ROLE OF PERENNIAL CROPS IN RURAL HOUSEHOLD INCOME IN CENTRAL DRY ZONE OF MYANMAR UNDER THE CLIMATE CHANGE SCENARIO

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NOVEMBER 2017

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A Thesis submitted to the Post-Graduate Committee of the Yezin Agricultural University as a Partial Fulfillment of the Requirements for the Degree of Master of Agricultural Science (Agricultural Economics)

Yezin Agricultural University

NOVEMBER 2017

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

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DEDICATED TO MY BELOVED PARENTS,

U THET HTWE AND DAW WIN WIN MAW

ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to Dr. Myo Kywe, Rector, Dr. Soe Soe Thein, Pro-Rector (Academic) and Dr. Nang Hseng Hom, Pro-Rector (Administration), Yezin Agricultural University (YAU), for their kind permission and administrative support to conduct my research work.

I wish to express my serious gratitude to Dr. Cho Cho San, Professor and Head, Department of Agricultural Economics, YAU, for her invaluable advice, kind help to be able to complete my research work and motherly concern.

Sincere gratitude goes to Dr. Theingi Myint, Professor, Department of Agricultural Economics, YAU, for her professional guidance, advices and invaluable comments to be good in the whole thesis.

Sincere appreciation and gratitude goes to my beloved supervisor Dr. Shwe Mar Than, Deputy Director, Participatory Knowledge Management Division, Advanced Centre for Agricultural Research and Education, YAU, for her wise advice, constant guidance, encouragement, very helpful suggestions and evaluations for successful completion and invaluable overall supervision throughout this study.

My sincere thanks are due to external examiner, Dr. Amy Soe, Assistant Director, ASEAN Division, Department of Planning, Nay Pyi Taw for her warm encouragement, valuable suggestions and comments.

I am indebted gratitude to supervisory committee members, Dr. Thanda Aung, Lecturer, Department of Horticulture and Agricultural Biotechnology, YAU and Daw Nang Ei Mon The, Lecturer, Department of Agricultural Economics, YAU, for their kindly guidance, valuable suggestions and their critical and patient reading, and comments in this research.

My sincere thanks are also due to the teachers from Department of Agricultural Economics, YAU, for their knowledge contribution and suggestions to my research and all of senior and junior master students for their supporting, kindness, and assistance throughout my study period.

My special thanks also go to respondent farmers for their patiently answering my survey questionnaires. I really appreciate to Township Manager, village leaders and staffs of Department of Agriculture, Kyaukpadaung Township and Nyaung U

Townships, for their kindly help in obtaining the necessary primary and secondary data for this thesis.

I wish to express my deep and special thanks to Japan International Corporation Agency, Technical Cooperation (JICA-TCP), for the financial support to conduct a master research.

Last but not least, my deepest and greatest dedication is to my beloved father, U Thet Htwe and mother, Daw Win Win Maw for their financial support, encouragement and a lot of help whenever I need.

ABSTRACT

In Myanmar, climate change affects both on seasonal crops and perennial crops productions, however, obviously more on seasonal crop production. Central Dry Zone is said to be very vulnerable to Climate change. This study was carried out with three objectives: (i) to analyze income diversification of rural households in Central Dry Zone of Myanmar, (ii) to point out the important role of income from perennial crops in rural household income to combat climate change impacts, and (iii) to find out the most practicing strategies for climate change adaptation in Central Dry Zone of Myanmar. Kyaukpadaung and Nyaung U townships were selected as the study areas and 100 respondents from each township were interviewed. Respondents were chosen by using simple random sampling method and interviewed by using structured questionnaire sets. Descriptive statistics, Herfindahl index, multiple regression analysis, enterprise budget, intertemporal budgeting and adaptation strategies index were used to fulfill the research objectives. According to the results, the types of occupation of sample households were seasonal crop cultivation, perennial crop cultivation, farm labor, livestock rearing, government staff, broker, wage labor, tailor, hairdresser, self-employment, driver, mason, carpenter, shopkeeper, vendor, and casual labor. Respondents had moderate income diversification with the average Herfindahl index of 0.65 in Kyaukpadaung and 0.59 in Nyaung U Township. In addition, dummy of having perennial crop income was positively and significantly influenced on annual household income at 5% and 1% level in Kyaukpadaung and Nyaung U townships, respectively. Number of income sources was also positively influenced on annual household income at 1% significant level in both townships. Furthermore, expanding perennial crop cultivation was the first choice of climate change adaptation strategies for farmers in Kyaukpadaung Township. In Nyaung U Township, changing cropping pattern was the first one followed by expanding perennial crop cultivation. In order to raise income level of the rural household for combating climate change impact, perennial crop income is vital and it would be enhanced.

Key words: perennial crops, climate change, Herfindahl, intertemporal, adaptation strategy

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF APPENDICES

Page

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
CRF	Capital Recovery Factor
°C	Degrees Celsius
DoA	Department of Agriculture
FAO	Food and Agriculture Organization
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change.
Kg	Kilogram
MCCA	Myanmar Climate Change Alliance
MMK	Myanmar Kyat
MOALI	Ministry of Agriculture, Livestock and Irrigation
N	Number of respondents
NCEA	National Commission for Environmental Affairs
NPV	Net Present Value
TR	Total Revenue
TVC	Total variable cost
TVCC	Total variable cash cost
UNFCC	United Nations Framework Convention on Climate Change

LIST OF CONVERSION FACTORS

1 Basket of Pigeon Pea	= 32.7 kilogram
1 Basket of Groundnut (unhusked)	= 11.4 kilogram
1 Hectare	= 2.47 acres
1 ton	= 1000 kilogram

CHAPTER I

INTRODUCTION

Myanmar is still heavily dependent on the agriculture sector for income, survival and economic growth. However, climate change has been the important factors that can reduce agricultural crop productivity and the income of rural household farmers gradually. Vulnerability, uncertainty and risk are essential features in agricultural sector. There are numerous potential effects of climate change on agriculture. It affects crop growth, yield and quality, livestock health and pest infestation (MercyCorps 2015).

In the Dry Zone of Myanmar, the agriculture sector is a vital and historic source of livelihood, and most of the farmers are poor and so vulnerable to climate change. Furthermore, climate change causes low productivity, low profitability, high debt and traps rural majority in poverty. Central Dry Zone of Myanmar is the most serious region in terms of land degradation because of climatic change impacts on crop production, productivity and income generation of the farmers and the social welfare are affected (Myo Win Maung *et al.* 2016).

Climate change affects both on seasonal and perennial crop production. However, Zhang (2011) stated that relative to annual crop species, perennial crops would solve many agricultural problems, as well as substantial ecological and economic benefits. Perennial crop cultivation can earn higher income relative to seasonal crops. Therefore, when farmers faced with lost in annual crop production due to climate change, perennial crop production would become an important role in income generation. In addition, they can produce more ground cover and more extensive root systems and more effective on capturing nutrients and water. Therefore, perennial crops can be used in reducing soil erosion and minimizing nutrient leaching, which would be a strong support for sustainable agriculture. Perennial crops would address many agricultural problems as well as substantial ecological and economic benefits.

On the other hand, rural households in many different countries have found to diversify their income sources allowing them to spread risk and achieve better consumption. The diverse rural income is less vulnerable than undiversified ones. This is often necessary in peasant based agricultural economies because of risks such as variability in soil quality, livestock and crop diseases, price shock, unpredictable rainfall and other weather related events. The number of poor people in many developing economies has continued to increase and income diversification has been necessary, have been identified as an essential strategy for raising income and reducing rural poverty (Nelson *et al*. 2016).

1.1 Impact of Climate Change on Agriculture in Myanmar

The economy of the country and the livelihoods of the majority of its people are increasingly at risk due to climate change. In Myanmar, the agriculture sector is the backbone of Myanmar economy (NCEA 2010), and crop sector contributed 28.6% of GDP, 25.5% of total export earnings and employed 61.2% of the labor force in 2016 (MOALI 2016). Around 70% of the country's population reside in the rural areas and mainly depend on agriculture, livestock and fishery for their livelihoods (MOALI 2016).

According to NCEA (2010), in Myanmar, climate change has become apparent since 1977 and the climate data have indicated a general warming trend and a decreasing precipitation trend. MCCA (2017) stated that, in Myanmar, the observed evidence of change over the last 60 years includes a nationwide increase in temperature of on average around 0.08°C per decade and an increase in total rainfall (29 to 215 millimeters per decade).

While climate change is mainly related to global phenomena, developments in Myanmar are exacerbating the human health impact, agricultural insecurity, and loss of biodiversity. Deforestation is of particular concern, as decreasing forest cover and deterioration of its quality reduce adaptive capacity and the absorption of greenhouse gases. Forest fires represent an additional climate change pressure, especially in the dry forests that dominate the central part of the country (ADB 2013).

Climate related changes and its consequences in Myanmar involve an increase in the occurrence of drought events, increase in intensity and frequency of cyclones, rainfall variability, prevalence of flooding and storms, extreme high temperature and sea-level rise. In Myanmar, climate change impact on almost all sectors, especially (1) on agriculture, livestock and food security, (2) environment, natural resources and biodiversity, (3) energy, industry and transport, (4) human settlement and cities, and (5) public health (MCCA 2017).

Agriculture in Myanmar is extremely vulnerable to climate change. The wide variety of agro-ecological tracts lead to farmers growing more than 60 different crops including both tropical and temperate varieties. Agriculture and crop production in Myanmar are strongly affected by rainfall as crop cultivation is mostly rain-fed. According to NAPA (2012), in case of agricultural sector, climate change impacts can be categorized in three ways; (1) impact on productivity of the current agricultural techniques and crops, (2) sudden destruction of cultivations by severe hazards such as flood, hails, fogs etc. or lack of production because of droughts and (3) land degradation in the long-term. Dry season last for more than six months in arid and semi-arid regions, and wind erosion was a problem. In such areas, natural vegetation was steppe-like with large parts of bare soil. The fine participles of the soil such as clay, silt and organic matter were blown away by strong winds while coarse materials were left behind (ADPC 2009). Climate change will impact on low income rural populations that depend on conventional agricultural systems or on marginal land. The predicted rise in temperature in Myanmar is expected to have major negative impacts on agricultural production and food security (NAPA 2012).

Higher temperatures would reduce yields of desirable crops (e.g. rice, wheat, maize, soybean and groundnut) and encourage weed and pest proliferation. Changes in precipitation patterns would increase the likelihood of short-term crop failures as well as long-term production declines. According to the IPCC 4th Assessment Report, climate change is expected to affect agriculture in South East Asia in several ways: (i) irrigation systems would be affected by changes in rainfall and runoff, and subsequently, water quality and supply; (ii) temperature increases of about 2 to 4°C would threaten agricultural productivity, stressing crops and reducing yields; (iii) changes in temperature, moisture and carbon dioxide concentrations would negatively affect major cereal (e.g. rice, wheat, maize and millet) and tree crops; and (iv) increases in rice and wheat production associated with CO_2 fertilization would be offset by reductions in yields resulting from temperature and/or moisture changes. In particular, the increases in occurrence of droughts would result in crop failure in rain-fed agricultural areas and would increase the demand for irrigation. Conversely, increases in the occurrence of intense rains and resulting extreme floods would result in higher yield losses from crop damage. A rise of 1 to 2 ºC combined with lower solar radiation has the potential to cause rice spikelet sterility (i.e. infertile rice seeds).

Rice becomes sterile if exposed to temperatures above 35 ºC for more than one hour during flowering and consequently produces no grain. This would limit rice production. Furthermore, higher temperatures would increase the incidence of crop diseases, insect pests and rodents. Agricultural impacts would particularly affect low-income rural populations that depend on traditional agricultural systems or on marginal lands (NAPA 2012).

Agricultural losses would have negative consequences on the nation's economy as well as result in human suffering through increased rates of malnutrition, health problems and mortality. In 2010, severe drought diminished village water sources across the country and destroyed agricultural yields of peas, sugar cane, tomato, and rice (MCCA 2017).

1.2 Climate Change in Central Dry Zone of Myanmar

It is important to note that the impacts of climate change are not going to be the same for every developing country or even for each region inside a country. The central Dry Zone of Myanmar is a place of longer droughts and higher incidents of wildfires from the combination of higher temperatures and lower rainfall. Although satisfactory progress has been achieved in the important sectors for rural people in many parts of the country, the people in the Dry Zone of the Central Myanmar are still struggling to combat poverty due to adverse climatic conditions, low productive, infertile soil and insufficient water availability (MOF 2005). Severe droughts have increased in frequency from 1992 to 2002, with the most severe drought took place in 2010 with extreme temperatures up to 47.2 °C. The scarcity of water has also become a serious issue in the Dry Zone of Myanmar (Lwin Maung Maung Swe *et al.* 2014).

The deterioration of natural resources such as soil erosion and deforestation has made the agricultural production unstable. The main reasons include increased human as well as cattle population and demand of fuel wood for domestic and industrial use. The natural resources of Dry zone have been depleted more rapidly than nature can renew itself.

The temperature of Dry Zone was very high and some of the locations record temperature over 43°C, while the highest mean temperature was around 32°C. An increase in extreme high temperatures was already creating problems in the Dry Zone, for example the severe drought in 2009, which impacted major cereal crops (WFP

2009). The annual precipitation in Dry Zone was less than 750 mm, while the national average precipitation was 2353.06 mm. The Dry Zone was once a heavy deforestation region. The heavy cuttings of forests were to be primary cause of forest destruction since 11 AD. The inevitable consequence of forest destruction was drastic change in climate, gradually moving from bad to worse. Other main causes of deforestation in Dry Zone could be grouped into population growth, agricultural encroachment, increasing livestock population, increasing demand for fuel wood.

1.3 Perennial Crops Production in the Dry Zone

In Myanmar Dry Zone, perennial plants were grown for many reasons. Perennial plants give shade to all living creatures, protect from extreme weather, provide green environment for living things, generate income for farm households, are source of very important fuel woods, serve as wind break and hedge row, can be used as animal feed, and give both cash and non-cash income. Most farmers are growing perennial crops for many purposes in Central Dry Zone (CDZ) of Myanmar for income, for fuel wood, for animal feed or for shade tree. Common perennials in CDZ are toddy palm, jujube, mango, tamarind, dragon fruit, thanakha, acacia tree, neem tree, lead tree and rain tree. In CDZ of Myanmar, jaggery production from palm tree was very common and it requires 0.342 million tons of wood annually (ADPC 2009). According to MercyCorps (2015), small-scale production of perennial crops can also help smallholder farmers adapt to variable weather conditions in the Dry Zone of Myanmar.

Dragon fruit can be grown in both tropical and sub-tropical region. In addition, the scarcity of irrigation water and the weather conditions of Central Dry Zone push the farmers to grow dragon fruit. Dragon fruit is the most suitable and profitable crop in the Dry Zone, and it became a potential perennial crop. However, secondary data for dragon fruit production was not available. Mango and jujube production in Mandalay region within six years were shown in table 1.1 and 1.2, respectively.

Table 1.1 Mango productions in Mandalay Region

Year	Grown Area (Acre)	Harvested Area (Acre)	Yield Rate (Number)	Total Yield (Number)	Growth Rate
2009-2010	18,086	17,552	10,495	184,208,240	
2010-2011	18,661	13,146	14,654	192,641,484	0.05
2011-2012	20,848	18,842	13,915	262,186,430	0.36
2012-2013	22,441	18,977	13,120	248,978,240	-0.05
2013-2014	22,746	20,112	12,531	252,023,472	0.01
2014-2015	22,829	20,203	12,471	251,951,613	-0.00

Source: MOALI (2016)

Table 1.2 Jujube productions in Mandalay Region

Year	Grown Area (Acre)	Harvested Area (Acre)	Yield Rate (Viss)	Total Yield (Viss)	Growth Rate
2009-2010	10,662	10,659	4,338	46,238,742	
2010-2011	10,618	8,294	5,499	45,608,706	-0.01
2011-2012	10,154	10,118	4,183	42,323,594	-0.07
2012-2013	10,112	9,963	3,961	39,463,443	-0.07
2013-2014	10,112	10,081	4,176	42,098,256	0.07
2014-2015	10,109	10,081	3,947	39,789,707	-0.05

Source: MOALI (2016)

1.4 Problem Statements of the Study

Although the agricultural development is critical for poverty alleviation and economic growth in Myanmar, climate change has been the important factors that declining agricultural crop productivity and leading to decrease household income.

The Dry Zone of Myanmar holds 20% of total population and majority of them live in rural area and engaged in agricultural activities. The Dry Zone receives limited rain compared to country averages that leads to drought. Most are engaged in marginally profitable agriculture-based livelihoods and are subject to shock and stress such as erratic rainfall patterns, price fluctuations and degrading soil fertility (MercyCorps 2015). Low agricultural profitability is a critical constraint to farming communities in the Dry Zone. Therefore, income for many farming communities is low, which, in turn, stifles their ability to invest in productive assets and skills. These conditions create a foundation of vulnerability, leaving communities unable to adapt to shift in market conditions such as variability in crop prices, environmental conditions such as pest and disease outbreaks, and erratic weather patterns such as floods or drought. Therefore, agricultural production is low and faced with loss instead of profits.

In this condition, rural people are going to migrate to urban areas such as Yangon, Mandalay, and Taunggyi within the country or even to cross border to go to countries like Thailand, Malaysia, Korea, etc. As a consequent, labor shortage becomes a problem and agricultural sector is affected again. Therefore, it is important to find a solution to improve agricultural production and household income.

Perennial crop production may be one of the solutions to reduce their risks and vulnerable conditions. Climate change adversely affects not only on seasonal crop production but also on perennial crop production. However, perennial plants can be cultivated in both tropical and sub-tropical regions. Most of the perennial trees are hardy in nature, and they can be grown in a wide-range of soils. Moreover, yield can be obtained even in low maintenance, and it can earn higher income relative to seasonal crops. Therefore, Perennial crops would address many agricultural problems as well as substantial ecological and economic benefits.

Moreover, Nelson *et al.* (2016) stated that non-farm activities contribute substantially to household income increase. Therefore, income diversification is one of the important factors to increase rural household income. In this case, it is needed to identify the income diversification of the Dry Zone of Myanmar. In addition, a large reduction in adverse impacts of climate change is possible when adaptation strategies are wholly applied. Therefore, local level initiatives are important to promote adaptation strategies for climate change, and it is important to know climate change adaptation strategies followed by farmers.

1.5 Objectives of the Study

The overall objective of the research is to know the role of perennial crops in income of rural household in Central Dry Zone under climate change scenario. The specific objectives are as follows:

1. To analyze income diversification of rural households in Central Dry Zone of Myanmar;
2. To point out the important role of income from perennial crops in rural household income to combat climate change impacts; and
3. To find out the common adaptation strategies for climate change in Central Dry Zone of Myanmar.

CHAPTER II

LITERATURE REVIEW

2.1 Concept of Climate Change

Climate change is defined as changes in distributional patterns of weather over different time periods that may range from a few years to several decades. Rising global average temperature, increasing ocean temperature, changes in rainfall pattern and gradual melting of glaciers are the most prominent effects of climate change (UNFCCC 2007).

Change in climate is mainly attributed to the unabated increase in greenhouse gases, including fluorinated gases, carbon dioxide, methane, and nitrous oxide, which bring changes in rain pattern, temperature, and negative effects on water and land resources, floods, and droughts. Climate change is considered to be a global phenomenon; however, its impacts are more widely felt in the developing countries, due to their greater vulnerabilities and lesser ability to mitigate the effects of climate change (IPCC 2007).

