Why Climate Change Adaptation is Elusive: The Lived Reality of Farming Households in the Central Dry Zone of Myanmar

Aye Sandar Phyo

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School of Geosciences, Faculty of Science
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STATEMENT OF ORIGINALITY

This is to certify that, to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes. I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and its sources has been acknowledged.

Aye Sandar Phyo

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"This thesis is dedicated to the memory of fallen heroes during Myanmar's political crisis from 1st February 2021, until the present"

ABSTRACT

Farming households in the Global South are vulnerable to climate change because of their livelihoods' direct link to the natural environment. Farm households adapt to climate through altering their agricultural practices and by diversifying their livelihoods through the non-farm sector and migration. However, previous research has suggested that most of these adaptations are incremental, meaning they may not address the root cause of climate change vulnerability in the long term. The aim of this thesis is to assess these claims using the experiences of farm households in Myanmar's Central Dry Zone, a highly climate stressed region. To assess farmers' responses and adaptation to intensified climate stresses in the Central Dry Zone, fieldwork was conducted including interviews and focus groups with rural households in 2019. These qualitative methods revealed that farmers' responses to climate change vary considerably. In many cases, although farmers may be aware of the effects of climate change, their livelihood adaptations are motivated by a wider array of concerns, which mitigate or even subvert their capacities to respond to climate challenges. These mixed responses, and the notable reluctance of many farmers in the Central Dry Zone to take adaptive measures to the clear and present risks of climate change, forms the central problem this research seeks to resolve. Therefore, this research asks: How is climate change positioned in the livelihoods of farming households and what explains the mixed, and often reluctant, adaptive responses by farmers in Myanmar's Central Dry Zone to changing agricultural conditions brought on by climate change? The thesis argues that these outcomes can be explained through the adoption of a broad-based livelihoods approach which acknowledges that although climate change is an important factor influencing famers' decision making, other factors are also involved, and these are often prioritized over climate risks. This highlights the position of climate change on farmers' daily lives by emphasising the significance of geographical context and local traditions in relation to making decisions about rural livelihoods, farming, non-farm activities and migration. These findings underscore the need to recognise and comprehend how multiple stresses interact with climate effects to exacerbate the vulnerability of rural households and spotlight the importance of understanding the underlying causes of vulnerability. This perspective is crucial for understanding how farmers and agriculture-dependent communities respond to climate risks. Using the Central Dry Zone of Myanmar as a case study, the research generates an analytical framework that explains why incremental adaptation to climate change occurs even though farm households are fully aware of the issue.

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List of Abbreviations

ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Centre
ASEAN	South-East Asian Nations
CDZ	Central Dry Zone
DAP	Department of Agricultural Planning
DAR	Department of Agricultural Research
DMH	Department of Meteorology and Hydrology
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GAP	Good Agricultural Practices
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
Kg	Kilogram
LIFT	Livelihoods and Food Security Fund
MAS	Myanmar Agricultural Service
MCA	The Myanmar Censuses of Agriculture
MLIP	Ministry of Labor, Immigration and Population
MMK	Myanmar Kyat
MoNREC	Ministry of Natural Resources and Environment Conservation
IPCC	International Panel on Climate Change
MOAI	Ministry of Agriculture and Irrigation
MOALI	Ministry of Agriculture Livestock and Irrigation
NCEA	National Commission for Environmental affair
IFAD	International Fund for Agricultural Development
RIMES	Regional Integrated Multi-Hazard Early Warning System
WFP	World Food Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
USAID	United State Agency for International Development

1. CHAPTER ONE: INTRODUCTORY BACKGROUND, RATIONALE OF RESEARCH AND STUDY OUTLINE

1.1 Introduction

Farming households in the Global South are especially vulnerable to climate change because of their direct link to the natural environment and limitations on their adaptive capabilities due to poverty. Climate change has negative effects on yields for key staple crops such as rice and wheat on which many farmers in the Global South depend (Porter et al., 2014; Ortiz-Bobea et al., 2021). Vulnerabilities are especially strong for farmers who rely only on rainfed agriculture, due to increased seasonal uncertainties in precipitation (Abu et al., 2014). The incidence of food insecurity becomes higher with climate change because of the importance of food production in meeting households' food needs. For example, in Sub-Saharan Africa, where more than 90% of farm households rely only on rainfed agriculture, climate change has been found to negatively affect household food and nutrition security (Parry et al., 2007; Gandure et al., 2013).

