read and/or write? 1…CANNOT R/W 2…CAN READ ONLY 3…READ + WRITE	What was the highest grade completed by [NAME]? CODE EDUCATION	What s [NAME]'s main (and other) activity during the past 12 months? CODE OCCUPATION	Since 2018, has [NAME] 1-Undertaken Salaried Employment 2- Done any casual work? 3- Been involved in business (formal or informal) 4- Received rent 5-Received retirement Pension 6- Received subsidy or assistance from the govt 7-Remittances 8-Sold Fish 9-Sold other agricultural/livestock product 10-Been a student 11- disabled 12- looking for work [Mark al
		M=1 F=2			Years				1st / 2nd	#,#,#,#,#,#
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0

Code: Education	Code: Occupation	
01…none	1…Fish farmer	10…government employee (specify____________)
02…informal education	2…crop production	11…private sector employee (specify_________)
11…Nursery	3…animal husbandry	12…trader
12…Primary	4…mixed crop and livestock prod.	13…own enterprise (e.g. weaving)(specify_____)
13…Secondary	5…domestic work (e.g. housewife)	14…looking for job
14…Technical College	6…agricultural wage labor (crops)	15…disabled/chronic illness
15…National Diploma	7…livestock herder	16…retired
16…Higher National Diploma	8…non-agricultural wage labor	17…other (specify__________)
17…Bachelor	9…student/pupil	For 2 nd occupation > 0…no other occupation
18…Master		
19…PhD		
20..Professor		

Section 2: Pond Productivity

1. Please rank the income generating activities you are operating

	Very important	Important	Moderately Important	Slightly Important	Not Important
Tilapia					
Rohu					
Poultry and eggs					
Duck					
Cows					
Water Buffalos					
Sheep					
Goats					
Pigs					
Crops					

2.A How much lands do you

A. own. ______ acres.

B. lease/rent ______ acres

3. Do you use the land for tilapia production? 1:Yes 2: No

If yes, how much

4. How many years have you been into fish production?

1-5 years	1	
5-10 years	2	
More than 10 years	3	

5. How much of your fish production did you sell last year?

none at all	1	
less than 10%	2	
between 10-25%	3	
between 25-50%	4	
50%	5	
50-75%	6	
>75%	7	

5. What Production method do you use (Aquaculture)?

Earthen Pond	1	
Concrete Pond	2	
Flow through system	3	
Cages	4	#,#,#
Tanks	5	
Recirculating systems	6	
Others	7	

6. Has your household changed area under fish production in the last 5 years?

1 - Yes	2- No	

6.b If increased/decreased why? ………...

7.a How do you envisage your fish farm in the next five years?

7.b What do you require to meet your goals?

7.c Problems Faced

Please describe your attitude towards the following activities

	Not Problematic	Slightly Problematic	Moderately Problematic	Problematic	Very Problematic
Pond Construction					
Fish Feeding					
Fish Stocking					
Fish Harvesting					
Access to Materials and Tools					
Access to Training					
Access to Credit					
Access to Labor					
Cost of Labor					
Water Quality					
Marketing Your Fish					
Robbery/Security					
Transportation of Fish					
Other ( )					

7.c - Motivation

Rank the motivation for starting your aquaculture practice

Profit	1	#>#>#>#
Personal Consumption	2	
Relatives/Friends	3	
Technical Training/Education	4	

8.A Pond - Information

# of Fish pond	1	2	3	4	5	6	7	8	9	10
	Ownership Status	Size of Pond	Source of water	Distance from pond to water source	Pond Type	Year of Construction	Fish stock	Stocking Density	When did you last stock the pond?	Polyculture ?
	1…Own 2…Rent 3…Gift 4…Inheritance 5…Community Land 6…Bought	Feet ^2		km	1…Earthen Pond 2…Concrete Pond 3…Flow through system 4…Cages 5…Tanks 6..Recirculating systems 7…Others		1.Tilapia 2. Rohu 3. Carp 4. Other #,#,#	#/area		1. Yes 2. No
PID1	0	0	0	0	0	0	0	0	0	0
PID2	0	0	0	0	0	0	0	0	0	0
PID3	0	0	0	0	0	0	0	0	0	0
PID4	0	0	0	0	0	0	0	0	0	0
PID5	0	0	0	0	0	0	0	0	0	0
PID6	0	0	0	0	0	0	0	0	0	0
PID7	0	0	0	0	0	0	0	0	0	0

8.B Pond - Consumption & Selling

# of Fish pond	10	11	12	13	14	15	16	17	18	19
	Amount of fish harvested In past 12 months	Amount of fish sold in past 12 months	Price achieved for sale	Distance to point of sale	Mode of transport to point of sale	Transport Costs	Total Given Away	Amount of fish Processed	Price of sold processed fish	Where Was your fish sold
	fiss	fiss	Kyat	miles	1. Car/Motorcycle 2. Bus 3. Foot 4. Ox	Kyat	fiss	fiss	Kyat	1. Local Market 2. Bulk Buyer 3. Contract
PID1	0	0	0	0	0	0	0	0	0	0
PID2	0	0	0	0	0	0	0	0	0	0
PID3	0	0	0	0	0	0	0	0	0	0
PID4	0	0	0	0	0	0	0	0	0	0
PID5	0	0	0	0	0	0	0	0	0	0
PID6	0	0	0	0	0	0	0	0	0	0
PID7	0	0	0	0	0	0	0	0	0	0