2.2 Climate Change Impact on Agriculture

Most developing nations are agriculture-based economies, and thus their agricultural sector is affected the most due to direct exposure to nature. The major impact of climate change is on agricultural production due to changes in rain pattern, temperature, floods, droughts, and negative effects on water and land resources. In the developing countries, the latest work has progressively considered the impacts of climate change on agricultural production (Ali *et al*. 2017).

Climate change could affect food production through different ways: (1) by changing overall growing conditions such as temperature, precipitation, carbon dioxide fertilization, climate variability and surface water runoff (World Bank 2008), (2) by inducing more extreme weather such as floods, droughts and storms and (3) by increasing extent, type and frequency of infestations, including that of invasive alien species (Nellemann *et al.* 2009).

The croplands, pastures and forests that occupy 60% of the Earth's surface are progressively being exposed to threats from increased climatic variability and, in the longer run, to climate change. Increase intensity and frequency of storms, droughts, and floods, altered hydrological cycles and precipitation variance have implications for future food availability. Abnormal changes in air temperature and rainfall and resulting increases in frequency and intensity of drought and flood events have long-term implications for the viability of these ecosystems. As climatic patterns change, so also do the spatial distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production (FAO 2007).

The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines. In developing countries, 11% of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16% of agricultural GDP (FAO 2005).

Climate change impacts can be roughly divided into two groups: biophysical impacts and socio-economic impacts. Biophysical impacts include physiological effects on crops, pasture, forests and livestock (quantity, quality), changes in land, soil and water resources (quantity, quality), increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise, changes to ocean salinity and sea temperature rise causing fish to inhabit different ranges. Socio-economic impacts include decline in yields and production, reduced marginal GDP from agriculture, fluctuations in world market prices, and changes in geographical distribution of trade regimes, increased number of people at risk of hunger and food insecurity and migration.

Tropical and subtropical agriculture in developing countries is more climate sensitive than temperate agriculture. Crops are also sensitive to changes in precipitation. In semi-arid locations, increased rainfall is beneficial. However, in very wet places, increased rainfall can be harmful. If climate scenarios turn out to be relatively hot and dry, they will cause a lot of damage to farms in low latitude countries. However, if climate scenarios turn out to be relatively mild and wet, there will be only modest damages and may be even beneficial effects. The magnitude of the damage depends greatly on the climate change scenario (Mendelsohn 2009).

The largest known economic impact of climate change is upon agriculture because of the size and sensitivity of the sector. Warming causes the greatest harm to agriculture in developing countries primarily because many farms in the low latitudes already endure climates that are too hot. Although there are many impacts expected from global climate change, one of the largest impacts is expected to be on agriculture. Even though adaptation will blunt some of the worst predicted outcomes, warming is expected to cause large damages to agriculture in developing countries over the next century.

Food is one of society's key sensitivities to climate. A year of not enough or too much rainfall, a hot spell or cold snap at the wrong time, or extremes, like flooding and storms, can have a significant effect on local crop yields. There is some evidence that climate change is already having a measurable effect on the quality and quantity of food produced globally (Ranger 2012).

Improved crop production strategies aim to sustainably boost profitability by yielding more from less, better absorbing the impacts of variable conditions, and increasing the market power of farmers and laborers. Diversifying income streams aims to help household better management risk by spreading investments across more than one type of livelihood strategy. Individual development strategies are purposefully broad because of the wide-ranging context found in the Dry Zone.

In areas where crops are being grown in their warmest productive temperature ranges, heat stress or increased disease could reduce crop yields. Extreme weather events such as heat waves, droughts, strong winds, and heavy rains can be detrimental to crop growth. Droughts are damaging because of the long-term lack of water available to the plants. Heat waves can cause extreme heat stress in crops, which can limit yields if they occur during certain times of the plants' life-cycle (pollination, pod or fruit set). Heavy rains that often result in flooding can also be detrimental to crops and to soil structure. In addition, flooding can erode topsoil from prime growing areas, resulting in irreversible habitat damage. Changes in climate may also impact the water availability and water needs for agriculture. If temperature increases and more sporadic rainfall events result from global warming, it is possible that irrigation needs could increase in the future.

Nang Ei Mon The (2012) studied that impact of climate change on rural livelihoods in Pakokku Township in Magway Region in Myanmar. The major effect of climate change on crop production were low productivity, reduced cultivated land water shortage and increase disease and pests. Sample rural households revealed that climate change impacts like drought and flood were the main concerns in their villages and these impacts causes vulnerable to crop production. According to the responses of rural farm households, low productivity for crop production was the most serious factor in the study area.

Enete (2014) examined impacts of climate change on agricultural production in Enugu State in Nigeria. In many crops, a significant increase in daytime temperature maxima during the growing season reduces photosynthesis and increase evapotranspiration, leading to a reduction in yield. However, if warming does occur primarily at night, rather than during the day, this could greatly reduce the negative impacts of climate change on crop productivity. A decrease in water availability would results in decreased food production in regions where water becomes critical. Also, as crops are stressed by climate change they become more vulnerable to damaging pests and diseases.

Kumar and Gautam (2014) reviewed climate change and its impact on agricultural productivity in India. Throughout the 21^{st} century, India is projected to experience warming above global level. Longevity of heat waves across India has extended in recent years with warmer night temperatures and hotter days, and this trend is expected to continue. The average temperature change is predicted to be 2.33°C to 4.78°C with a doubling in CO_2 concentrations. These heat waves will lead to increased variability in summer monsoon precipitation, which will result in drastic effects on the agriculture sector in India. Local weather conditions such as rain, temperature, sunshine and wind, in combination with locally adapted plant varieties, cropping systems, and soil conditions can maximize food production as long as plant diseases can be controlled.

Ali *et al*. (2017) observed that climate change and its impact on the yield of major food crops: evidence from Pakistan. The results of the study revealed that some climate variables affect the crop yield negatively and significantly, while others are not significant. The most influential climatic variables for wheat crop production in Pakistan were observed to be maximum temperature, rainfall, and relative humidity.

The finding confirmed that maximum temperature is significant and negatively influenced on the yield of wheat crop, while rainfall and relative humidity are insignificant and negatively influenced on wheat crop yield. The influence of maximum temperature is significant for the rice crop. Both temperature and relative humidity displayed positive interrelation with sugarcane crop yield. Overall, climate change has adverse impacts on the yield of major food crops.

2.3 Role of Perennial Crops for Rural Household Income

If perennial crops are grown only one or more plants in the back yards, it can earn extra income for the household. Household who grown only a few tamarind plant in the back yards or on the bund of the fields, they can earn extra income by selling young tamarind leaves, young fruits and ripe fruits. Like that, if some mango plants were grown in home garden, household can earn a lot of money by selling green fruits and ripe fruits.

If perennial cash crops were grown for commercial production, higher income and higher net profits can be obtained. Belyi (2015) stated that perennial fruit crop can resilient climate change impact through higher incomes. Those extra earnings allowed them to invest in inputs which lead increase in productivity and their income. With higher income, access to credit, and training, the percentage of farmers rehabilitating their farms increased fivefold. With higher regular incomes, smallholder farmers have extra cash to invest in their farms. One of the best ways to raise the incomes of smallholder farmers was to link them to value chains that pay a premium over the local commodity price and allow them to capture a larger share of those price premiums.

2.4 Role of Perennial Crops in Climate Change

Perennial crops can be used as a renewable resource but only rare information concerning their site-specific biomass production is available. Also, their yield stability as well as the quality of the produced biomass, whether for energetic or material utilization, is relatively unknown. Perennial crops offer several ecological benefits such as protection of soil and water bodies, long flowering and cover for wild animals during winter. Most of these crops have a high yield potential and are after planting and establishing is completed labor efficient to cultivate. Concerning with climate change and the presumed higher risk of extreme weather conditions, perennial crops might be a good supplement to common annual crops (Fritz and Hartmann 2015).

According to FAO (2011), perennial crops can take sustainable intensification to the next level and achieve productivity goals as well as social benefits and functioning ecosystem processes and services. Perennial systems can transform agriculture for smallholders and family farmers because perennial crops are more flexible and resilient to climate.

Perennial plants are able to re-grow and continue to reproduce grains, seeds, fruits, and biomass after a single harvest. Perenniality is built into agriculture systems to make farming more financially resilient and diversified, to contribute to the overall well-being of farmers, farm workers, and rural communities, to enhance diversity and productivity of farm and landscape level, to prevent soil erosion and promote efficient water storing, to reduce amount of energy for agricultural operations; and to learn and build on farmers' ecological knowledge and operationalize sustainable intensification (FAO 2011).

Perennial plants provides more consistent, abundant and affordable food, feed, fiber, and fuel, enhance the natural-resource base and environment that underpins productivity, make farming more financially viable and contribute to overall well-being of farmers, farm workers, and rural communities. Perennial crops offer many advantages over annual crops both above and below the ground in terms of maintaining ecosystem functions. Perennials maintain the soil cover, soil structure and biota and have deeper root systems than annuals and thus provide soil stability and enhanced soil health. They can also tap available soil nutrients, enhance biodiversity, make more water available to plants, and capture and sequester carbon. Perennial crop offers multiple products such as dual purpose food, feed, fiber and bio-fuel. The flexibility and resilience of dual-purpose perennial crops makes them most attractive on soils or in situations where other cereal systems are considered marginal. Farmers, pastoralists and forest dwellers need multiple options to increase and maintain their livelihoods, especially in less favorable areas or fragile environments. Increasing the availability of perennial grains, oilseeds and legumes expands the opportunities to rotate perennial and annual crops and to grow multiple crops together in perennial intercropped or poly culture systems thus increasing biological and economic diversity and achieving additional ecosystem services and multiple goods (FAO 2014).

Perenniality is integrated within agriculture and natural systems in diverse environments. The concepts and benefits of perennial landscapes and perennial agriculture need to be brought more strongly into the local, national, regional and global discourse to contend with climate change enhance biological diversity to attain safe and sustainable food and environmental security. The integration of perennial species into farming systems, whether crops, forages, shrubs or trees can contribute to achieving multiple global development goals, including: increased food security and nutrition; the mitigation of an adaptation to climate change; and the enhancement of ecosystem services such as biological diversity, water, nutrients and land health (FAO 2014).

Perennial crops would address many agricultural problems as well as substantial ecological and economic benefits, relative to annual crop species; they can produce more ground cover, and perform longer growing seasons and more extensive root systems, which make them more competitive against weeds and more effective at capturing nutrients and water. Thereby, perennial crops can be used in reducing soil erosion and minimizing nutrient leaching (Zhang *et al.* 2011).

Rainforest Alliance (2016) recommended that climate-smart practices of planting trees a lot on farm. Tree can act as windbreaks, reducing soil erosion, enrich soil, filter water, resulting in higher water quality, provide shade for workers and shade-loving plants, create habitat for wildlife and wildlife corridors, suck up and store greenhouse gasses. Approximately 80% of deforestation is caused by agricultural expansion, and that conversion from forest to cropland produces a significant amount of greenhouse gas. But farmers who utilize climate smart agriculture practices have lesser need to expand their farms.

Perennial tree plant can have positive effects for farmers, the land, water, and wildlife. It helps to reduce negative impact of climate change on agriculture and to boost positive effects, for protecting surrounding forests and ecosystems, and promoting healthier, more resilient landscapes, which in the aggregate, contributes to climate change mitigation and food security (Rainforest Alliance 2016).

Table 2.1 Indicative advantages of integrating perennials into agriculture

Seasonal-based agriculture	Perennial-integrated agriculture
Protecting soil only during crop canopy time frame	Year round soil protection and lack of soil disturbance
Shallow rooting system, less organic material, reduced soil quality	Deep rooting systems, stable soil structure and soil health
Trap nutrients only in shallow depths	Increased nutrient availability and efficiency with deeper roots
Yields consistent depending with consistent inputs	Yields not high but consistent, but overall farm income is higher from diverse sources such as multi-purpose crops.
Greater potential for water runoff and soil erosion	Increased water infiltration and more effective water cycle
Greater potential for carbon loss through tillage and erosion	Greater potential to capture and store carbon
Often grown as mono-crop and loss of soil biota upon tillage	Typically greater biological diversity above and below ground
Increased labor and productive inputs	Reduced labor and inputs
Reduces system flexibility and increases risk to potential crop failures.	Offers flexibility to adopt novel farming systems which can increase diversity, reduce risk and redirect labor to livelihoods

(FAO 2014)

On the other hand, perennial crop production provides for human health. In Myanmar Dry Zone, perennial fruits are mostly unavailable in rural market, and rural people rarely consume fruits that are in high cost. If such crops were grown in their field and back yards, it can be obtained for home consumption, neighbor and within village. If the perennial fruits were grown in commercial production, this can produce for the people who live in near village or town or until nationwide to have fresh fruits and vegetables. As a result, they all can obtain the valuable nutrition of fresh fruits.

2.5 Perennial Crops in Central Dry Zone of Myanmar

Central Dry Zone of Myanmar is a place of longer droughts from the combination of higher temperature and lower rainfall. Conventional perennial cash crops grown in Central Dry Zone were toddy palm, tamarind, mango and jujube. Perennial crops commercially grown in recent years were dragon fruit, guava, cashew nut and custard apple. The general descriptions of the perennial crops commonly grown in Central Dry Zone of Myanmar were described as below.

2.5.1 Toddy palm

Toddy palm is a unique of Dry Zone area and economically valuable for its multi-purpose as almost every part of the tree is useful. Indeed, palm wine and jaggery are the most well-known and famous products of Myanmar Dry Zone.

Toddy palm can be used for various purpose such as sap drunk as a beverage, fermented in palm wine and vinegar, distilled in alcohol, or concentrated in sugar, fruit pulp eaten in desserts or beverage, gelatinous seed eaten (palm seeds), seedling eaten as a starchy vegetable, or in flour bud eaten as palm heart, leaf blades used as writing base for sacred texts, leaves used for thatching roofs, petioles for posts, weaving, fiber from base of leaves, wood and from stem, medicinal (all parts).

Sap of toddy palm is also known as toddy palm juice. It can be divided into two kinds, the sweet toddy juice and the bitter ones. In Myanmar, sweet one is either made into brown sugar called jaggery, or fermented into alcoholic bitter juice. About 40% of jaggery production was employed to produce palm sugar (Khin Si Win 2008).

The central Myanmar region is significant with plenty of toddy palm plants. In fact, toddy palm plants are in a nature of adjusting the eco-system of hot and dry regions which receive least number of rainfalls annually. Number of toddy palm plants in Kyaukpadaung and Nyaung U Townships, Mandalay Region, is larger than other regions. Indeed, local people in these regions are engaged in toddy palm farms as main business.

According to Yadanabon news (2016), Kyaukpadaung and Nyaung U townships annually produce more than 1,000 tons of jaggery, which is 60% of the products across the nation. Nowadays, toddy palm farm owners face shortages of laborers to collect toddy sap. Moreover, some old toddy palm plants were cut down to use firewood in the region. In consequence, the hot and dry zone of Myanmar is losing a lot of toddy palm plants yearly due to climate change impacts.

If there is some subsidy on toddy palm especially modern technology, investment and market share, toddy palm products will be contributed a great deal to development of socio-economic status of the rural people. Manufacturing the quality toddy sap through advanced technology for exportation can lift up the living standard of toddy farmers. Toddy sap-based products are being produced across the world.

2.5.2 Tamarind

Tamarind is commonly grown in the villages of Myanmar especially in the Dry Zone. It is presently cultivated in home gardens, farm lands, on roadsides, and on common lands. Tamarind is economically valuable and multi-purpose in almost every part of the tree has a use, but the tree is best known for its fruit and the marketability of tamarind fruit has increased consistently over the years. It is used in many dishes around the world, and may even have medicinal properties. Tamarind also plays an important role in traditional medicine. Tamarind is high in many nutrients. It contains vitamins, minerals, amino acids and beneficial plant compounds. It also contains a lot of sugar (Jennings *et al.* 2016).

Tamarind is useful in various forms, such as young leaves, green pod, ripe pod, candy, paste and also as wood. Leaves, flowers and immature pods are eaten as vegetables. Tamarind leaf salad is a one of the famous culture of Myanmar Dry Zone. Both green and ripe pods can be used in cooking. Tamarind is widely grown as a subsistence crop for meeting local demands. Rural people can get extra money by pickling and selling young tamarind leaves. Rural people can earn a lot by selling tamarind paste. As a value-added product, tamarind candy making with tamarind pulp and sugar is a famous food of Myanmar Dry Zone. Therefore, it is grown commercially (Siddig *et al*. 2006).

In addition, Tamarind is a useful tree for its delightful shade in the Dry Zone. The woody stem of the tamarind can be used for shelter and firewood. For cropland areas, tamarind tends to a positive effect on soil organic matter and on soil biological properties (Ranaivoson *et al.* 2015).

2.5.3 Mango

Mango is one of the most important and delicious seasonal fruits, and widely cultivated in the tropics and subtropics, and the commercial mango production is reported in more than 87 countries (Tharanathan *et al.* 2007). Currently mango ranked in the fifth of total production (FAO 2016). It is referred to as “the King of fruits” in world market, because of its excellent flavor, attractive fragrance, beautiful shape, delicious taste and nutritive value.

Commercial cultivation of mango crop is very much successful in Southeast Asia including Myanmar. Mango is also a popular fruit and can grow well in various climatic conditions in Myanmar. Mangoes are mainly produced in the areas of Ayeyawady, Bago and Yangon Divisions in the Southern region, Mandalay and Sagaing Divisions in the central region and Southern Shan State in the Eastern region of Myanmar. Although many other local varieties were also grown in the study area, Kyaukpadaung Township, Sein Ta Lone variety is a famous variety (Chia and Wanitprapha 1998). Myanmar is the 6th largest country of mango production in Asia. Cultivation and production of Myanmar mango gradually increases year after year. In 2014-2015, the total planted area for mango was 97,180 hectares and the harvested area was 79,585 hectares with total production of 557,070 metric tons (MOALI 2016). Fresh mangoes are mainly exported to China by border trade and to Singapore by overseas trade.

Mangoes can be utilized in all stages of its development. Mango can be eaten raw as a dessert fruit or processed to various products. Ripe fruits can be sliced and canned or processed to juice, jams, jellies, nectars and preserves. Eastern and Asian cultures use unripe mangos for pickles, chutney and relishes. The timber is used for boats, flooring, furniture and other applications.

2.5.4 Dragon fruits

In the past two decades, dragon fruit has gained popularity among producers, exporters and consumers like in Indonesia, Malaysia, Philippines, Taiwan, Thailand,

and Vietnam where agro-environmental conditions are conductive for growing this fruit plant. Dragon fruit can be grown in both tropical and sub-tropical climate conditions, and it loves light. It can be grown with minimum requirement of water, thus it survives with minimal average annual rainfall. Dragon trees are very sensitive to frost conditions. It can be grown in wide range of soils (Luders and McMahon 2006).

According to Phyo Phyo Win Pe (2011), in Myanmar, dragon fruit plant grows well and it becomes a promising new crop. Dragon fruit have been commercially grown in Popa, Nyaung U, Heho, Naungcho, Aungban, Kyaukme, Nay Pyi Taw, Kyaukpadaung, Pakokku, Meiktila, Taunggyi and Hlegu. In other areas, commercial production has been recently started.

Dragon fruit belongs to a cactus family and it can be grown in everywhere especially in Dry Zone. Dragon fruit is one of the most diseases and pests resistance crop in Central Dry Zone. Therefore, chemical pesticides were rarely used for dragon fruit production. As a consequence, dragon fruit reduced side-effects of chemicals and it can be flexible with climate change.