The question of how farmers respond to climate change is vital to understand their current and future vulnerability. However, there is mounting evidence that adaptive practices by farm households in the Global South remain inadequate when compared to the climate challenge. The Intergovernmental Panel on Climate Change (IPCC) Working Group II, in its 6th Assessment Report (Final Draft) argued that "smallholder farmers tend to address short-term shocks or stresses by deploying coping responses rather than transformative adaptations" (2022: Chapter 9 page 10). The IPCC (2022: Chapter 4 page 110) documents the top four adaptation responses by smallholder farmers as being changes in cropping patterns and agricultural systems, improved crop cultivars and agronomic methods, irrigation and water management practises, and water and soil conservation measures. These four responses bring numerous advantages, including increased incomes and yields, improved water usage efficiency, and associated results. However, those benefits are incremental. Farmers' incremental adaptations can offset the detrimental impact of climate change on agricultural production in that they help boost crop production and incomes in the short run but do not necessarily lead to transformative outcomes with substantive reductions in climate risk (Pelling et al., 2015; Fedele et al., 2019). To address the vulnerability of climatic stresses, long-term

effective transformative adaptation must be designed. As a result, there has been major concern about how to address the root cause of vulnerability to climate change in the Global South, particularly in farming communities.

These concerns are highly relevant for Myanmar. This nation has the highest level of economic sensitivity to climate change in Southeast Asia (ADPC, 2015), and ranks second in terms of the frequency of extreme weather-related occurrences (Kreft et al., 2015). In an investigation of Myanmar's climate, the Department of Meteorology and Hydrology (DMH) (2011) discovered a tendency towards higher temperatures and a decrease in the length of the rainy season and monsoon strength. As an agriculture-based country, where one third of national Gross Domestic Product (GDP) is generated by this sector, climate change is rapidly endangering the livelihoods and constantly challenging the socioeconomic conditions of farm households. Agricultural production has suffered as a result of climate change in Myanmar. Many studies show that agriculture is extremely vulnerable to changes in hydroclimate; and the negative effects of climate change have resulted in agricultural production instability (Hallegatte et al., 2016; WFP, 2009 and 2013; Yi et al., 2012).

Within Myanmar, farming in the Central Dry Zone (CDZ) has particular vulnerability to climate change (Adaptation Fund, 2012). Monthly rainfall distribution is irregular, unstable, and has a large annual range. With farming fortunes highly dependent on climatic conditions, increasingly erratic rainfall, extreme heat days, and unpredictable weather conditions associated with climate change intensifies problems of water availability for farming (Kyi, 2012). During the 1980s-1990s, drought years of moderate intensity were reported on a regular basis, with prolonged dry seasons and higher temperatures. Between the years 1990 and 2002, droughts were more severe and happened more frequently (NAPA, 2012). Since 2004, an average decrease in rainfall of between 45 and 65 percent has been observed (MOALI, 2016). As an example of the impacts of these changes to climate, in 2009 a weak monsoon reduced the rice crop in Myanmar by between 50 and 70 percent, and between 80 and 90 percent for the sesame and sunflower crops (MOALI, 2016; McCartney et al., 2013). In 2010, a second year of severe drought reduced village water supplies throughout the nation and had an impact on agricultural yields of numerous crops, most visibly in the CDZ (MOAI, 2016; Yi et al., 2012; RIMES, 2011). According to Slagle (2014), the escalating frequency of droughts in the CDZ is the result of a shortened monsoon season, aggravated by El Nino cycles, both of which are expected to compound the negative consequences already experienced by the region.

Agricultural livelihoods, farm communities, and food security in the CDZ are all being negatively impacted by key risk factors, the most significant of which are seasonal water shortages, decreasing rainfall, and an increase in the frequency of droughts (WFP, 2011). In Myanmar, there has been a discernible pattern of rising temperatures in recent years (Government of Myanmar, 2019). In the CDZ throughout the past three decades, groundwater irrigation and river pumping projects have increased at a higher rate than dam irrigation (Belton et al., 2017), adding to the depletion of available water supplies.

These climate-related problems are coinciding with population and environmental pressures in the CDZ. There is a high population density (123 people per square kilometre), a high rural population (81% of the total regional population is rural), and problems of fragile soil formation and serious soil erosion. The increasing human population, in conjunction with changing weather and climate, speeds up the process of soil depletion and the overuse of natural resources (NCEA, 2010). The cumulative effects of soil erosion, the continued decimation of native vegetation and the general deterioration of the land are all speeding up in the CDZ. Consequently, agricultural production is coming under greater stress (Oo, 2018; Herridge et al., 2019).