8.C Pond - Inputs used in fish production

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	Type of seed	Source of seed	Seed quantity	Did you buy the seed?	How much did you pay IN TOTAL for the seed used in this pond?	Amount of chemical fertilizer used for this pond	TOTAL COST of fertilizer used for this pond	Amount of manure used for this pond	TOTAL COST of manure used for this pond	Amount of pesticide used for this pond	TOTAL COST of pesticides used for this pond	Amount of lime used for this pond	TOTAL COST of lime used for this pond	Amount of commercial feed	TOTAL COST of commercial feed
				1 - Yes 2 - No											
PID1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PID7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8.D Pond - Operating Costs (Past 12 months)

	Amount/Units	Cost
Equipment & Tools	0	0
Routine repairs, constructions	0	0
Drugs and water treatment	0	0
Taxes and Insurance	0	0
Security	0	0
Maintenance of fences	0	0
Pumping rental	0	0
Fuel	0	0
Gasoline/Oil	0	0

8.E Investment Costs (Lifetime)

	Amount/Units	Cost
Pump	0	0
Netting	0	0
Vehicle	0	0
Containers/Storage	0	0
Refrigerator	0	0
Piping	0	0
Tools	0	0
Pond Constuction	0	0

Section 3 Labor Productivity

1. In the last 12 months, did you use hired labour for fish production activities? 1:yes 2: No

2. What is the daily wage rate for general farm labour for men and women in this area?

Men day rate (Kyat)	Women day rate (kyat)

3. Typically, how many hours do men work in a day?

3.b Typically, how many hours do women work in a day?

4. Have you had problems hiring laborers? 1:yes 2:no

5. Is there a labor shortage? 1:yes 2:no

6. Are there times of year when there is insufficient access to labor? 1:yes 2:no

7.B Labor Makeup

	Number of Permanent Laborers				Number of Temporary Laborers			
	Male	Female	Children		Male	Female	Children	
			Boys	Girls			Boys	Girls
	-1	-2	-3	-4	-5	-6	-7	-8
1. Number of Employees	0	0	0	0	0	0	0	0
2. Hours Worked (Days)	0	0	0	0	0	0	0	0
3. Wage Paid	0	0	0	0	0	0	0	0

7.C Labor Costs - Past 12 months

					Seasonal Activities					
	Number	Work per day total (hrs)	Cost per hour (kyat)	Days per month	Stocking		Harvesting		Maintenance	
					Days	Wage	Days	Wage	Days	Wage
Permanent Employees	0	0	0	0	0	0	0	0	0	0
Seasonal Employees	0	0	0	0	0	0	0	0	0	0
Family Members	0	0	0	0	0	0	0	0	0	0

7.D Labor Seasonality - Past 12 months

	May	June	July	August	September	October	November	December	January	February	March	April	May
Number of Seasonal Employees	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours Worked total	0	0	0	0	0	0	0	0	0	0	0	0	0
Wage Paid	0	0	0	0	0	0	0	0	0	0	0	0	0

7.C Labor Costs - Past 12 months - Detailed

Pond ID	Activity	How many person-days did **female family** members work in [ACTIVITY] on this pond in the past 12 months?	How many person-days did **male family** members work in [ACTIVITY] on this pond in the past 12 months?	How many person-days were **women hired** to work in this [ACTIVITY] on this pond in the past 12 months?	Usually when you hire a female worker for [ACTIVITY], how many hours do they work in a typical day?	What is the price per person-day of female labor for doing this activity	How many person-days were **men hired** to work in this [ACTIVITY] on this pond in the past 12 months	Usually when you hire a male worker for [ACTIVITY], how many hours do they work in a typical day?	What is the price per person-day of male labor for doing this activity?
PID1	Pond Construction	0	0	0	0	0	0	0	0
	Stocking	0	0	0	0	0	0	0	0
	Weeding	0	0	0	0	0	0	0	0
	Fertilizer Application	0	0	0	0	0	0	0	0
	Feeding	0	0	0	0	0	0	0	0
	Harvesting	0	0	0	0	0	0	0	0
PID2	Pond Construction	0	0	0	0	0	0	0	0
	Stocking	0	0	0	0	0	0	0	0
	Weeding	0	0	0	0	0	0	0	0
	Fertilizer Application	0	0	0	0	0	0	0	0
	Feeding	0	0	0	0	0	0	0	0
	Harvesting								

Appendix B: Statement of authorship

Declaration

I,

Name, First name____

Born on ____

Matriculation number____hereby declare on my honor that the work attached to this declaration

□ Homework/Presentation

□ Bachelor Thesis

□ Master Thesis

□ Diploma Thesis

has been independently prepared, solely with the support of the listed literature references, and that no information has been presented that has not been officially acknowledged. All parts of this work that were taken verbatim or in spirit from publications or outside communications are individually marked as such.

Supervisor
Lecturer
____

Thesis topic
____

Semester ____

I declare herewith, that I have transferred the final digital, not write-protected text document (in the format doc, docx, odt, pdf, or rtf) to my mentoring supervisor and that the content and wording is entirely my own work. I am aware that the digital version of my document can and/or will be checked for plagiarism with the help of an analyses software program.

Place, date, signature

*This declaration has to be attached to your final, independently compiled document. Work without this declaration will not be accepted.