In addition, it is a fast return perennial crop with production in the second year after planting and reaches full production within 5 years. The fruit is eaten fresh. The frozen pulp can be used to make ice-cream, yogurt, jelly, preserve, marmalade, juice, candy and pastries. The food and cosmetic industries use red dragon fruit as a color ingredient. Flowers and flower buds are used in tea, soup, salads and can be eaten as a vegetable (Gunasena *et al*. 2006).

There are several factors for the popularity of dragon fruit such as (1) high net returns, (2) functional properties because of its high level of antioxidants and (3) emerging export potential to high-value markets in developed countries due to its uniqueness and health benefits. It also shows certain agronomic features that improve its potential as a replacement crop with high commercial value. These characteristics include (1) the relative ease of propagation by cuttings, (2) its relatively low crop maintenance, (3) the short turn-around time between planting and harvesting compared to other tropical fruit trees, (4) its high yield rate and (5) as a perennial crop, with proper care, it can provide a steady income. Therefore, dragon fruits become one of the important crops for rural farmers in Central Dry Zone of Myanmar.

Dragon fruit possesses medicinal properties. The red fleshed varieties are rich in antioxidants. It is known to prevent colon cancer and diabetes. It neutralizes toxic substances such as heavy metals, and reduces cholesterol and high blood pressure. Fruit is rich with vitamin C, phosphorus and calcium and it helps to develop strong bones, teeth and skin. So it is known as a" health fruit" (Gunasena *et al.* 2006).

2.6 Income Diversification

Rural households in many different countries have been found to diversify their income sources allowing them to spread risk and achieve better consumption. This is often necessary in agriculture based peasant economies because of risks such as variability in soil quality, livestock and crop diseases, price shock, unpredictable rainfall and other weather related events. Income diversification with respect to agrarian livelihood is the process of switching from low-value crops (stable food crops) to higher value crops (typically commercial crops), livestock and non-farm activities. Diverse rural income is less vulnerable than undiversified ones (Nelson *et al.* 2016). Improved access to diversification options will allow households to more effectively manage financial risk, leading to more stable incomes.

The main economic incentive for farm diversification is the expected income increase or resource allocation, whereas risk minimization is less relevant. Diversification involves the introduction of an alternative activity to a farm household to generate a novel source of income. It is indicated that the main motivation for income diversification in Schleswig-Holstein is the expectation of higher income after diversification. Non-agricultural activities essentially supplement farm household income and, therefore, are ancillary to the farming component (Ellis 2007).

According to Tasie *et al*. (2012), it is widely agreed that a capability to diversify is beneficial for households at or below the poverty line. Reducing poverty will only become feasible when the livelihoods of the rural poor are improved directly or indirectly and this can be achieved through income diversification.

Ersado (2003) studied that income diversification: welfare implications from urban and rural areas in Zimbabwe. A higher share of nonfarm income amounts to higher diversification and less vulnerability to weather-related shocks, the main risk factor in rural environment where agriculture is the main livelihood. It suggested that households with a more diversified income base are better able to withstand the unfavorable impacts of the financial and weather shocks. The poor are more vulnerable to economic changes. It is suggested that the rich have better access to pursue multiple income sources in rural areas. While in urban areas diversification is driven more by survival than wealth accumulation motives, in rural areas diversification serves as a means of both wealth accumulation as well as shock protection.

Nelson *et al.* (2016) observed that income diversification for reducing rural poverty among farm households in Umuahia north local government area of Abia state in Nigeria. Off-farm activities contribute substantially to the many household income increases. Income diversification with respect to agrarian livelihood is the process of switching from low-value crops (stable food crops) to higher value crops (typically commercial crops), livestock and non-farm activities. High value crops are regarded in terms of value per unit of weight. It is probably more useful to define them as crops that generate high economic return per unit of labor and land such as cassava, cocoa etc.

Pieniadz *et al*. (2009) revealed that non-farm activities contributed substantially to the rural household income. In order to successfully alleviate poverty and raise income level of the rural dwellers, the government should take measure to enhance the level of education of the rural people through sustainable formal and informal education system. This will enhance their receptivity to innovations that will increase their output and earnings.

Khai and Danh (2010) confirmed that income diversification is the dynamic of rural income improvement. Households can increase their income through diversify their activities in both farm and nonfarm. The results show that human capital in both quantity and quality terms play a substantial role in encouraging rural households to diversify their income generating activities. Rural households with higher education level and higher diversification ability tend to have more diverse income sources. Income diversification typically occurs due to instability of income sources and risk-averse behavior of household. The empirical findings often show that poor rural households are more likely to have diverse income sources than richer households.

The welfare of diversified households is better than ones who have only one or a few fundamental income sources. But the diversified household is expected to have more assets, less risk-averse behavior to cope with the high variation in term of price of both commercial crop and foods. Therefore, the poor farmers face more constraints to participate in commercial production due to their liquidity constraints. Thus, farmers who live in more remote areas or sparsely populated areas rely more self-sufficient and less on commercial production. Many empirical evidences in Asia and Latin American show that the fundamental income source of poor household is from agricultural sector, while the non-poor household is more likely to participate in wage-earning and off-farm jobs (Lanjouw and Lanjouw 2001).

Khai and Danh (2010) revealed that determinant of income diversification and its effect on household income in rural Vietnam. The results showed that human capital in both quantity and quality terms play a substantial role in encouraging rural households to diversify their income-generating activities. Rural households with higher education level and higher diversification ability tend to have more diverse income sources. Owning larger sources of physical capital, or better credit accessibility, and social capital also helps rural households improve income diversity. The study results also confirmed that income diversification is the dynamic of rural income improvement. Households can increase their income by diversifying their farm and non-farm activities.

Schwarze and Zeller (2005) reviewed that income diversification of rural households in Central Sulawesi in Indonesia. Differentiating the income sources by poverty groups showed that less-poor households derive 40% of their income from activities outside agriculture whereas it accounts only for 10% of the income of the poorest households. In contrast, it also showed that poor households are already involved in a number of different activities. It showed that poor households tend to have more income sources and a more evenly distribution of the income between these sources.

Mat *et al*. (2012) studied that non-farm income improve the poverty and income inequality among agricultural household in rural Kedah. The result indicated that non-farm income can improve the level of poverty or non-farm income sources contributed towards poverty reduction among agricultural household. It showed that the inclusions of non-farm income into the agricultural household reduce the level, depth and severity of poverty. However, on the other hand, non-farm income increased income inequality among agricultural household in Kedah.

Adebayo (2012) examined determinants of income diversification among farm households in Kaduna State in Nigeria. The significant variables that increased income diversification strategies of farm households were educational level, farm size, membership of cooperatives and non-farm income while farm size decreases the income diversification of households.

2.7 Adaptation Strategies to Climate Change in Agriculture

There are two main types of adaptation, namely, autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or response strategies, often multi-sectorial in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events, considerable efforts would be required to prepare developing countries to deal with climate-related impacts in agriculture (FAO 2007).

The traditional farming systems and cultivation practices are not adapted to these new climatic conditions, which have made the area more vulnerable to the impacts of climate change (NCEA 2010). Adaptation is any change in behavior or capital that an actor (household, firm, or government) makes to reduce the harm or increase the gains from climate change.

Myanmar’s climate is changing and climate variability already affects communities and socioeconomic sectors in the country. Even with significant global climate mitigation (activities and technologies that reduce greenhouse gas emissions), economic sectors, local communities and natural ecosystems in Myanmar will be strongly affected by climate change as a result of the emissions already in the atmosphere. Adaptation is therefore necessary for reducing Myanmar’s vulnerability to climate variability and change (NAPA 2012).

Table 2.2 Adaptation project options ranked in importance for implementation for reducing the vulnerability of the agriculture sector to climate change impacts

AGRICULTURE SECTOR: Adaptation Project Options	Rank
Reduced climate change vulnerability of rural and subsistence farmers through locally relevant technologies, climate-resilient rice varieties, and ex/in-situ conservation of plant genetic resources.	1
Increased climate change resilience of rural and subsistence farmers in the Dry and Hilly Zones through legume crop diversification and climate-resilient varieties.	2
Increasing the climate change resilience of Dry Zone communities by diversifying and intensifying home-gardens through solar-power technology, high-income fruit crops and climate-smart agriculture approaches.	3
Reducing the vulnerability of livelihoods in agro-ecological zones to climate change through the transfer of a wide range of high-yielding and climate-resilient rice varieties.	4
Enhancing the climate change resilience of rural communities in the Coastal and Dry Zone through intensified and diversified cropping systems.	5
Enhancing the resilience of the agriculture sector to climate change impacts through postharvest technologies to ensure grain/feed supplies despite climate change impacts.	6
Strengthening adaptive capacity of agriculture in coastal areas through implementing mixed (crop, livestock and fish) farming systems.	7
Enhancing the resilience of flood-prone agricultural regions to climate change through the introduction of integrated/mixed farming systems for greater food security and improved household nutrition levels.	8
Improving the resilience of the agriculture sector to climate change using organic farming technologies.	9
Enhancing the resilience of rain-fed agriculture in the highlands to climate change impacts using ecosystem-based approaches and climate-smart agriculture.	10

(NAPA 2012)

According to NAPA (2012), the adaptation options have been incorporated into ten Adaptation Project Options for potential implementation in Myanmar. Adaptation Project Options have been ranked in importance (1 = highest priority, 10 = lowest priority) for reducing the vulnerability of the agriculture sector and related communities to climate change impacts.

Mendelsohn and Dinar (1999) stated that large reductions in adverse impacts from climate change are possible when adaptation is fully implemented. Therefore, local level initiatives are important to promote adaptation strategies for climate change. According to Reilly and Schimmelpfennig (1999), major classes of adaptation was defined into: seasonal changes and sowing dates; different variety or species; water supply and irrigation system; other inputs (fertilizer, tillage methods, grain drying, other field operations); new crop varieties; forest fire management, promotion of agroforestry, adaptive management with suitable species and cultural practices.

Lwin Maung Maung Swe (2014) observed that even though the Dry Zone farmers were adapting to climate change using numerous strategies, they were very weak in anticipatory adaptation measures for the possible threats. In the Dry Zone, there was almost no technological support to the farmers in order to be able to adapt to climate change. In addition, the poor extension strategy could not help the technical poor farmers to get the new techniques from the research and technical centers. However, the Dry Zone farmers have been attempting to adapt with increasing barriers for agricultural production by using their own means.

Enete (2014) studied impacts of climate change on agricultural production in Enugu State in Nigeria. He also observed that there were a number of influences that could mitigate the negative effects of climate change on crop production. First, and perhaps most important, was the potential for farming practices to adapt to climate change by planting different climate-adapted species, using pesticides, or altering the dates of planting, harvesting and mitigation. Such adoptions could minimize the impacts of climate change on crop yields.

Ndambiri *et al.* (2008) examined an evaluation of farmers' perceptions of and adaptation to the effects of climate change in Kenya. The most common adaptation strategies among farming households who perceived increases in temperature were: crop diversification, planting different crops, varying land area under cultivation, and migration to a different site. Adaptation methods used by those who perceived extended periods of temperature were: planting different crops, crop diversification, increasing water conservation practices, adjusting the number and management of livestock and changing the size of land under cultivation. With regard to precipitation, most farmers who observed an increase in the frequency of droughts and a decrease in precipitation migrated to new sites and also adjusted the number of livestock and livestock management practices.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Study area

Myanmar Dry Zone covers 13% of the country's total land area in 13 districts or 55 townships of Magway, Mandalay and lower Sagaing Region. Dry Zone is one of the poorest but most densely populated region of Myanmar. In this area, soils are sandy and rainfall is low. Among 55 townships of Dry Zone, Kyaukpadaung and Nyaung U Townships which are located in Nyaung U district of Mandalay region. These townships were selected on the basis of perennial crops cultivation for this research.

Kyaukpadaung Township is situated between North Latitudes from 20˙ 32' to 21˙5' and East Longitude from 95˙ to 95˙ 32' 46", and it is located at 252 meter above sea level. Although Kyaukpadaung was situated in the Dry Zone area, the two selected villages were located in special region (oasis) of the Dry Zone. Popa village is far about 16 km North-East from Kyaukpadaung and located at 366 meter above sea level. Nagale village is far about 32 km North-East from Kyaukpadaung and located at 457 meter above sea level. A map of the Kyaukpadaung Township is shown in Appendix 1.

Nyaung U Township lies in North Latitudes 21° 12′ and East Longitude 94° 55′, and it is located at 252 meter above sea level. It lies on the eastern bank of Ayeyawady River. Nyaung U Township has a typical tropical climate and it is relatively hot and dry throughout the year. A map of the Nyaung U Township is shown in Appendix 2.

3.1.2 Climatic statistics

In Myanmar, there are three seasons: the rainy season (mid-May to mid-October), winter (mid-October to mid-February) and summer (mid- February to mid-May). The rainy season is defined May-June as early monsoon season, July-August as mid monsoon season and September-October as late monsoon season.

In Kyaukpadaung Township, the precipitation was found mainly from May to November. The highest precipitation was found October, and the lowest precipitation was in the months from January to April and in December (Figure 3.1). The average annual rainfall trend from 2007 to 2016 was presented in Figure 3.2. The highest total precipitation was 1214 mm in 2010, and the lowest total precipitation was 551 mm in 2012. The linear of annual rainfall was increased within 2006 to 2015, and the ten year average was 803 mm and in Kyaukpadaung Township.

In Kyaukpadaung Township, the average monthly temperature ranged from minimum of 19°C to maximum 39°C within a year according to the temperature recorded data from 2007 to 2016. The hottest months were April and May, and the coldest were December and January (Figure 3.3). Trends of maximum and minimum temperatures from 2007 to 2016 were illustrated in Figure 3.4, the linear of average maximum was not different, but that of average minimum temperature was decreased. The average maximum temperature and average minimum temperature were 33.9°C and 23.5°C, respectively.

In Nyaung U Township, the precipitation was found mainly from May to November. The highest precipitation was found in October, and the lowest precipitation was in the months from January to April and in December (Figure 3.5). The average annual rainfall trend from 2007 to 2016 was presented in Figure 3.6. From 2007 to 2016, the highest total precipitation was 1024 mm in 2011, and the lowest total precipitation was 343 mm in 2009. The linear of annual rainfall was increased within 10 years, and the average annual rainfall was 679 mm/year in Nyaung U Township.

According to the temperature recorded data from 2006 to 2015, the average monthly temperature ranges from minimum of 19°C to maximum 39°C within a year in Nyaung U Township. The hottest months were April and May, and the coldest were January, February and December (Figure 3.7). Trends of maximum and minimum temperatures from 2006 to 2015 were demonstrated in Figure 3.8. The linear of average maximum temperature was increased within 10 years while that of average minimum temperature was decreased. Therefore, different between maximum and minimum temperature is becoming extreme. From 2007 to 2016, the average maximum temperature and average minimum temperature were 35.1°C and 21.5°C, respectively.

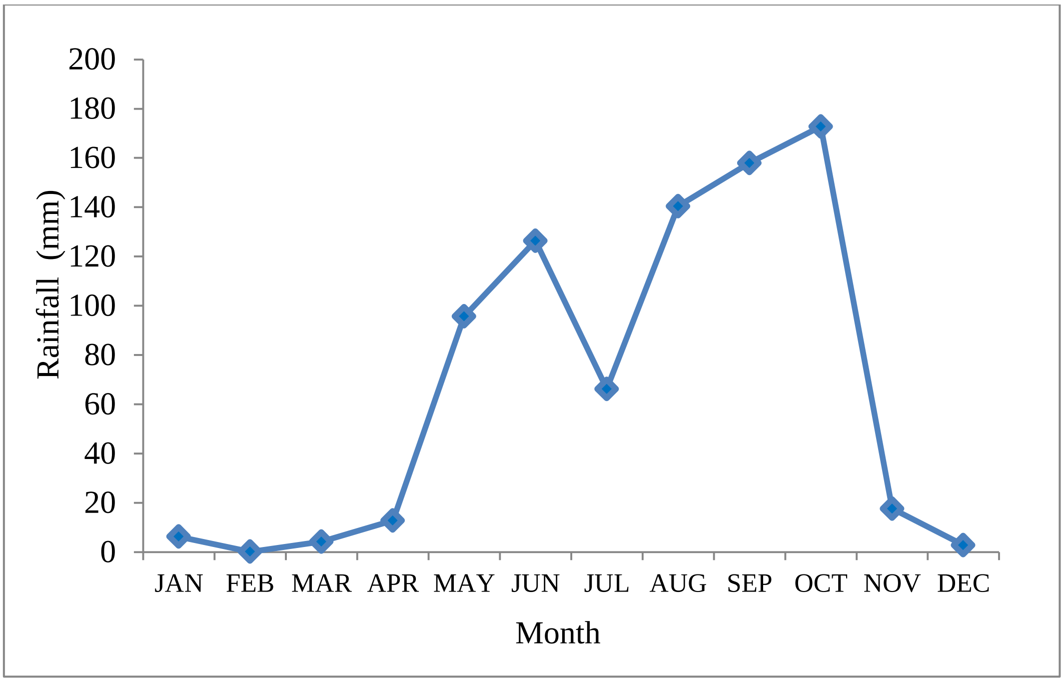

Figure 3.1 Monthly average rainfalls of Kyaukpadaung Township from 2007 to 2016

Source: DoA (2016)

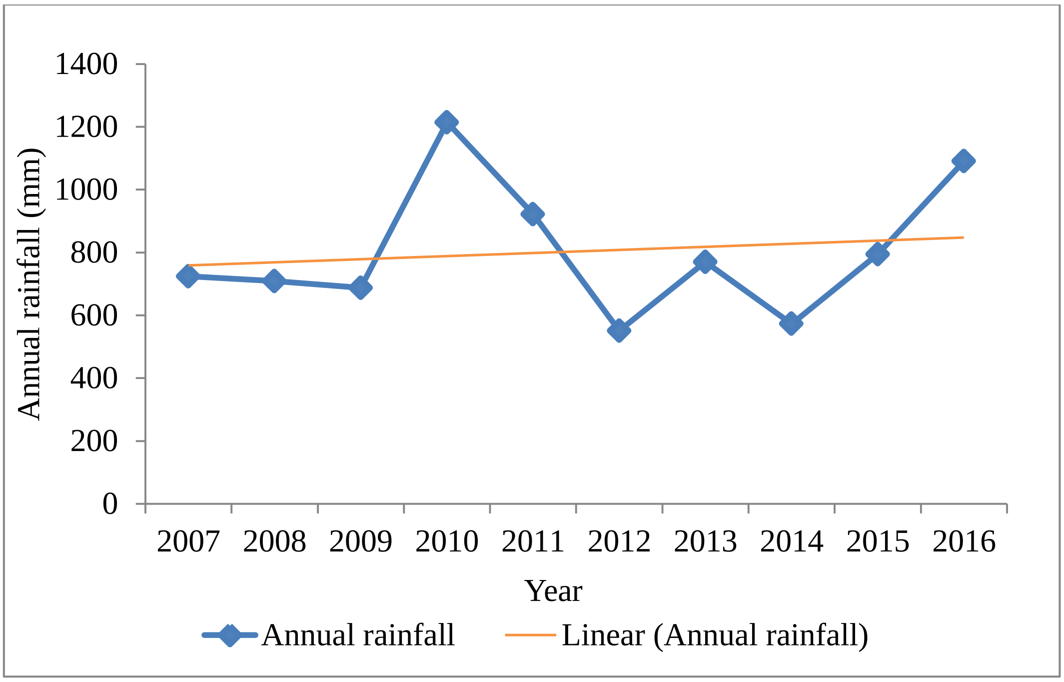

Figure 3.2 Rainfall trends of Kyaukpadaung Township

Source: DoA (2016)