The current climate stress being faced in the CDZ provides a valuable context to assess the concerns, articulated in the IPCC Working Group II's 6th Assessment Report, cited above, about farm households' adaptive capabilities to climate change. There is a need to document current adaptive practices in the CDZ and assess their adequacy in light of the magnitude of climate change. If in the CDZ, farming households remain dependent on incremental adaptation, there is an imperative to understand why, and then, what potential exists for developing transformative adaptation to address climate challenges.

To assess farmers' responses and adaptation to intensified climate stresses in the CDZ, fieldwork was conducted including interviews and focus groups with households and agricultural communities. These were undertaken in the context where government and non-government organizations have been engaged in numerous projects related to climate change adaptation, such as climate smart agriculture, to help farmers in response to drought and irregular rainfall. Myanmar's agricultural research institutes are also heavily involved in trials for drought resistance crops which can be grown in the CDZ, and research for cultivation practices which can reduce crop yield losses due to the drought. These projects have generated

a host of recommendations in the CDZ. Although agricultural extension services are not very fully developed in Myanmar, fieldwork confirmed widespread knowledge and awareness by farmers of these recommendations, and the issue of climate change more broadly.

Nevertheless, surprisingly, research field work in the CDZ identified a very mixed set of responses to these threats. Some farm households who had already experienced the adverse effect of climate change, especially in dryland (not irrigated) areas, have adopted adaptation practices based on their traditional knowledge of farming. However, these were minimal adaptive responses to these stresses. This is not because of ignorance. In the interviews conducted for this research, it is clear that farmers understand the effect of irregular rainfall and drought and their connection to long term changes in climate. Many farmers complained about how they faced crop failure due to these changing climatic conditions.

These mixed responses, and the notable reluctance of many farmers in the CDZ to take adaptive measures to the clear and present risks of climate change, forms the central problem this research seeks to resolve. I argue that reluctance or failure to adapt can be explained through the adoption of a broad-based livelihoods approach which acknowledges that although climate change is an important factor influencing famers' decision making, other factors are also involved, and these are often prioritised over climate risks. This perspective is crucial for understanding how farmers and agriculture-dependent communities respond to climate change. Therefore, this thesis asks:

> *How is climate change positioned in the livelihoods of farming households and what explains the mixed, and often reluctant, adaptive responses by farmers in Myanmar's Central Dry Zone to changing agricultural conditions brought on by climate change?*

1.2 Climate change and rural communities in the Global South

To respond to the question above requires an overarching perspective on how climate adaptation intersects with rural livelihood aspirations among farming households. This thesis follows in the tradition of examining climate change vulnerability through "place-based qualitative ethnographic methods" (Miller and McGregor, 2020, p. 664). As discussed in the conclusion, this approach has much merit, although there is an additional need to connect the

results of place-based studies to one another, for the full implications of climate change to be translated into effective policy responses.

Specifically, the place-based approach here utilises the sustainable livelihoods approach (SLA), first developed by Chambers and Conway (1992) as a framework to consider these issues. The framework is conceptualised in Figure 1. The following text elaborates on this diagram, starting with discussion of climate change, and then moving into the issue of livelihoods and adaptation.