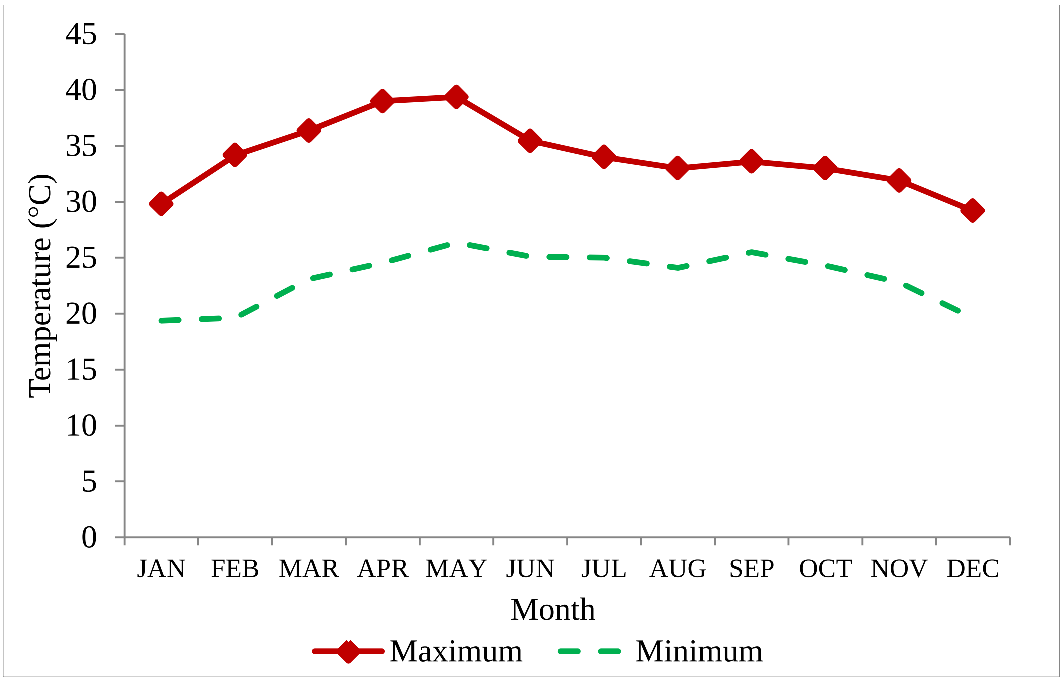

Figure 3.3 Monthly average temperature of Kyaukpadaung Township from 2006 to 2015

Source: DAR (2016)

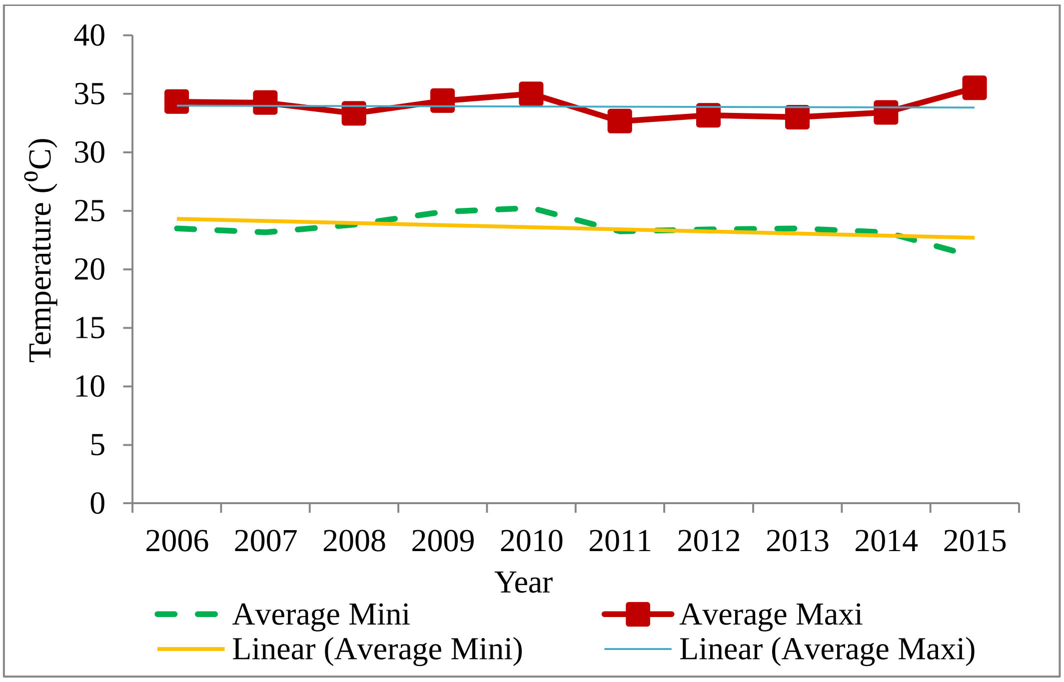

Figure 3.4 Trends of maximum and minimum temperature of Kyaukpadaung Township

Source: DAR (2016)

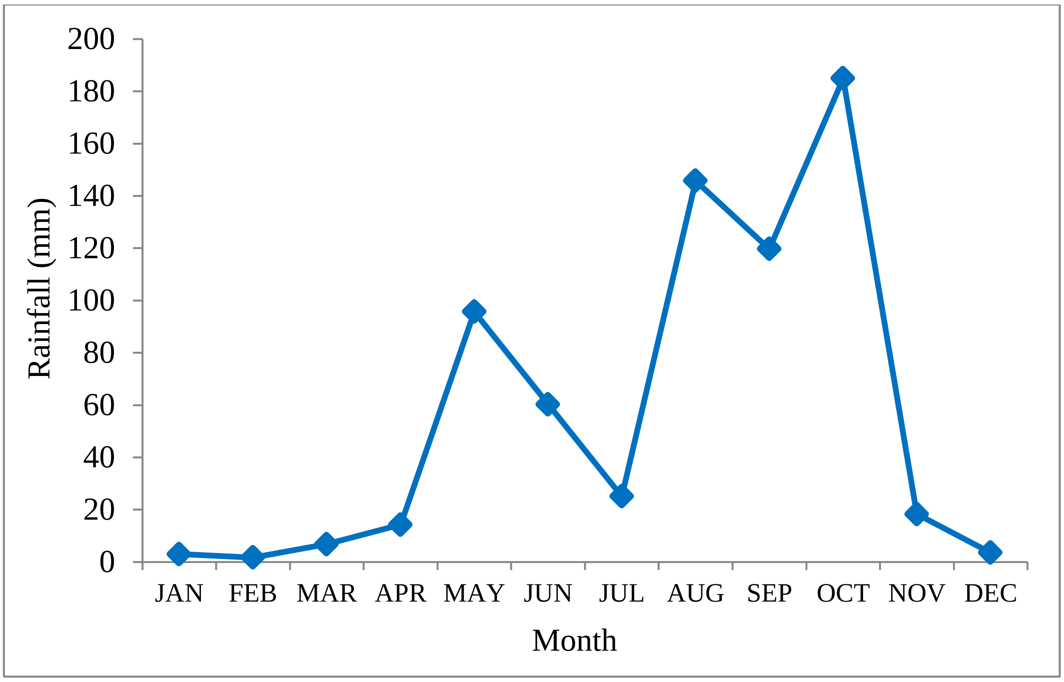

Figure 3.5 Monthly average rainfalls of Nyaung U Township from 2007 to 2016

Source: DoA (2016)

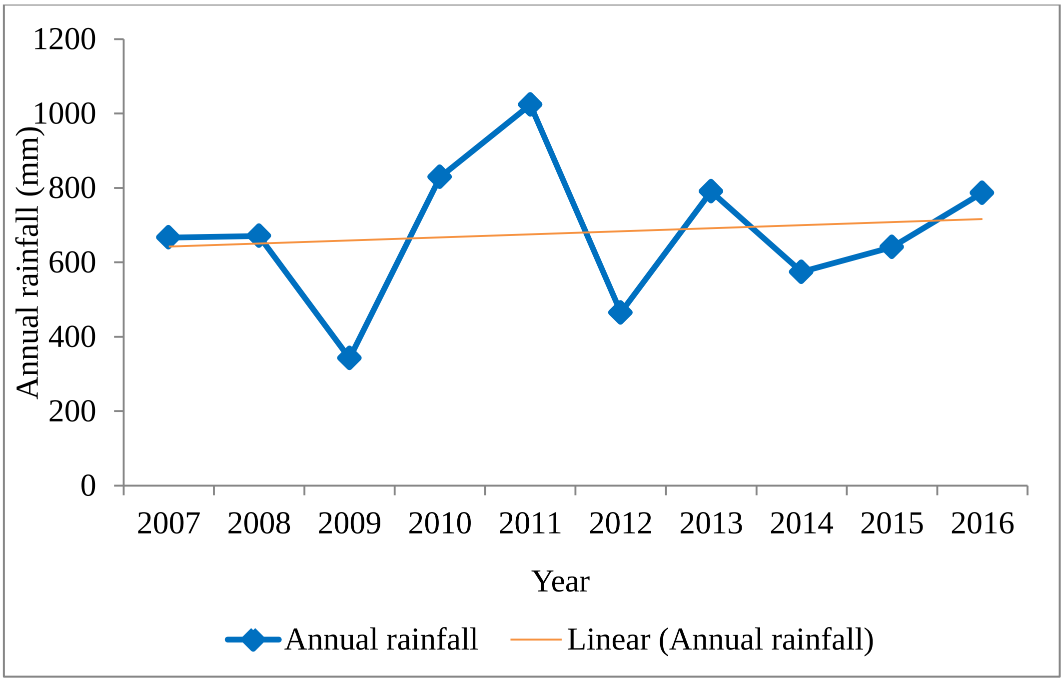

Figure 3.6 Rainfall trends of Nyaung U Township

Source: DoA (2016)

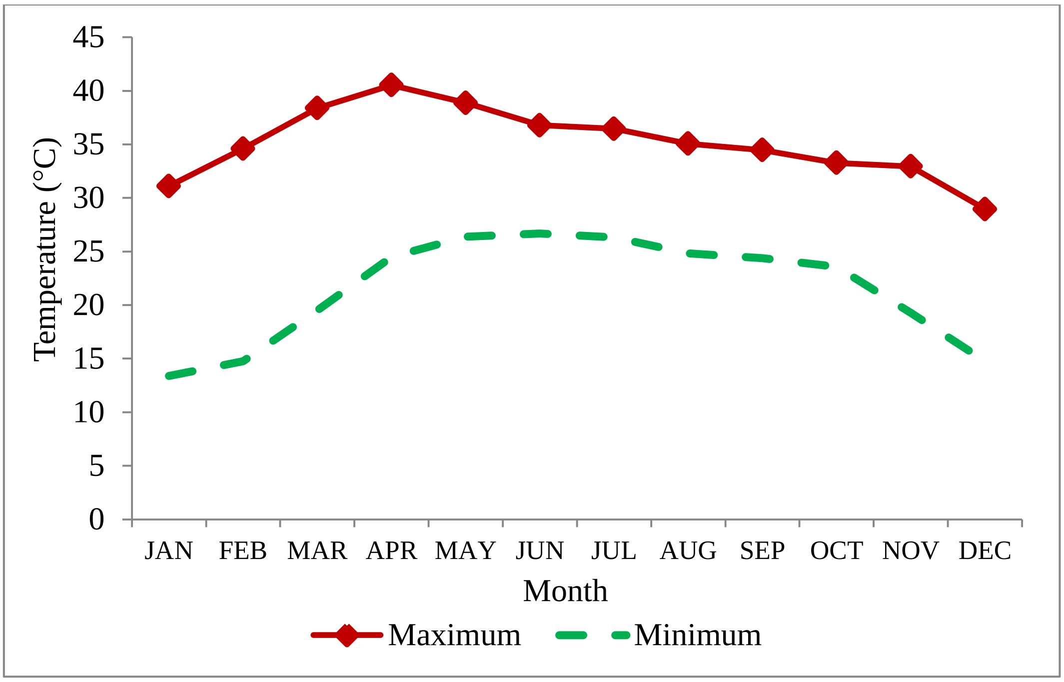

Figure 3.7 Monthly average temperature of Nyaung U Township from 2006 to 2015

Source: DAR (2016)

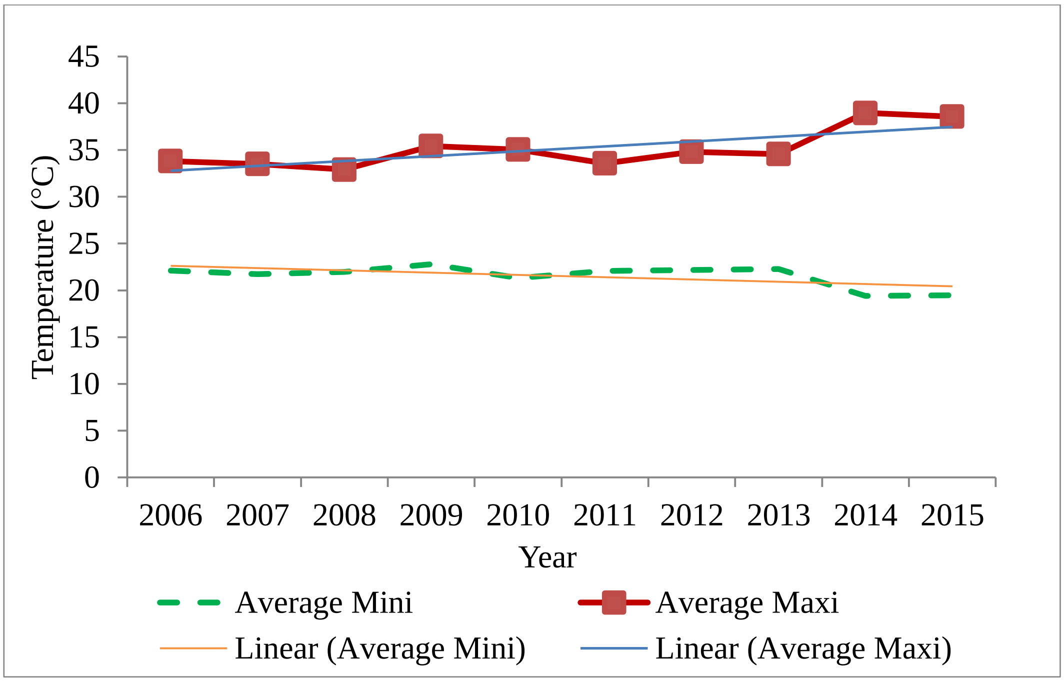

Figure 3.8 Trends of maximum and minimum temperature of Nyaung U Township

Source: DAR (2016)

3.1.3 Land use pattern

Land utilization in Kyaukpadaung Township was illustrated in Figure 3.9. Total land area of Kyaukpadaung Township is 196,494 hectares and agricultural land occupies 105,970 hectares, 53.9% of the total area. Forest area occupies 59,088 hectares, and it is about 30% of the total area. Fallow land occupies 1,536 hectares (0.8%) and 29,901 hectares (around 15%) is others. Agricultural land utilization in Kyaukpadaung Township was presented in Figure 3.10. Among the agricultural land, upland occupies 94,762 hectares (89.4% of agricultural land) and lowland occupies 11,002 hectares (10.4%). The Kai/Kyun land comprises 205 hectares (0.2%).

Land utilization in Nyaung U Township was illustrated in Figure 3.11. Total land area of Nyaung U Township is 148,409 hectares and agricultural land occupies 84,734 hectares, and it is 57.09% of the total area as the largest share. Forest area occupies 24,157 hectares (about 16%), and 5561 hectares (3.75%) is fallow land and 33,956 hectares (nearly 23%) is others. Agricultural land utilization in Nyaung U Township was represented in Figure 3.12. Among the agricultural land, upland occupies 81713 hectares (96% of agricultural land) and lowland occupies 104 hectares (0.1%). The Kai/Kyun land and orchard land comprises 2834 hectares (3.34%) and 83 hectares (0.1%), respectively. The Dry Zone receives limited rain compared to country average, and insufficient rain lead to drought. Therefore, upland occupies the largest portion of the total agricultural land.

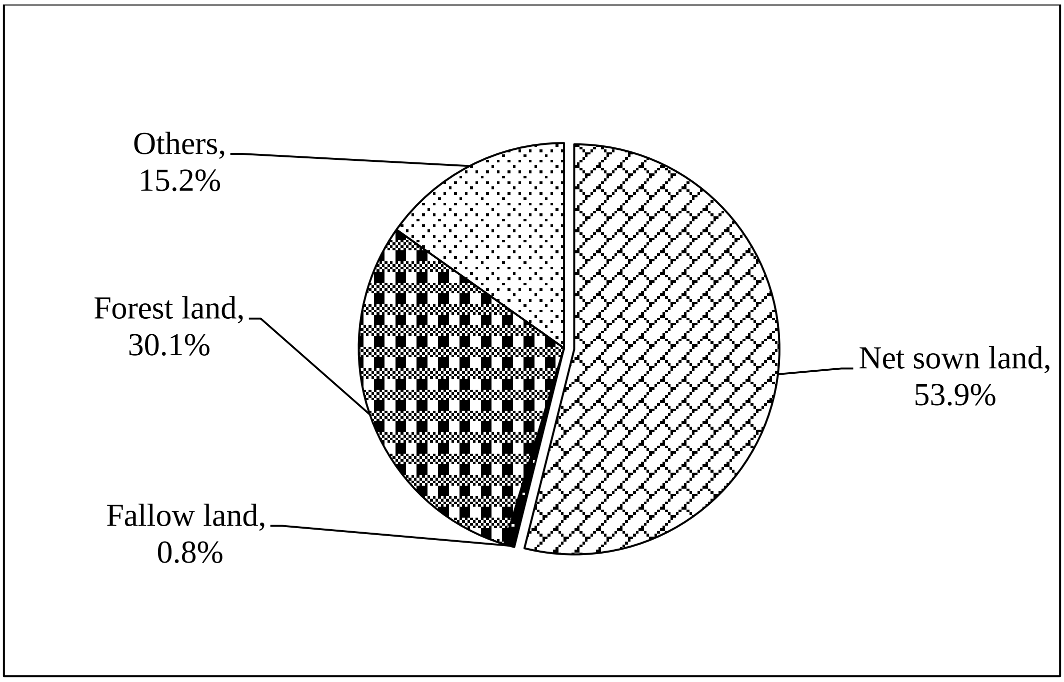

Figure 3.9 Land utilization in Kyaukpadaung Township (2015-2016)

Source: DoA (2016)

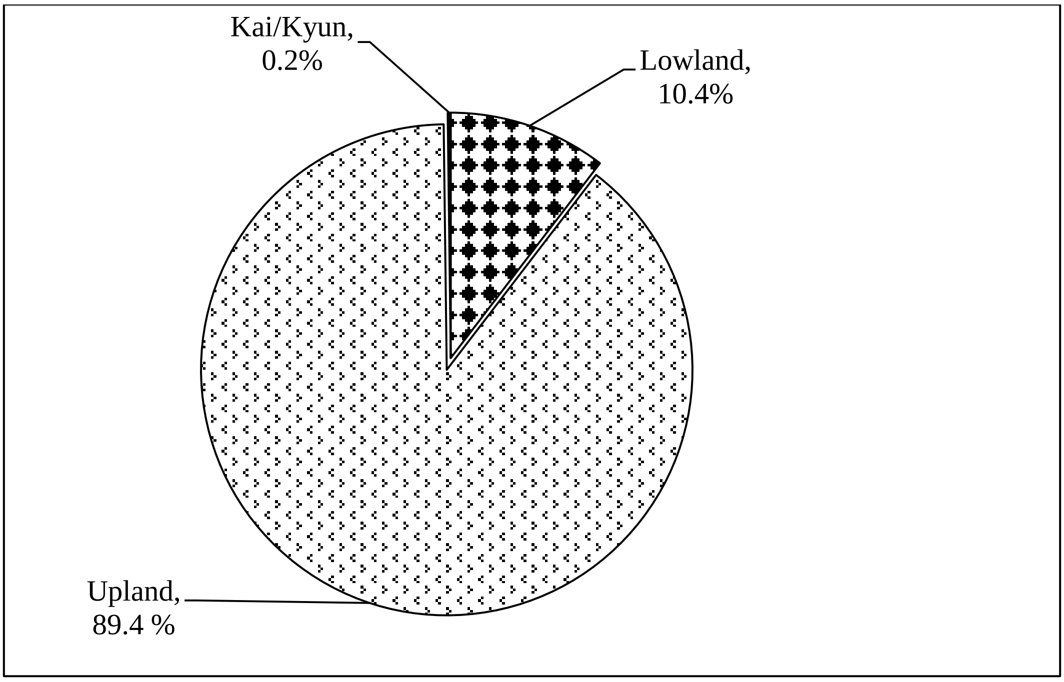

Figure 3.10 Agricultural land utilization in Kyaukpadaung Township (2015-2016)

Source: DoA (2016)

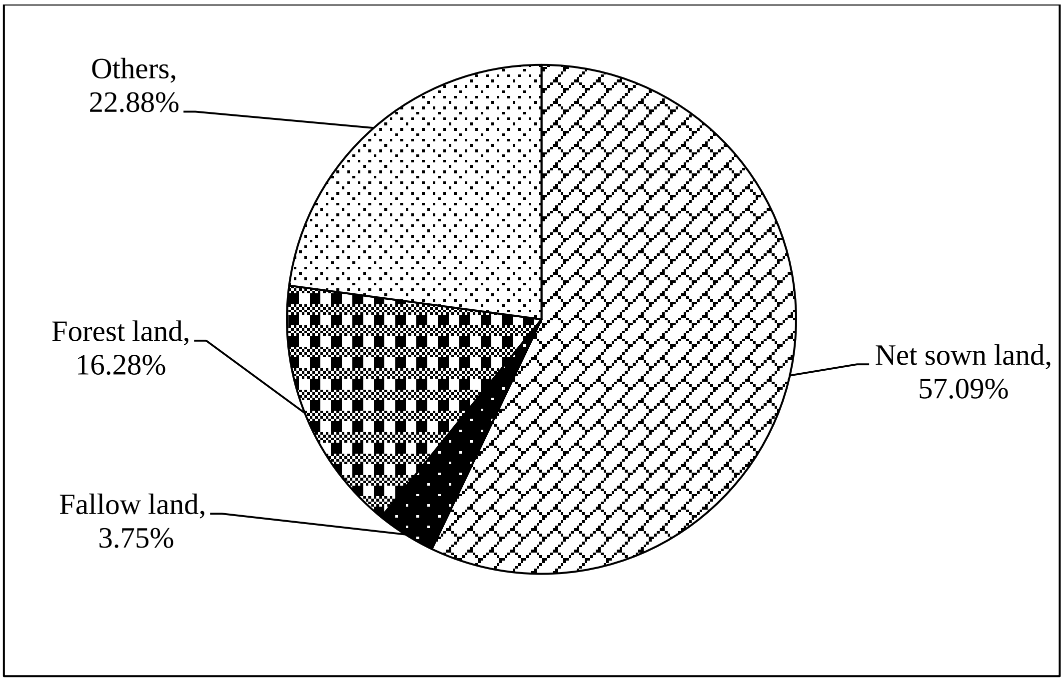

Figure 3.11 Land utilization in Nyaung U Township (2015-2016)

Source: DoA (2016)

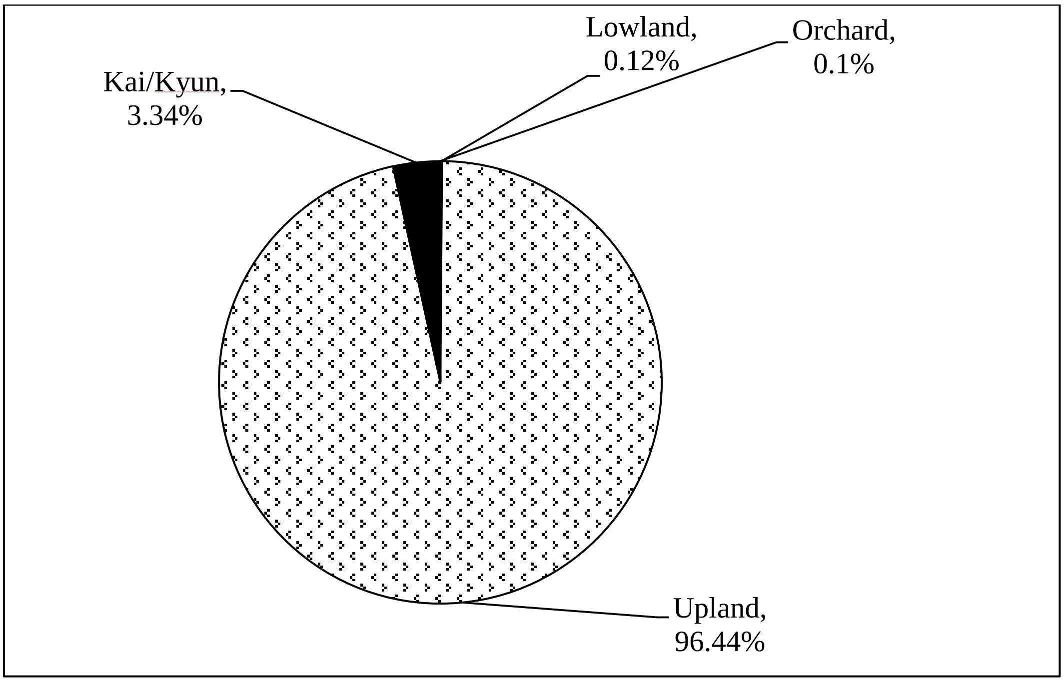

Figure 3.12 Agricultural land utilization in Nyaung U Township (2015-2016)

Source: DoA (2016)

3.2 Data Collection and Sampling Procedure

In this study, both primary and secondary data were used. The primary data were collected by using simple random sampling method. Field survey was conducted in two villages from Kyaukpadaung Township and three villages from Nyaung U Township in November 2016. A total of 200 sample farmers were personally interviewed in which 100 farmers from Kyaukpadaung Township and 100 farmers from Nyaung U Township.

Primary data, both qualitative and quantitative data, such as demographic characteristics of sample farmers, farm production, income and their climate change adaptation strategies were collected by using structured questionnaire sets.

Secondary data were gathered from published and official records of Ministry of Agriculture, Livestock and Irrigation (MOALI), Department of Agriculture (DoA), Department of Agricultural Research (DAR), Department of Planning (DoP), various journal articles, books, thesis and other relevant data sources from internet websites.

3.3 Method of Analysis

Both qualitative and quantitative data were firstly entered into the Microsoft Excel program. These data was analyzed by Statistical Packages for Social Science (SPSS) version 16.0 software. Descriptive statistics, Herfindahl index, multiple regression analysis, enterprise budget, intertemporal budgeting and adaptation strategies index were used to fulfill the research objectives.

3.3.1 Descriptive analysis

Descriptive analysis was used to describe the socio-economic characteristics such as age, farming experience, education level, family size, family labor, farm size, occupation, cropping pattern, crop production and income of the sample households.

In case of household income, income amount earned from each income source was calculated based on the average number of those income earners. Annual total household income was calculated by adding income amount of all income sources.

3.3.2 Herfindahl index method

Herfindahl index (Ogundari 2013) was used to analyze income diversification of rural households in Central Dry Zone of Myanmar.

$$H_D = \sum_{j=1}^{J} \left(\frac{Y_j}{\sum_{j=1}^{J} Y_j} \right)^2 \quad 0 \leq H_D \leq 1$$

Yj = Income share by the j^{th} occupation in total household income Y

J = Total number of occupations

The index ranges from zero to one. In the case of interpretation, index zero reflects complete diversification and index one reflects complete specialization.

3.3.3 Regression analysis

Multiple regression function was used to point out the important role of income from perennial crops in rural household income. In this analysis, annual household income was used as the dependent variable. The independent variables were age of households' head, education level of households' head, family size, total farm size, number of income sources, having perennial crop income, gender of households' head and migration of household member.

$$\text{Ln } Y = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + b_1D_1 + b_2D_2 + b_3D_3 + e$$

Where,

Y	= Annual household income (MMK/year)
X_1	= Age of households' head (Years)
X_2	= Education of household head (Years)
X_3	= Family size (Number)
X_4	= Total farm size (Number)
X_5	= Number of income sources (Number)
D_1	= Perennial crop income (Have = 1, If not = 0)
D_2	= Gender of Household's head (Male = 1, Female = 0)
D_3	= Having migrants among family members (Yes = 1, No = 0)
β and b	= Estimated coefficients
e	= Error term

3.3.4 Cost and return analysis

Enterprise budget was used to examine the profitability of specific farm enterprise and compare the profitability of the major seasonal crops. In this calculation, gross return was the level of production per hectare multiplied by the product price. Total variable cost was the total of all variable inputs into the enterprise, multiplied by their respective prices. An interest rate or cost of capital charged for material inputs was also included in total variables costs. Gross margins were calculated by deducting total variable costs in gross return (Olson 2009). The current variable inputs included seeds, FYM, fertilizers, fuel, pesticides and labor cost. Expressions for estimating returns to various factors were given in Table 3.1.

3.3.5 Intertemporal budgeting for perennial crop (dragon fruit)

Intertemporal budgeting was calculated to point out the important role of income from perennial crops in rural household income to combat climate change impacts. Intertemporal budgets are statements of the physical and financial characteristics of a cropping programme that extend over several years. Net present values could be determined using the rate of time preference as the discount factor. Because of the relatively high investment durable inputs that used in establishing perennial crop farming, method of analyzing intertemporal production situations will often be required. The internal rate of return is that rate of interest used in calculating present values that makes the NPV equal zero (Rae 1982).

$$\mathrm{NPV} = \sum_{t=1}^{T} [\mathrm{CB}_t/(1 + r^t)]$$

$$A = \mathrm{NPV} \times \mathrm{CRF}$$

$$\mathrm{CRF} = [r(1+r)^T]/[(1+r)^T-1]$$

$$\mathrm{IRR} = r_a + \frac{\mathrm{NPV}_a}{\mathrm{NPV}_a - \mathrm{NPV}_b}(r_b - r_a)$$

Where:

NPV	= Net present value	IRR	= Internal rate of interest
CB	= Annual cash balance	r_a	= lower discount rate chosen
r	= Discount rate	r_b	= higher discount rate chosen
t	= Time period	NPV_a	= NPV at r_a
A	= Annuity	NPV_b	= NPV at r_b
CRF	= Capital recovery factor		

Table 3.1 Estimating returns to capital for production of seasonal crops

Factor	Unit	Formula
Return above variable cost	MMK/ha	TR -TVC
Return above variable cash cost	MMK/ha	TR - TVCC
Return per unit of cash cost	MMK	TR/TVCC
Return per unit of capital (BCR)	MMK	TR/TVC
Break-even yield	ton/ha	TVC/Average price per ton
Break-even price	MMK/ton	TVC/Average yield per ha

Where:

TR = Total revenue

TVC = Total variable cost

TVCC = Total variable cash cost

BCR = Benefit-cost ratio

3.3.6 Adaptation strategies scoring method

The climate change adaptation strategies of the respondents were measured on a 4-point Likert scale of a lot (3), fair (2) few (1) and never (0). The weighted average score was determined and used to order the rank. Descriptive statistics such as frequency counts, percentages, and weighted average were used to describe the data (Iyela and Ikwuakam 2015).

$$\text{Weighted Average} = \frac{\text{Sum of Weighted Terms}}{\text{Total Number of Terms}}$$

According to literature and pilot survey, in the study areas, twelve adaptation strategies were selected for this analysis.

1. Expanding perennial crop cultivation
2. Changing cropping pattern
3. Changing crop varieties
4. Adjusting sowing time
5. Crop diversification (growing more than 3 crops)
6. Agro forestry
7. Organic farming
8. Migration of household member
9. Selling out the livestock assets
10. Selling out the land
11. Willingness to migrate, and
12. Willingness to change occupation

On the other hand, the climate change adaptation strategies of the respondents were measured by Yes (1) or No (0). If sample households use the given strategy, it was scored as (1), and if they did not use, it was scored as (0). Likely, the weighted average score was determined and used to order the rank.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Farm Households, Sample Size and Major and Minor Crops Grown in Kyaukpadaung and Nyaung U Townships

Farm households, sample size and major and minor crops grown in Kyaukpadaung and Nyaung U Townships were shown in Table 4.1. In this study, two villages namely Popa and Nagale villages from Kyaukpadaung Township and three villages namely Hta Naung Su, Kaung Pin Si and Shwe Hlaing villages were selected from Nyaung U Township. A total of 100 respondents were interviewed in Kyaukpadaung Township in which 20 respondents from Popa and 80 from Nagale village because total farm population in Nagale was quite bigger than that of Popa. In Nyaung Township, a total of 100 respondents were interviewed in which 20 respondents from Hta Naung Su, 53 from Kaung Pin Si and 27 from Shwe Hlaing. Sample sizes were determined based on farm population.

Major seasonal crops grown were pigeon pea, maize and sunflower in Popa and pigeon pea in Nagale village. Groundnut and pigeon pea were grown in Hta Naung Su, Kaung Pin Si and Shwe Hlaing villages as the major seasonal crops. Major perennial crops grown were dragon fruit, mango and tamarind in Popa village, and banana, custard apple, guava, jackfruit and papaya in Nagale village. Major perennial crop grown was toddy palm in Hta Naung Su and toddy palm and jujube in Kaung Pin Si and Shwe Hlaing villages. Minor seasonal crops were bean, groundnut, onion, sorghum, tomato and winged-bean in Popa while bean, chickpea, maize, onion, rice, sorghum, sunflower and tomato were grown in Nagale. Sesame and tomato, cowpea, maize, millet, sesame and sorghum and cowpea, green gram, maize and sesame were minor seasonal crops grown in Hta Naung Su, Kaung Pin Si and Shwe Hlaing villages, respectively. In Popa village, banana, custard apple, guava, jackfruit and papaya were grown as minor perennial crops whilst cashew nut, coffee, guava, jackfruit and papaya were grown in Nagale village. Minor perennial crops were dragon fruit, jujube, mango, tamarind and thanakha in Hta Naung Su, custard apple, dragon fruit, mango, tamarind and thanakha in Kaung Pin Si, and mango and tamarind in Shwe Hlaing village (Table 4.1).

Table 4.1 Farm households, sample size and major and minor crops grown in the study area

Township	Village	Total Farm HH	Seasonal Crops		Perennial Crops	
			Major	Minor	Major	Minor
Kyaukpadaung	Popa (N=20)	284	Pigeon pea, Maize, Sunflower	Bean, Groundnut, Onion, Sorghum, Tomato, Winged-bean	Dragon fruits, Mango, Tamarind	Banana, Custard apple, Guava, Jackfruit, Papaya
	Nagale (N=80)	855	Pigeon pea	Bean, Chickpea, Maize, Onion, Rice, Sorghum, Sunflower, Tomato	Banana, Custard apple, Dragon fruit, Mango, Tamarind	Cashew nut, Coffee, Guava, Jackfruit, Papaya
Nyaung U	Hta Naung Su (N=20)	170	Groundnut, Pigeon pea	Sesame, Tomato	Toddy Palm	Dragon fruit, Jujube, Mango, Tamarind, Thanakha
	Kaung Pin Si (N=53)	150	Groundnut, Pigeon pea	Cowpea, Maize, Millet, Sesame, Sorghum	Toddy Palm, Jujube	Custard apple, Dragon fruit, Mango, Tamarind, Thanakha
	Shwe Hlaing (N=27)	150	Groundnut, Pigeon pea	Cowpea, Green gram, Maize, Sesame	Toddy Palm, Jujube	Mango, Tamarind

4.2 Demographic Characteristics of Sample Households in Kyaukpadaung Township

The demographic characteristics of sample farmers such as age, farming experience and education of the household head, family size, number of family labor and farm size in Kyaukpadaung Township were described in Table 4.2. The average age of household head in Kyaukpadaung Township was 55.6 years and ranging from 26 to 78 years. Farmers in Kyaukpadaung had 57 years of maximum, 1 year of minimum and 28.4 years of farm experience on average. Farming experiences of farmers play an important role in agricultural production to make correct decision and or to take risk.

Education of the farmers is also an important aspect of learning about modern agriculture, farm management and adoption of new technology and so on. The average schooling year of farmer was 7.2 years. The maximum schooling year was 14, and this means that there were farmers with university education level in Kyaukpadaung Township, but the minimum was 3 years.

In case of family size, the average total family size was 4 persons ranging from 1 to 9 persons. The maximum numbers of family labor was 5, and minimum was only one person with average family labor 2.4. Thus, about half of the family members work on their own farm. Respondents in Kyaukpadaung Township owned the average farm size of 2.4 hectares, the maximum was 8.5 hectares and minimum was 0.2 hectare.

4.3 Demographic Characteristics of Sample Households in Nyaung U Township

The demographic characteristics of sample farmers in Nyaung U Township were described in Table 4.3. The oldest of the sample farmers in Nyaung U Township was 80 years old and the youngest was 28 years with the average age of sample farmers was 55.7 years. Farmers in Nyaung U had 56 years of maximum, 1 year of minimum and 28.1 years of farm experience on average. The average schooling year of farmer was 5.8 years where the maximum schooling year was 13 and the minimum was 3 years.

In case of family size, the average total family size was 4 persons ranging from 1 to 11 persons. The maximum family labor was 5 persons, and minimum was only one person with the average family labor was 2. Thus, about half of the family members work on their own farm. Respondents in Nyaung U Township owned the average farm size of 2.2 hectares where the largest farm size was 8.1 hectares, and the smallest farm size was 0.4 hectare.

4.4 Source of Credit and Migration of Sample Households in Kyaukpadaung and Nyaung U Townships

Source of credit was illustrated in Figure 4.1. The sample households took credit from various sources. In Kyaukpadaung Township, respondents took credit from Myanmar Agricultural Development Bank (MADB), Cooperatives, United Nations Development Program (UNDP) and The United Nations International Children's Emergency Fund (UNICEF). MADB lend only 20,000MMK per acre for upland crops and, only 2% of respondents took the credit from MADB in Kyaukpadaung Township. In addition, 16%, 15% and 3% of respondents took credit from cooperatives, UNDP and INUCEF, respectively. In Nyaung U Township, 40% of respondents took credit from MADB. Moreover, 14% and 15% of respondents took credit from Cooperatives and UNDP, respectively. Around 8% of respondents took credit from other credit source such as money lender, relative and friends.

Migration was one of the important aspects of their household income. The migration of the respondents was illustrated in Figure 4.2. Most migrants stayed within Myanmar mainly in Yangon, Mandalay, and also stayed in Nay Pyi Taw, Kyaukse, Meiktila, Myingyan, Taunggyi, Lashio and Tachileik. Some migrants went outside Myanmar such as Malaysia, Thailand, Korea and Japan. In Kyaukpadaung Township, there was 25% migrant in which internal migrant and cross border migrant were 18% and 7%, respectively. In Nyaung U Township, there was 39% migrant in which internal migrant were 36% and cross border migrant were 3%.