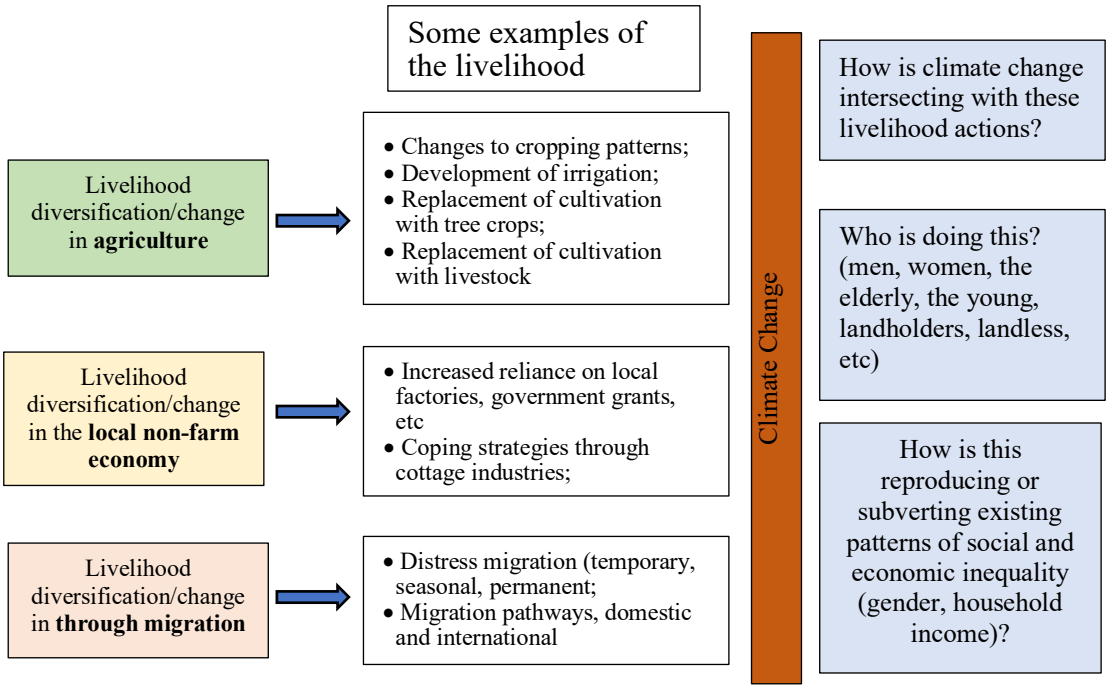

Figure 1: Conceptual framework of the study

Note: Livelihood diversification patterns are based on Chambers and Conway (1992)

Climate change has become a global threat in recent decades (IPCC, 2007, 2014, 2022; FAO, IFAD, UNICEF, WFP and WHO, 2017). Many sectors, including agriculture, have been negatively impacted as a result of changes in climatic factors, particularly in regions of the Global South where agriculture is a primary source of income. Farmers in many nations of the Global South rely on rain to sustain their crops since they have extremely limited access to irrigation. As a consequence of this, the struggle that they confront is becoming increasingly difficult from one year to the next as the climate becomes increasingly unpredictable.

Consequently, climate change has had a considerable impact on food security, nutrition, and livelihoods. Depending on the scales of production that farmers utilise, crop failure can lead to problems of household, community or national food security. Climate-related disasters can be a primary trigger of food insecurity (Porter et al., 2014). For example, floods and tropical storms have an impact on food security because they damage assets that people rely on for their livelihood. In addition, drought is a primary factor that contributes to food insecurity, which in turn has a negative effect on nutrition. Creighton et al. (2015), Herrero et al. (2015), and Lobell et al. (2011) have pointed out how climatic stress causes a negative impact on agricultural productivity, fisheries, and livestock production. Climate-related disasters also exact a psychological toll on farmers and can contribute to decisions to abandon farming by shifting their focus or livelihoods towards non-farm occupations or migrating. Farmer abandonment can then have implications for the food security of a whole region (Craven and Gartaula, 2015; Sumner et al., 2017).

The unpredictability of the climate can also have extra, indirect social effects. For example, Jensen (2000) argues that the implications of unexpected shocks, such as children being forced to drop out of school, have huge repercussions for society. These negative indirect effects are tied to the fact that people living in countries of the Global South have less capacity to adapt in the face of shocks such as drought or flood since households tend to have a lack of savings or insufficient formal resources such as insurance (Deaton, 1991).

In addition, rural landless households might be indirectly affected by climate change in terms of their income through the labour market. This is because rural landless households often work in agricultural fields as farm labour. In the case that climate stressors result in a reduction in agricultural yields as well as a decrease in crop market prices, there will be a negative impact on rural wages, which will subsequently have a direct influence on the income of landless farm labour households (Hertel and Bosch 2010; IPCC 2014).

Therefore, it has become crucially important to take account of climate change adaptations in designing agricultural and rural development policies for countries in the Global South, not only at the country level but also in terms of regional and global level cooperation. For these reasons, in order to reduce the risks of climate stress on agricultural production, significant investments have occurred in adaptation practices to tailor crop production to a changed climate. For example, scientists have conducted extensive studies on climate-resistant crops

and agricultural techniques. This entails altering crop varieties, irrigation methods and adopting alternative growing techniques to cope for crop loss caused by unfavourable climatic circumstances (Thornton and Lipper, 2014).