Table 4.2 Demographic characteristics of sample farmers in Kyaukpadaung Township in 2016 (N=100)

Items	Unit	Mean	Max.	Min.	SD
Age of HH's head	year	55.6	78	26	10.60
Farming experience of HH's head	year	28.4	57	1	12.62
Education of HH's head	year	7.2	14	3	3.39
Family size	No.	4.4	9	1	1.77
Family labor	No.	2.4	5	1	0.95
Farm size	ha	2.4	8.5	0.2	1.86

Table 4.3 Demographic characteristics of sample farmers in Nyaung U Township in 2016 (N=100)

Items	Unit	Mean	Max.	Min.	SD
Age of HH's head	year	55.7	80	28	13.88
Farming experience of HH's head	year	28.1	56	1	16.72
Education of HH's head	year	5.8	13	3	2.67
Family size	No.	4.4	11	1	1.76
Family labor	No.	2.0	5	1	0.9
Farm size	ha	2.2	8.1	0.4	1.81

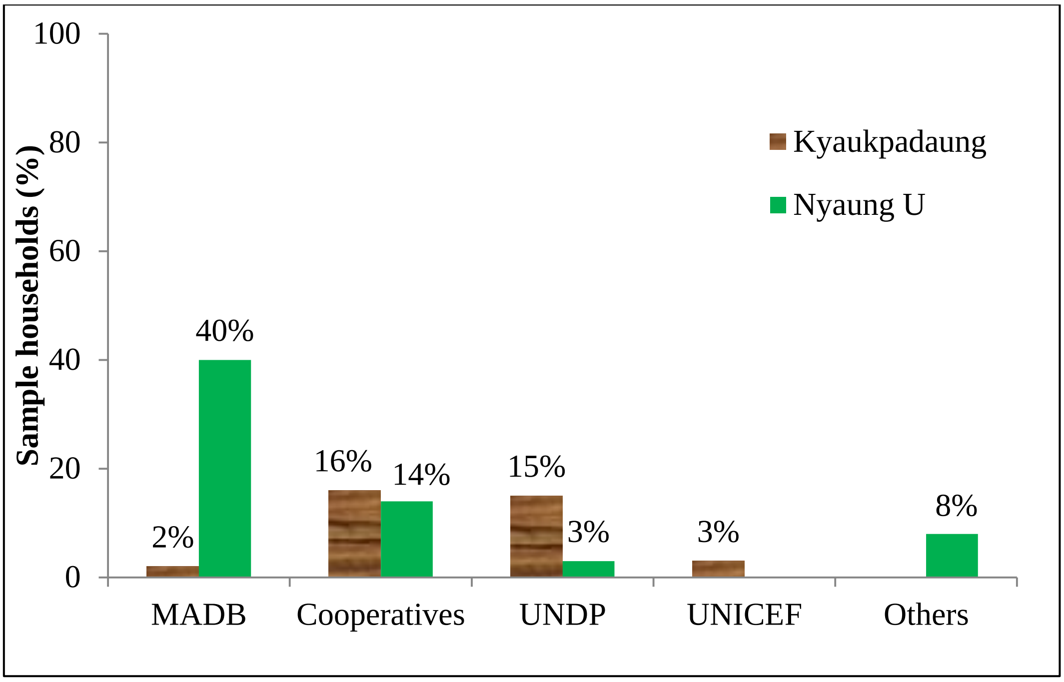

Figure 4.1 Source of credit received by percentage of sample households in 2016

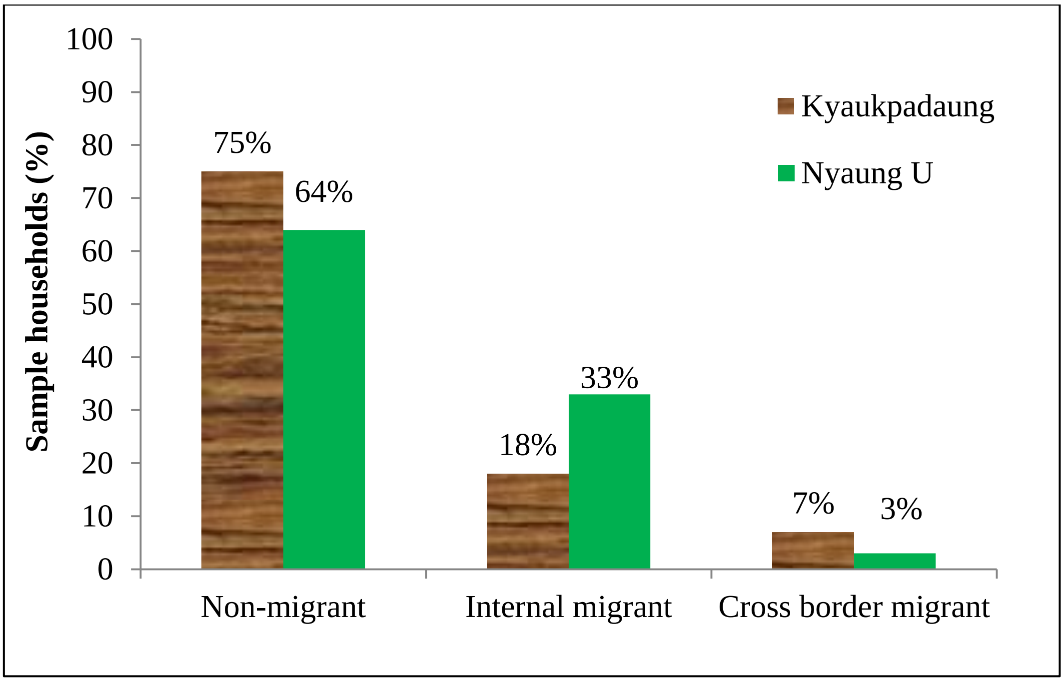

Figure 4.2 Migrant family members of sample households in Kyaukpadaung and Nyaung U Townships in 2016

4.5 Opinions of Respondents for the Most Vulnerable Social Group to Climate Change Impacts in Kyaukpadaung and Nyaung U Townships

To determine the vulnerable social groups due to climate change in the study areas, the question about health problems caused by climate change was included in the field survey. In this study, social groups were categorized into six groups such as elders, only wife, only husband, both husband and wife, children and all family members. In all social groups, respondents of the Nyaung U Township were more vulnerable to climate change than that of Kyaukpadaung Township, except both husband and wife group. In Kyaukpadaung Township, in 21% of sample households, old people were most vulnerable to climate change, and in 10% of the respondents, all family members were vulnerable to climate change. Husband, children and wife were also vulnerable social groups to climate change impacts accounts for 9%, 7% and 6%, respectively. In Nyaung U Township, old people, wife and husband were the most vulnerable to climate change impacts accounts for 27%, 19% and 15%, respectively. About 3% of the sample household responded both husband and wife of the family were vulnerable to climatic impacts in Kyaukpadaung Township, and only 1 % responded that in Nyaung U Township. In both townships, old people are more vulnerable than children and all other social groups (Figure 4.3).

4.6 Occupation Diversification of Sample Households

The types of occupation of the sample households in the Kyaukpadaung and Nyaung U Townships were seasonal crop cultivation, perennial crop cultivation, livestock rearing, farm labor, palm climber, non-farm wage labor, casual, tailor, hairdresser, self-employment, driver, mason, carpenter, shopkeeper, vendor, broker, government staff, salary earner and services. Occupational status of the sample households in the study areas was shown in Figure 4.4.

In Kyaukpadaung Township, among the sample households, the largest group (40%) had two occupations, and followed by 29% of the sample households who had three occupations. In Nyaung U Township, respondents who had three occupations was the largest group and occupied by 45%, and it followed by the respondents having two occupations (36%). In Kyaukpadaung Township, 25% of the sample households had only one occupation, and 6% had more than three occupations. In Nyaung U, 11% and 8% of respondents had only one occupation and more than three occupations, respectively.

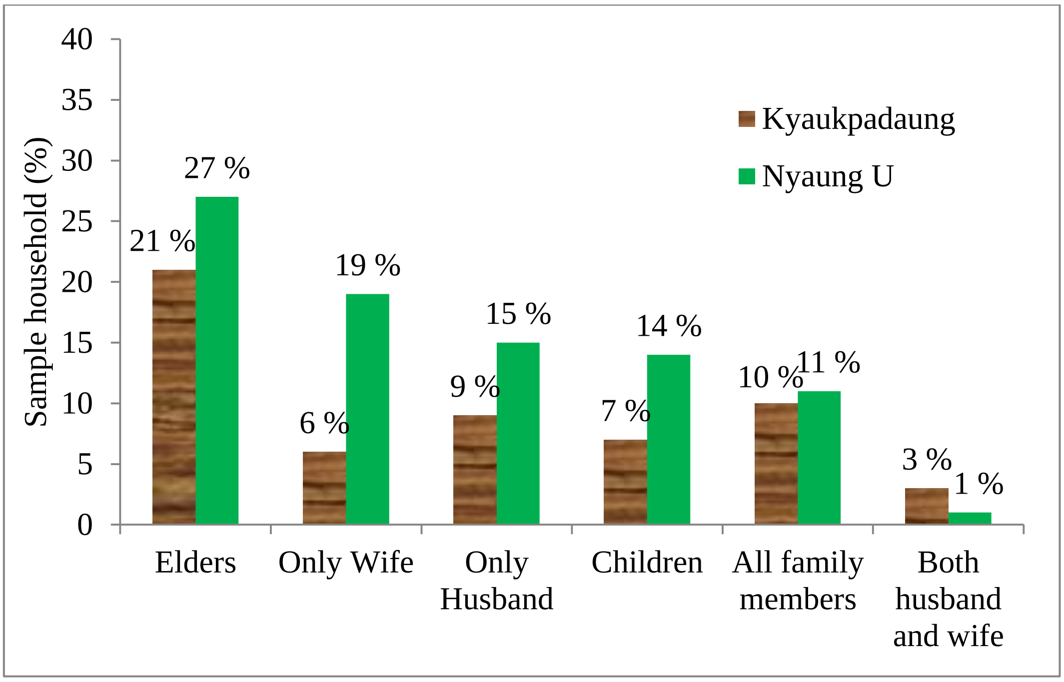

Figure 4.3 Opinions of respondents for the most vulnerable social group to climate change in Kyaukpadaung and Nyaung U Townships in 2016

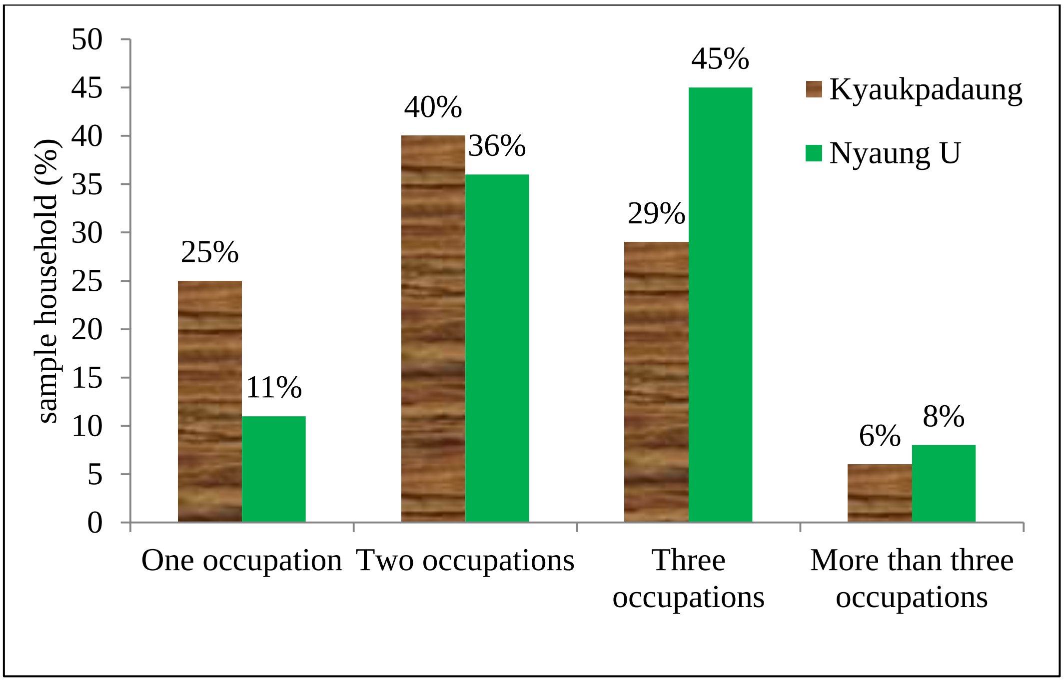

Figure 4.4 Occupation diversification of sample households in Kyaukpadaung and Nyaung U Townships in 2016

4.7 Income Composition of Sample Households

Amount of income earned by sample households in Kyaukpadaung Township was shown in Table 4.4. Annual household income was categorized into seven groups; perennial crop income, seasonal crop income, non-farm income, remittance, salary income, farm labor income and livestock income. Among the sample farmers, 83% of respondents had perennial crop income, and the average annual income of perennial crops was 2.9 million MMK per household per year. Seasonal crops were grown by 58% of respondents and its average income was 1.02 million MMK per household per year. There were 35% non-farm income earners and average amount was 1.3 million MMK per year. In addition, the average income of the respondents earned from remittance, salary, farm labor and livestock rearing amounted to 1.4 million MMK, 2.1 million MMK, 70,000 MMK and 0.4 million MMK, respectively.

Amount of income earned by sample households in Nyaung U Township was shown in Table 4.5. In Nyaung U Township, majority of sample households relied on seasonal crop production. Among the sample farmers, 83% of respondents had seasonal crop income, and the average annual income of seasonal crops was 0.7 million MMK per household. Perennial crops were grown by 75% of respondents and its average income was 1.2 million MMK per household per year. There were 50% of non-farm income earners and average amount was 1.6 million MMK per year. Salary income was the highest amount of income per year (3.3 million MMK), however, only 12% of respondents had salary income. In addition, the average income of the respondents earned from remittance, farm labor and livestock amounted to 1.7 million MMK, 0.6 million MMK and 0.2 million MMK per household, respectively.

The maximum total income of Nyaung U Township (2.6 million MMK) was higher than that of Kyaukpadaung Township (2.2 million MMK). However, was higher than that of Nyaung U Township amounted to 3.3 million MMK. The minimum total income of Kyaukpadaung was 0.5 million MMK while that of Nyaung U was 0.2 million MMK.

Table 4.4 Average amount of income for sample households in Kyaukpadaung Township in 2016 ('000 MMK/year)

Types of Income	% of HH	Mean	Max.	Min.	SD
Perennial crop income	83	2,901	13,250	60	2,992
Seasonal crop income	58	1,027	8,902	75	1,374
Non-farm income	35	1,343	3,960	100	1,011
Remittance	23	1,458	4,920	200	1,152
Salary income	17	2,138	5,940	960	1,128
Farm labor income	5	70	150	20	54
Livestock income	4	425	500	350	106
Total Income		4,347	22,152	540	3,596

Table 4.5 Average amount of income for sample households in Nyaung U Township in 2016 ('000 MMK/year)

Types of Income	% of HH	Mean	Max.	Min.	SD
Seasonal crop income	83	728	6,300	80	997
Perennial crop income	63	1,226	6,152	42	1,269
Non-farm income	50	1,654	24,000	120	3,413
Remittance	32	1,703	8,000	200	2,042
Farm labor income	21	636	1,800	35	554
Salary income	12	3,381	6,960	1,800	1,991
Livestock income	2	250	300	200	70
Total Income		3,440	26,868	202	3,369

4.8 Income Sources and their Share for Sample Households

Household income was derived from seven main sources; perennial crop production, seasonal crop production, non-farm jobs, remittance, salary jobs, farm labor and livestock rearing. Non-farm income involved income from working as broker, tailor, mason, carpenter, shopkeeper, hair-dresser, self-employment, driver, wage labor and casual labor. Salary income included income from employing government staff, private company staff and staff in small or medium enterprise. Livestock income was income from renting or sale of products from cow, pigs, goat and poultry.

Income sources and their share for sample households in Kyaukpadaung Township were illustrated in Figure 4.5 (a). In the sample households, the main income source was perennial crop income which contributed 57.4% of the household income. About 14.2% and 11.2% of the household income earned from seasonal crop production and non-farm jobs, respectively. In addition, salary income was about 8.7% of household income and remittance was about 8% of the household income. Only about 0.4 % and 0.1% of the household income were livestock income and farm labor income.

Income sources and their share for sample households in Nyaung U Township were demonstrated in Figure 4.5(b). The main income source was perennial crop income which contributed 26.9% of the household income. About 24.2% and 17.1% of the household income earned from non-farm jobs and seasonal crop production respectively. Remittance contributed about 15.9% of the household income, and salary income contributed about 11.9% of household income. Only about 3.9% and 0.1% of the household income were earned from livestock rearing and working on other farm.

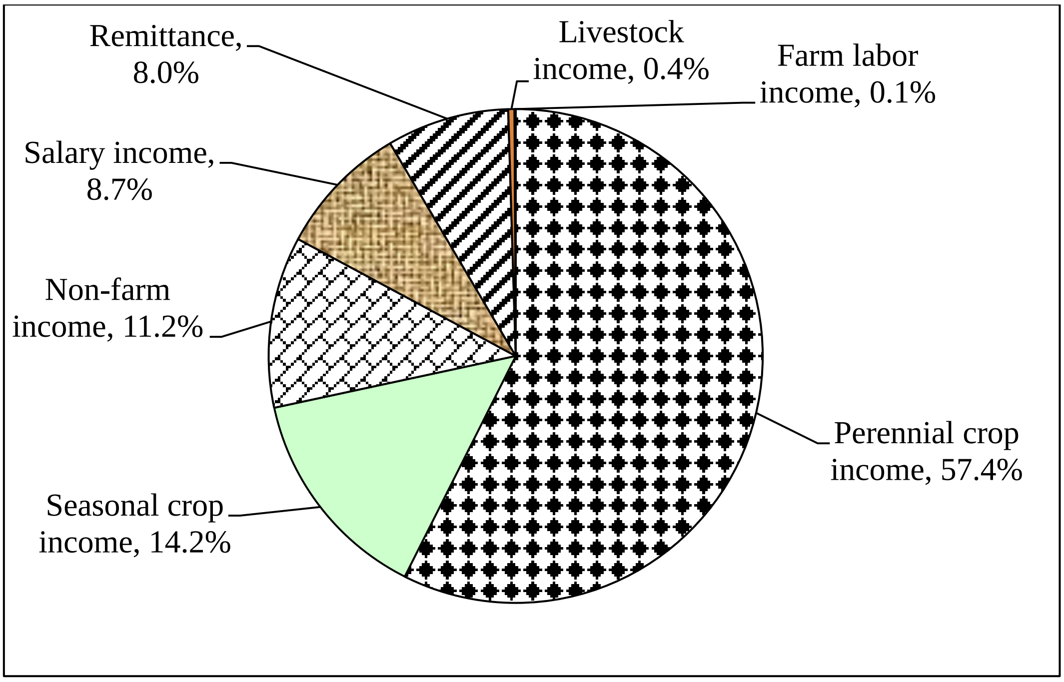

Figure 4.5 (a) Income sources and their share for sample households in Kyaukpadaung Township

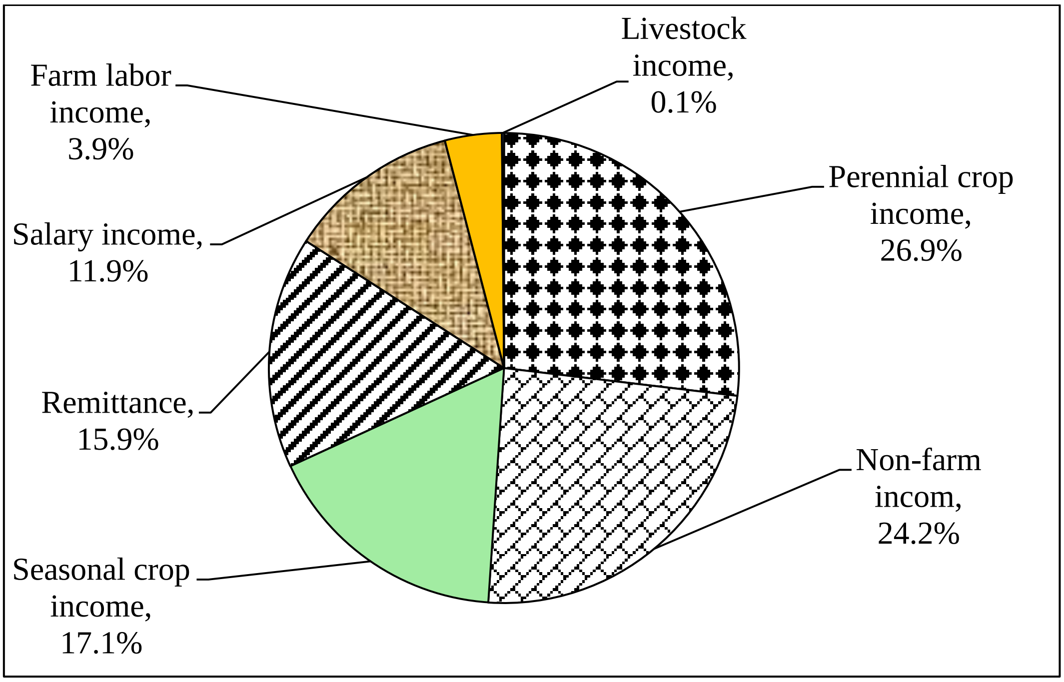

Figure 4.5 (b) Income sources and their share for sample households in Nyaung U Township

4.9 Income Diversification of Sample Households

Income diversification of sample households was shown in Table 3. Herfindahl index was used to determine income diversification of the respondents. Index ranges from zero to one; zero reflects complete diversification, and one reflects complete specialization. Sample households were categorized into three groups, high diversification (index range from 0 to 0.35), moderate diversification (index range from 0.36 to 0.7), and low diversification (index range from 0.71 to 1) group.

According to Herfindahl index method, 13% of the sample households had highly diversified income. The largest group of the respondents (46%) was within the index range of 0.36 to 0.7, and therefore, they had moderately diversified income. Moreover, 41% of the sample households had low income diversification with the index range of 0.71 to 1. The average Herfindahl index in Kyaukpadaung Township was 0.65, and maximum and minimum indices were 1 and 0.27, respectively.

In Nyaung U Township, 10% of the sample households were within the index range of 0 to 0.35, and that means they had highly diversified income. The largest group of the respondents (61%), and therefore they had moderately diversified income. In addition, 29% of the sample households had low income diversification with the index range of 0.71 to 1. The average Herfindahl index in Nyaung U Township was 0.59 and ranged from 0.23 to 1.

While 46% of respondents in Kyaukpadaung Township had moderately diversified income, 61% of respondents had moderately diversified income in Nyaung U Township. In Kyaukpadaung Township, 41% of respondents had low income diversification, but in Nyaung U Township, only 29% had low diversified income. Therefore, respondents in Nyaung U Township had higher income diversification than that in Kyaukpadaung Township.

Table 4.6 Distribution of Herfindahl index for income diversification in Kyaukpadaung and Nyaung U Townships

Herfindahl index	Kyaukpadaung (N=100)	Nyaung U (N=100)
Highly diversified income (0.0 - 0.35)	13	10
Moderately diversified income (0.36 - 0.7)	46	61
Low diversified income (0.71 - 1.0)	41	29
Average	0.65	0.59
Maximum	1.00	1.00
Minimum	0.27	0.23
SD	0.24	0.21

4.10 Factors Affecting Average Annual Household Income

Selected factors for Household's income were considered as independent variables in the model and their descriptive statistics were presented in Table 4.7. Factors affecting average annual household income were presented in Table 4.8. To identify the factor affecting average annual household income, nine independent variables such as age of household's head, education of household's head, number of family labor, total farm size, number of income sources, presence of perennial crop income (yes/no), gender of household's head and presence of migration (yes/no).

The result from the analysis shows that there was a strong positive relationship between the average annual household income and total farm size and number of income sources, which statistically significant at 1% level in Kyaukpadaung Township. This indicated that one percent increases in farm size and number of income sources expressing the average annual household income was expected to be increased by 0.43% and 0.58%, respectively. Having of perennial crop income significantly influenced on average annual household income at 5% and thus, if the household had perennial crop income, the average annual household income will increase significantly by 0.42%. Households earned high income from perennial crops because perennial crops cultivation could give high profit. Migration influenced on average annual household income at 10% significant level, and if the household had migrant labor, the average annual household income will be increased significantly by 0.29%. Number of family labor was negatively related to average annual household income. If most of the family members work only on their farm, the average annual household income will be decreased by 0.07%, but it was not significant.

According to the results of analysis in Nyaung U Township, there was a strong positive relationship between the average annual household income and number of income sources and perennial crop income, and it was statistically significant at 1% level. This indicated that 1% increases in number of income sources expressing the average annual household income was expected to be increased by 0.79%. In the household having perennial crop income, the average annual household income will increase significantly by 0.82%. Migration influenced on average annual household income at 10% significant level, and if the household had migrant labor, the average annual household income will be increased significantly by 0.29%.

In the result of regression analysis of both townships, total farm size, number of income sources and having perennial crop income were significantly influenced on average annual household income at 1% level. This means one percent increases in farm size, number of income sources and having perennial crop income expressing the average annual household income was expected to be increased by 0.18%, 0.58% and 0.79%, respectively. Migration influenced on average annual household income at 10% significant level, and if the household had migrant labor, the average annual household income will be increased significantly by 0.22%.

4.11 Cost and Return of Selected Major Crops

The enterprise budget was calculated for pigeon pea and groundnut in the study area. The gross revenue was computed by multiplying the yield and selling price of each crop. The variable cash cost included materials cost and labor cost which including family labor cost. The material cost included the cost of seed, farm yard manure, fertilizers, foliar and pesticides. The study was considered the interest on cash cost and it was valued at the 10% interest rate.

The enterprise budget of pigeon pea and groundnut was shown in Table 4.9. The yield of pigeon pea was 0.5 ton/ha, and that of groundnut was 0.9 ton/ha. The total gross revenue of pigeon pea (660,637 MMK/ha) was higher than that of groundnut (605,446 MMK/ha) although total variable cost of pigeon pea (419,185 MMK/ha) was lower than that of groundnut (569,325). The variable cash cost of pigeon pea was 277,915 MMK/ha and that was much lower than that of groundnut (407,383 MMK/ha). The gross margin in pigeon pea production was 241,452 MMK/ha, but gross margin of groundnut was 36,120 MMK/ha.

The break-even yield and the break-even price of pigeon pea were 0.32 ton/ha and 838,369 MMK/ton respectively. The return above variable cash cost of pigeon pea was 382,722 MMK/ha, and return per unit of cash cost was 2.38. The break-even yield and the break-even price of groundnut were 0.81 ton/ha and 632,584 MMK/ton respectively. The return above variable cash cost of groundnut was 198,062 MMK/ha, and return per unit of cash cost was 1.49. The return per unit of capital or benefit cost ratio (BCR) of pigeon pea was 1.58 while that of groundnut was 1.06. Therefore, pigeon pea production was more profitable than groundnut production.

Table 4.7 Descriptive statistics of dependent and independent variables of annual households income function in Kyaukpadaung and Nyaung U Townships

Description of variables	Unit	Kyaukpadaung		Nyaung U		Both township	
		Mean	SD	Mean	SD	Mean	SD
Dependent variable							
Annual household income	Million MMK	4.35	3.60	3.39	3.37	3.99	4.15
Independent variables							
Age of HH's Head	year	55.6	10.6	55.7	13.8	55.7	12.0
Education of HH's Head	year	7.2	3.4	5.8	2.7	6.5	3.1
No. of family labor	No.	2.4	1.0	2.0	0.9	2.2	0.9
Total farm size	ha	2.4	1.9	2.2	1.8	2.2	4.5
No. of income source	No.	2.2	0.9	2.5	0.9	2.4	0.9
Perennial crop income	Dummy						
Yes = 1	%	83		63		73	
No = 0	%	17		37		27	
Gender of HH's Head	Dummy						
Male = 1	%	91		83		87	
Female = 0	%	9		17		13	
Having migrant HH members	Dummy						
Yes = 1	%	25		39		32	
No = 0	%	75		61		68	

Table 4.8 Income function of the sample households in Kyaukpadaung and Nyaung U Townships

Independent Variables	Kyaukpadaung (N=100)		Nyaung U (N=100)		Both Townships (N=200)	
	B	t-value	B	t-value	B	t-value
Constant	12.124***	7.204	13.505***	7.673	12.287***	10.028
Age of HH's head	0.202ns	0.524	-0.097ns	-0.246	0.139ns	0.498
Education of HH's head	0.210ns	1.127	0.071ns	0.314	0.216ns	1.501
No. of family labor	-0.067ns	-0.334	-0.235ns	-1.241	-0.058ns	-0.426
Total farm size	0.432***	4.225	0.054ns	0.649	0.186***	2.986
No. of income source	0.584***	3.692	0.794***	3.467	0.581***	4.386
Dummy of having perennial crop income	0.420**	2.027	0.829***	4.060	0.799***	5.737
Gender of HH's head	0.259ns	0.853	0.056ns	0.220	0.262ns	1.378
Having migrant HH member	0.288*	1.769	0.296*	1.685	0.225*	1.857
R square	0.420		0.351		0.332	
Adjusted R square	0.368		0.294		0.304	
Durbin-Watson	1.990		2.177		2.095	

Note: Dependent variable = Annual household income

B= Unstandardized coefficient

HH=Household

***, ** and * are significant at 1%, 5% and 10% level respectively and ns = not significant

Table 4.9 Costs and returns of selected major crops in the study area

Item	Unit	Pigeon pea (N=108)	Groundnut (N=61)
Yield	ton/ha	0.5	0.9
Gross revenue	MMK/ha	660,637	605,446
Total variable cost	MMK/ha	419,185	569,325
Total variable cash cost	MMK/ha	277,915	407,383
Gross margin	MMK/ha	241,452	36,120
Return above variable cash cost	MMK/ha	382,722	198,062
Break-even yield	ton/ha	0.32	0.81
Break-even price	MMK/ton	838,369	632,584
Return per unit of cash cost	MMK	2.38	1.49
Return per unit of capital	MMK	1.58	1.06

Note: Interest rate 10% pa.

4.12 Intertemporal Budgeting for Dragon fruits

Among the perennial crop grown in the study area, dragon fruit was the most popular and the most profitable crop, and thus dragon fruit was selected to compute intertemporal budgeting in this study. The life period of dragon fruit production varied from fifteen to twenty years. In this study, the intertemporal budgeting was calculated based on fifteen years production. The intertemporal budgeting for dragon fruit was shown in Table 4.10.

The initial capital expense for establishing a hectare of dragon fruit was 20.3 million MMK. The revenue was continuously increased for three years, and it was assumed that the revenue was stable three years after sowing. Revenue obtained in the first year was 2.1 million MMK per hectare. The revenue increased to 31.7 million MMK per hectare in the second year production. From the third year to fifteen year revenue was 53.4 million MMK per hectare each year. The other expense included labor cost, transportation cost, pesticides, fertilizers and harvesting cost.

The variable cost was about 9.4 million MMK per hectare each year. The net present value was 249.8 million MMK per hectare. Annuity per hectare was 32.7 million MMK per hectare and annuity per plant was 9700 MMK. In this case, it was assumed that number of plants per hectare was 3364 plants. The internal rate of return was 78.8%. This means that dragon fruit production can be profitable until 78.8% of interest rate. If the NPV remain constant within 15 years, farmers earn 78.8% of profit from investment in dragon fruit production.

Table 4.10 Intertemporal budgeting for dragon fruit in the study area ('000 MMK/ha) (N=50)

Year	Revenue	Capital Expenses	Other expenses	Cash balance	Discount factor (10%)	PV for net revenue
0		20,316				(20,316)
1	2,116		9,457	(7,341)	0.9091	(6,674)
2	31,753		9,457	22,295	0.8264	18,425
3	53,478		9,457	44,020	0.7513	33,072
4	53,478		9,457	44,020	0.6830	30,066
5	53,478		9,457	44,020	0.6209	27,332
6	53,478		9,457	44,020	0.5645	24,849
7	53,478		9,457	44,020	0.5132	22,591
8	53,478		9,457	44,020	0.4665	20,535
9	53,478		9,457	44,020	0.4241	18,669
10	53,478		9,457	44,020	0.3855	16,970
11	53,478		9,457	44,020	0.3505	15,429
12	53,478		9,457	44,020	0.3186	14,025
13	53,478		9,457	44,020	0.2897	12,752
14	53,478		9,457	44,020	0.2633	11,590
15	53,478		9,457	44,020	0.2394	10,538
	Sum					**249,853**
	CRF					**0.131**
	Annuity per hectare					**32,731**
	Annuity per plant					**9.7**
	IRR (%)					**78.8**

Assumption: Number of plants per hectare = 3364 plants

4.13 Adaptation Strategies for Climate Change used by Sample Households

Distribution of respondents on adaptation strategies for climate change in Kyaukpadaung Township and Nyaung U Township was shown in Table 4.11 and Table 4.12, respectively. By using four-point scale method, the weighted average score for adaptation strategy was determined and used to order the rank. In Kyaukpadaung Township, as it was expected, weighted average score of expanding perennial crop cultivation was the highest, and it ranked the first strategy that farmers used to adapt with climate change impacts. Changing cropping pattern, changing crop varieties and crop diversification were in the 2^{nd}, 3^{rd} and 4^{th} because these farming practices were easy to follow by farmers to adapt with climate change. Those were followed by practicing agro-forestry and adjusting sowing time in the 5^{th} and 6^{th} rank. Migration of the household member ranked in 7^{th} in Kyaukpadaung Township, but in Nyaung U Township, migration ranked in 3^{rd} strategy.

In Nyaung U Township, changing cropping pattern was the first adaptation strategy and followed by expanding perennial crop cultivation. Migration was followed by changing crop varieties and crop diversification and ranked in the 4^{th} and 5^{th}. Those were followed by willingness to change occupation and selling out of livestock assets in the 6^{th} and 7^{th} rank.

In Kyaukpadaung Township, climate change adaptation strategies of willingness to change occupation, willingness to migrate and selling out of the livestock assets ranked in 8^{th}, 9^{th} and 10^{th} respectively. However, in Nyaung U Township, willingness to migrate, adjusting sowing time and agro forestry ranked in 8^{th}, 9^{th} and 10^{th}, respectively. In both townships, organic farming and selling out the land were the last two choices of farmers to adapt with climate change impact and ranked in 11^{th} and 12^{th}, respectively. Organic farming was rarely used in the study areas and farmers rarely sold out their land.

Table 4.11 Distribution of respondents on climate change adaptation strategies in Kyaukpadaung Township by using four-point scale method (N=100)

Adaptation Strategies	Never	A Few	Fair	A Lot	Weighted average	Rank
	0	1	2	3		
Expanding perennial crop cultivation	32	16	17	35	1.55	1st
Changing cropping pattern	69	10	3	18	0.70	2nd
Changing crop varieties	62	22	3	13	0.67	3rd
Crop diversification	59	32	1	8	0.58	4th
Agro forestry	86	3	2	9	0.34	5th
Adjusting sowing time	83	11	3	3	0.26	6th
Migration of household member	83	12	3	2	0.24	7th
Willingness to change occupation	83	12	4	1	0.23	8th
Willingness to migrate	86	11	2	1	0.18	9th
Selling out the livestock assets	97	2	1	0	0.04	10th
Organic farming	98	1	1	0	0.03	11th
Selling out the land	98	2	0	0	0.02	12th

Table 4.12 Distribution of respondents on climate change adaptation strategies in Nyaung U Township by using four-point scale method (N=100)

Adaptation Strategies	Never	A Few	Fair	A Lot	Weighted average	Rank
	0	1	2	3		
Changing cropping pattern	58	27	12	3	0.59	1st
Expanding perennial crop cultivation	67	20	7	6	0.51	2nd
Migration of household member	67	17	14	2	0.50	3rd
Changing crop varieties	67	19	13	1	0.48	4th
Crop diversification	86	7	4	3	0.24	5th
Willingness to change occupation	85	10	4	1	0.21	6th
Selling out the livestock assets	90	6	1	3	0.17	7th
Willingness to migrate	88	8	4	0	0.16	8th
Adjusting sowing time	91	4	4	1	0.15	9th
Agro forestry	93	1	5	1	0.14	10th
Organic farming	97	2	0	1	0.05	11th
Selling out the land	99	1	0	0	0.01	12th

Table 4.13 Distribution of respondents on climate change adaptation strategies in Kyaukpadaung Township (N=100)

Adaptation Strategies	Yes 1	No 0	Weighted average	Rank
Expanding perennial crop cultivation	68	32	0.68	1st
Crop diversification	41	59	0.41	2nd
Changing crop varieties	38	62	0.38	3rd
Changing cropping pattern	31	69	0.31	4th
Adjusting sowing time	17	83	0.17	5th
Migration of household member	17	83	0.17	6th
Willingness to change occupation	17	83	0.17	7th
Agro forestry	14	86	0.14	8th
Willingness to migrate	14	86	0.14	9th
Selling out the livestock assets	3	97	0.03	10th
Organic farming	2	98	0.02	11th
Selling out the land	2	98	0.02	12th

Table 4.14 Distribution of respondents on climate change adaptation strategies in Nyaung U Township (N=100)

Adaptation Strategies	Yes 1	No 0	Weighted average	Rank
Changing cropping pattern	42	58	0.42	1st
Expanding perennial crop cultivation	33	67	0.33	2nd
Migration of household member	33	67	0.33	3rd
Changing crop varieties	33	67	0.33	4th
Willingness to change occupation	15	86	0.15	5th
Crop diversification	14	85	0.14	6th
Willingness to migrate	12	90	0.12	7th
Selling out the livestock assets	10	88	0.10	8th
Adjusting sowing time	9	91	0.09	9th
Agro forestry	7	93	0.07	10th
Organic farming	3	97	0.03	11th
Selling out the land	1	99	0.01	12th

In four point scale method, the quantity of a few, fair and a lot scale were not specifically defined. Therefore, two point scale method was also used to be sure and scale of a few (1), fair (2) and a lot (3) were combined into yes (1). Distribution of respondents on climate change adaptation strategies with two point scale method in Kyaukpadaung Township and Nyaung U Township were shown in Table 4.13 and Table 4.14, respectively. By using two-point scale method, the weighted average score for adaptation strategy was determined and used to order the rank. In Kyaukpadaung Township, like the four point scale method, weighted average score of expanding perennial crop cultivation was the highest, and it ranked in 1st strategy. In Nyaung U Township, changing cropping pattern was the first coping strategy and it was followed by expanding perennial crop cultivation. In both townships, like the result of four point scale method, organic farming and selling out of their land were the last strategy followed by farmers to adapt with climate change impact. The results of two point scale method were slightly different from that of four point scale method.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings and Conclusion

Major seasonal crops grown were pigeon pea, maize amd sunflower in Kyaukpadaung Township and groundnut and pigeon pea in Nyaung U Township. Major perennial crops grown were banana, custard apple, dragon fruit, mango and tamarind in Kyaukpadaung Township. Toddy palm and jujube were major perennial crops in Nyaung U Township. Therefore, respondents in Kyaukpadaung Township have higher crop diversification.

In case of demographic characteristics of sample households, the average age of household head was around 56 years old, average farming experience was around 28 years, average family size was about 4 persons and average family labor was about 2 persons in both Kyaukpadaung and Nyaung U Townships. The schooling years of household head in Kyaukpadaung was 7.2 years and it was higher than that of Nyaung U Township (5.8 years). The average farm size were 2.4 hectares and 2.2 hectares in Kyaukpadaung and Nyaung U Township respectively. There was not much differnt demographic characters of respondents in Kyaukpadaung and Nyaung U Township, however, sample farmers in former were more educated than in latter. Therefore, respondents in Kyaukpadaung could be able to earn higher income than in Nyaung U.

In Kyaukpadaung Township, there was 25% migrant in which internal migrant and cross border migrant were 18% and 7%, respectively. In Nyaung U Township, there was 39% migrant in which internal migrant were 36% and cross border migrant were 3%. According to opinion of respondents for the most vulnerable social group to climate change impacts, old people were the most vulnerable group and it was 21 % and 27% in Kyaukpadaung and Nyaung U Township, respectively. Old people were susceptible and already suffered age-related health problems. The changing climate brings heightened vulnerability to environmental risks for them, and They are more vulnerable to the effects of temperature extremes.

In Kyaukpadaung Township, 40% of the respondents, the largest group, had two occupations, but 25% had only one occupation. Among the sample farmers, 83% of respondents had perennial crops income, and the average annual income earned from perennial crops was 2.5 million MMK per household. The main income source of the sample households was perennial crop income which contributed 58% of the household income. The annual average total income of sample households amounted to 4.5 million MMK.

In Nyaung U Township, 45% of respondents had three occupations while 11% had only one occupation. Among the sample farmers, 75% of total farmers had perennial crop income, and the average annual household income was 1.2 million MMK. In addition, 26.9% of the household income earned from perennial crop production. Although 83% had seasonal crop income, the average annual income earned from that was only about 0.7 million MMK per household. The highest amount of annual income (3.3 million MMK) earned from salary jobs, however, only 12% of respondents had salary income. The annual average total household income amounted to 3.3 million MMK.

According to Herfindahl index, majority of sample households had moderately diversified income. The average Herfindahl index was 0.65 and 0.59 in Kyaukpadaung and Nyaung U Township respectively. Based on the index value, respondents in Nyaung U Township had higher income diversification than in Kyaukpadaung Township.

Generally, high income diversification leads to high household income. However, if households do not have a good income source, they have to do all available casual works. In this study, respondents in Nyaung U do not have good income source while respondents in Kyaukpadaung earned good and more or less stable income from perennial crop cultivation. Therefore, although respondents in Nyaung U had higher income diversification than Kyaukpadaung, respondents in Kyaukpadaung earned more annual household income. If the households have diverse income sources, they will be more able to combat with climate change impacts.

According to income function analysis, in Kyaukpadaung Township, total farm size and number of income sources were positively and significantly influenced on annual household income at 1% level. In addition, perennial crop income and migration were positively and significantly influenced on annual household income at 5% and 10% level respectively. In Nyaung U Township, number of income sources and perennial crop income were positively related to annual household income at 1%

significant level. Migration was positively related to annual household income at 10% significant level.

In selected villages of Kyaukpadaung Township, almost all sample farmers grow perennial cash crops in their upland area. Therefore, farmers who had more farm size earned higher annual household income. In Nyaung U Township, majority of farmers grow seasonal crop in their upland area, thus farm size is not significantly influenced on annual household income. In the same township with same job opportunities, the more the number of income lead to the higher the annual household income. Therefore, households who have more number of income sources earned higher household income in both townships. In addition, households having perennial crop income earn higher annual household income in both townships. Moreover, households with migrant household member earn more annual household income because they receive a lot of remittance money from the migrant.

In cost and return analysis of seasonal crop, the total gross revenue of pigeon pea (660,637 MMK/ha) was higher than that of groundnut (605,446 MMK/ha) although total variable cost of pigeon pea (419,185 MMK/ha) was lower than that of groundnut (569,325 MMK/ha). The benefit cost ratio (BCR) of pigeon pea and groundnut was 1.58 and 1.06, respectively. Therefore, pigeon pea production was more profitable than groundnut production.

In dragon fruit production, the initial capital expense for establishing a hectare of dragon fruit was 20.3 million MMK. Annuity per hectare was 32.7 million MMK per hectare and annuity per plant was 9,700 MMK. The internal rate of return (IRR) for dragon fruit was 78.8%. This means that dragon fruit production can stand up to 78.8% of interest rate. If the NPV remain constant within 15 years, farmers earn 78.8% of profit from dragon fruit. Therefore, dragon fruit production was more profitable than pigeon pea and groundnut production.

Adaptation strategies for climate change impact used by sample households were computed in this study. In Kyaukpadaung Township, weighted average score of expanding perennial crop cultivation was the highest and ranked as the first strategy used by farmers to adapt with climate change impacts. Farming practices such as changing cropping pattern, changing crop varieties and crop diversification ranked in 2^{nd}, 3^{rd} and 4^{th} strategy respectively because farming practices were easier to follow by farmers than other strategies. In Nyaung U Township, changing cropping pattern was the first adaptation strategy and followed by expanding perennial crop cultivation as the second strategy. Organic farming and selling out of their farm land were the last two choices of farmers to adapt with climate change impact, thus ranked in 11th and 12th respectively.

5.2 Recommendation

In order to raise income level of the rural households for combating climate change impact, perennial crop income is vital and it would be enhanced. Share of non-farm income was very low that non-farm job opportunities would be created in order to increase income diversification in the villages. If farmers earn a lot from high income non-farm job, they will be able to bear risk and uncertainty and it may reduce migration, consequently.

According to BCR results, pigeon pea cultivation will give higher benefit to farmers. Some research and knowledge sharing would be done to increase the profit from groundnut production. Dragon fruit was the most profitable crop and its production would be increased. According to the adaptation strategies result, advanced technologies for cropping systems such as cropping pattern, changing crop varieties and crop diversification that farmer commonly used to adapt with climate change would be provided by extension services.

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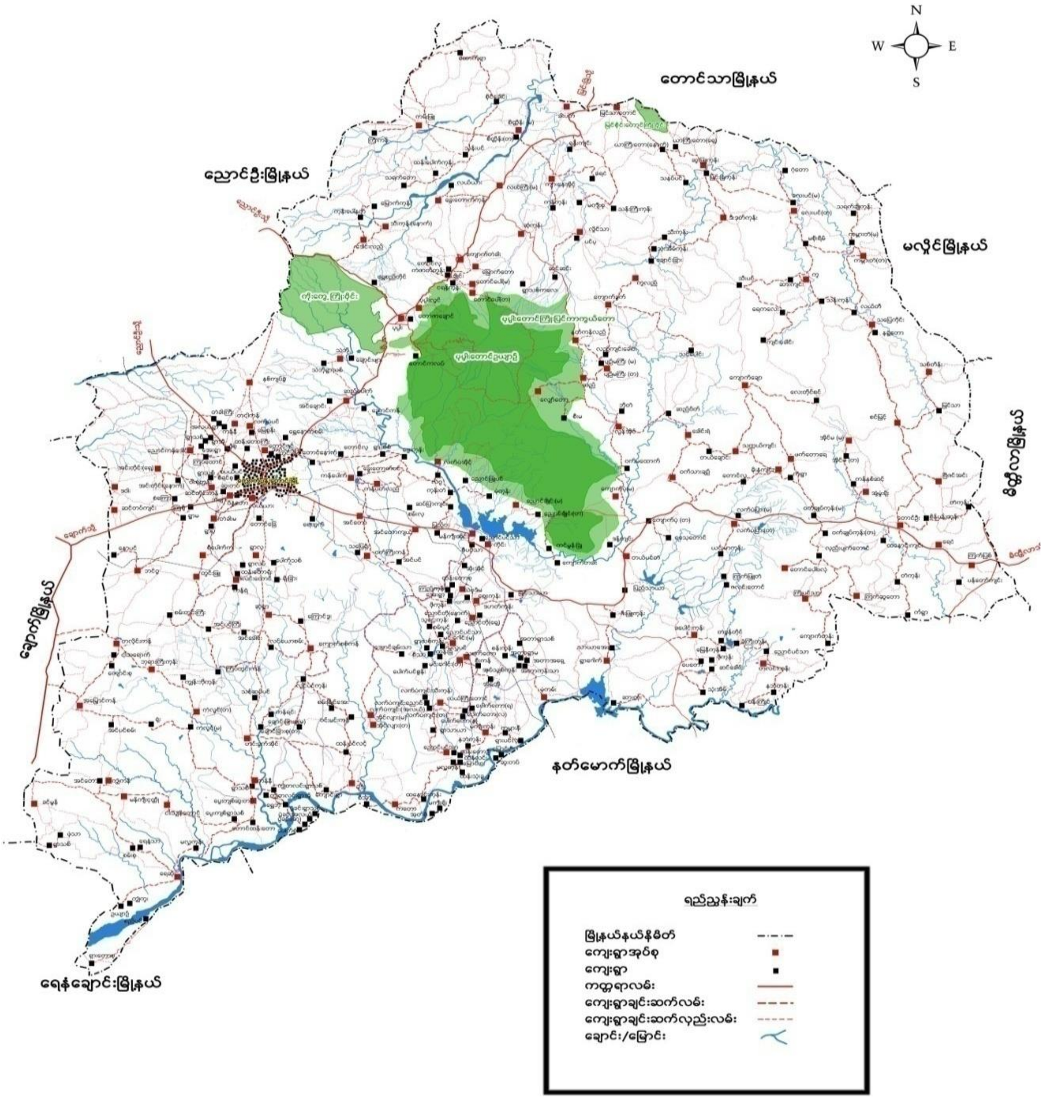
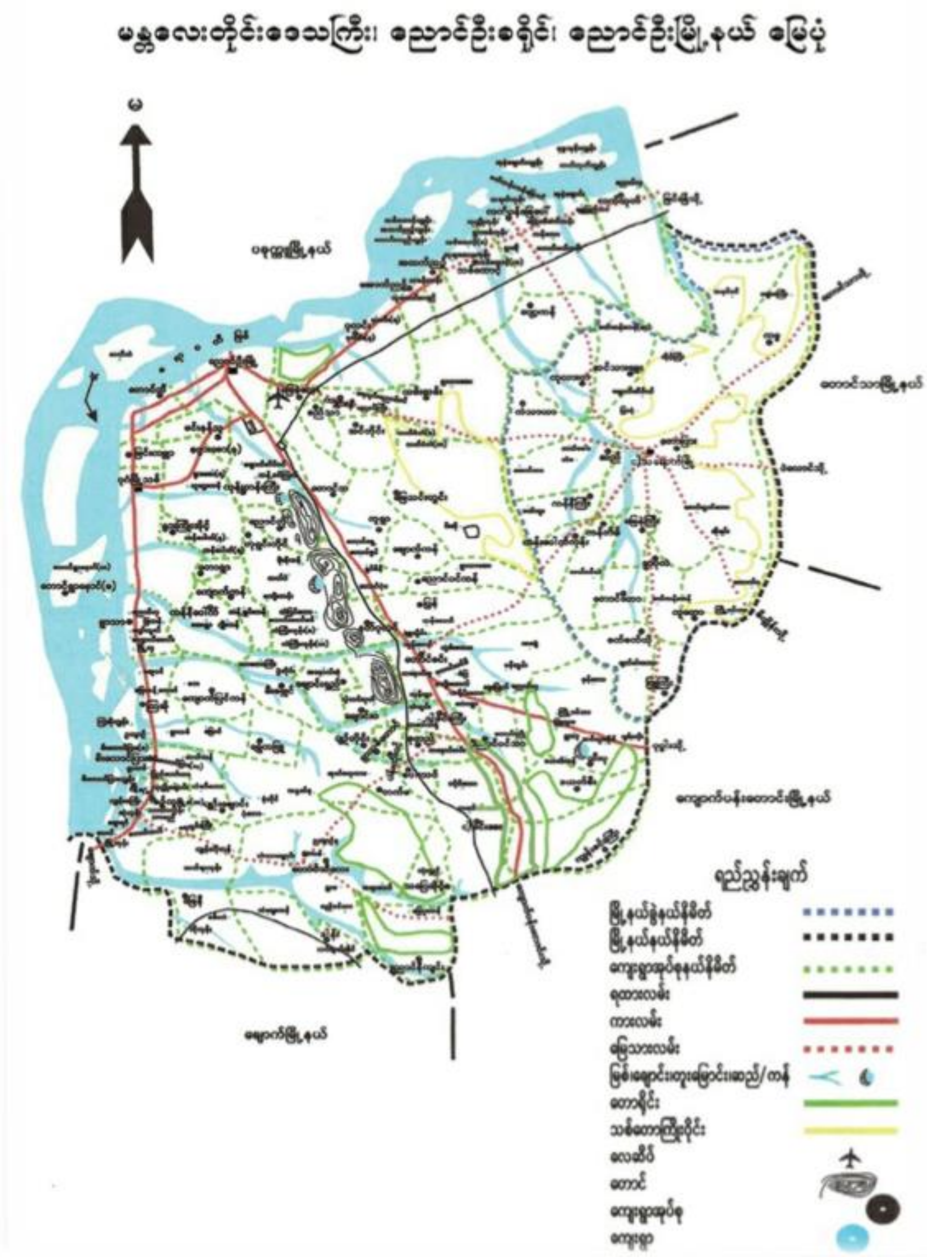
APPENDICES

Appendix 1 Map of Kyaukpadaung Township



Source: DoA, 2016

Appendix 2 Map of Nyaung U Township



Source: DoA, 2016

Appendix 3 Enterprise Budget of Pigeon Pea Production of Sample Farmers

Item	Unit	Level	Effective Price	Total Value
1. Gross Benefit				
Seed	ton/ha	0.5	1,329,250	660,637
Total Gross Benefit	**MMK/ha**			**660,637**
2. Variable Cost				
(a) Material Cost				
Seed	kg/ha	1.87	1,433	2,680
FYM	cart/ha	4.58	6,904	31,635
Urea fertilizer	bag/ha	0.69	20,189	13,869
Compound fertilizer	bag/ha	0.70	30,839	21,553
Other fertilizer	bag/ha	0.52	18,650	9,661
Foliar	sack/ha	0.26	5,444	1,432
Pesticide	bottle/ha	1.32	8,811	11,597
Total Material Cost (a)	**MMK/ha**			**92,427**
(b) Family labor				
Land preparation	amd/ha	3.01	9,544	28,766
Cleaning debris	md/ha	4.01	2,468	9,894
Seeding	md/ha	1.11	2,524	2,814
Manual weeding	md/ha	1.90	2,935	5,571
Inter-cultivation	amd/ha	1.29	7,804	10,031
Fertilizer application	md/ha	1.12	2,472	2,770
Pesticide spraying	md/ha	1.17	1,673	1,951
Harvesting	md/ha	10.95	3,808	41,682
Threshing	md/ha	8.74	3,787	33,103
Transportation	md/ha	1.05	3,039	3,197
Drying	md/ha	0.74	2,007	1,492
Total Family Labor Cost (b)	**MMK/ha**			**141,269**
(c) Hired Labor Cost				
Land preparation	amd/ha	6.36	9,343	59,422
Cleaning debris	md/ha	1.89	2,468	4,664
Seeding	md/ha	1.45	2,505	3,632
Manual weeding	md/ha	1.19	2,915	3,469
Inter-cultivation	amd/ha	2.31	8,856	20,466
Fertilizer application	md/ha	4.19	2,497	10,463
Pesticide spraying	md/ha	1.02	1,986	2,022
Harvesting	md/ha	6.24	3,809	23,775
Threshing	md/ha	6.08	3,476	21,149
Transportation	md/ha	1.52	2,783	4,232
Drying	md/ha	3.46	2,000	6,930
Total Hired Labor Cost (c)	**MMK/ha**			**160,223**
(d) Interest on cash cost				
Material cost	MMK/ha	92,427	0.1	9,242
Hired labor cost	MMK/ha	160,223	0.1	16,022
Interest on cash cost (d)	**MMK/ha**			**25,265**
Total variable cost (a+b+c+d)	**MMK/ha**			**419,185**
Total variable cash cost (a+c+d)	**MMK/ha**			**277,915**

Appendix 4 Enterprise Budget of Groundnut Production of Sample Farmers

Item	Unit	Level	Effective Price	Total Value
1. Gross Benefit				
Seed	ton/ha	0.9	701,754	605,446
Total Gross Benefit	**MMK/ha**			**605,446**
2. Variable Cost				
(a) Material Cost				
Seed	kg/ha	5.06	3,908	19,790
FYM	cart/ha	7.33	4,889	35,831
Fertilizer	bag/ha	5.25	16,061	84,315
Foliar	sack/ha	1.07	4,016	4,293
Pesticide	bottle/ha	3.23	7,200	23,280
Total Material Cost (a)	**MMK/ha**			**167,509**
(b) Family labor				
Land preparation	amd/ac	4.89	10,784	52,708
Cleaning debris	md/ac	2.79	2,421	6,764
Seeding	md/ac	2.04	2,545	5,205
Manual weeding	md/ac	0.65	1,750	1,134
Intercultivation	amd/ac	1.84	10,887	20,027
Thinning	md/ac	0.20	2,200	445
Thinning (animal)	amd/ac	0.17	10,400	1,811
Fertilizer application	md/ac	4.31	2,632	11,341
Pesticide spraying	md/ac	1.78	2,310	4,105
Harvesting	md/ac	3.11	3,621	11,276
Harvesting (animal)	amd/ac	0.97	10,231	9,942
Threshing	md/ac	3.00	2,619	7,847
Threshing (animal)	amd/ac	1.42	5,750	8,149
Transportation	md/ac	1.68	2,667	4,492
Drying	md/ac	7.44	2,244	16,695
Total Family Labor Cost (b)	**MMK/ac**			**161,942**
(c) Hired Labor Cost				
Land preparation	amd/ac	2.81	10,711	30,141
Cleaning debris	md/ac	6.03	2,133	12,871
Seeding	md/ac	3.29	2,729	8,971
Manual weeding	md/ac	2.39	1,750	4,181
Intercultivation	amd/ac	0.71	10,923	7,740
Thinning	md/ac	0.36	2,125	774
Thinning (animal)	amd/ac	0.47	9,909	4,654
Fertilizer application	md/ac	2.81	3,115	8,742
Pesticide spraying	md/ac	2.21	2,723	6,031
Harvesting	md/ac	11.0	3,924	43,233
Harvesting (animal)	amd/ac	0.9	11,083	9,649
Threshing	md/ac	10	2,696	25,927
Threshing (animal)	amd/ac	6	6,208	38,588
Transportation	md/ac	0.4	3,000	1,336
Total Hired Labor Cost (c)	**MMK/ac**			**202,840**
(d) Interest on cash cost				
Material cost	MMK/ac	167,509	0.1	16,751
Hired labor cost	MMK/ac	202,840	0.1	20,284
Interest on cash cost (d)				**37,035**
Total variable cost (a+b+c+d)				**569,326**
Total variable cash cost (a+c+d)				**407,384**