However, the question many researchers have asked is whether such investments are sufficiently comprehensive. Below et al. (2010) discovered 104 different practises related to climate change adaptation among small scale farmers in evidence from more than 16 countries throughout Africa, the Americas, Europe, and Asia. Crop management adaptation strategies constitute the majority of these adaptations, with an average increase from adoption equal to 15-18% of existing yields depending on crops, geographies, and management features. However, Below et al. (2010) also identified a large number of adaptation practices not related directly to crop management, including petty trade, sales of non-timber forest products and seasonal migration.

The importance of adaptation practices outside of crop management has been highlighted by a range of other studies. Numerous studies demonstrate that in response to climate stresses, farm households not only make adaptations through agriculture, but also, they adjust their livelihood activities. This can include diversifying their income resources, specifically wage jobs in the non-farm sector (Gao and Mills, 2018), and/or using domestic or international migration (Minale, 2018). These forms of adaptation can provide rural households with greater flexibility in allocating their resources among diverse income generating activities, leading to enhanced economic and environmental shock resilience (Ellis, 2000).

The discussion of these points leads into wider discussion of livelihood arrangements among rural populations of the Global South. Rigg (2006) reported that the proportion of the rural population that directly depends on agriculture was in consistent decline in rural Asia, and his arguments first published 16 years ago have been proven to have been sustained in more recent research (Rigg, 2020). A lesser share of the rural population, therefore, depends on land for their livelihoods via own-cultivation or as a source of labour. The agricultural production that takes place, furthermore, is increasingly destined for market-sale rather than own-consumption. Therefore, as argued by Lohmann and Liefner (2009), the potential of non-farm activities in reducing vulnerability to poverty is increasingly important. This is because non-farm activities may provide farm households with a type of insurance when faced with agricultural risks and minimise their dependency on natural resources.

Diversification both within and outside of agriculture is generally accepted as a strategy for reducing risk and improving well-being (Ellis, 2000). According to Chianu, Ajani, and Chianu (2008), agriculture is associated with a number of risks. As a result, family members frequently look for alternative ways of living in order to make ends meet and cope with the risks. Diversification contributes to livelihood resilience by spreading risk. As a result, rural households are increasingly reliant on a combination of agricultural and non-agricultural activities to make a living. Lemos et al. (2016) argue that nonfarm income may make rural communities less dependent on natural resources and less likely to be affected by environmental challenges. However, the ways in which these changes happen are complicated and need to be better understood.

However, many of the studies on rural livelihood diversification identify how engaging in non-farm activities can affect rural households' interest and investments in agriculture and consequently, they can produce negative impacts on crop productivity and regional food security. It has been found that there are also negative impacts on crop production resulting from male migration from rural areas because farm households face the lack of men to operate gender related roles of land operation and leaving the farm production very vulnerable (Sumner et al., 2017). When male household members migrate, female household members need to manage farm and other household activities and mostly they do not hire labour because poor households cannot afford to do this. Under these contexts, women's labour participation in the agriculture sector has increased, but this increased participation often cannot overcome the loss of the male labour force due to differences in gender related roles and norms in agricultural activities (Survey, 2011). Moreover, social issues can arise from rural household members' migration to other places to find out non-farm job opportunities. Jacobson et al. (2018) reported that migration can cause child welfare-related concerns when parents are leaving their children in villages. In the case of female migration, there are also considerations of female safety when females engage in low-income non-farm sector, for example domestic helpers.

These changes to rural livelihoods are because of the need to respond to pressure and opportunities (Barrett et al., 2005). Crucially important here is that the way that rural households change their livelihood strategies is based on the assets they have, their contexts and the internal stresses they face. These situations provide the basis through which they develop resilience and maintain sustainability of their livelihoods (Scoones, 2009).

1.3 Placing climate change stresses in the context of dynamic rural livelihoods

The discussion above highlights the inter-relationships between climate stress, adaptation, and livelihood decision-making. However, the extensive research on climate change often sheds the spotlight on climate change exclusively and positions rural households as victims without comprehensive theorisation of their agency. Climate change is certainly a destructive actor for poor rural households; however, its impacts are wound together with daily human life. Therefore, it is important to incorporate climate change in the complexity of rural households' livelihoods. In the context of very dynamic rural livelihoods, there is a need to know where the role of climate change is placed in their life-worlds. Although farmers know climate stresses are problematic, the question of how they take account of climate change in considering their livelihood arrangements is very crucial to understand.

While policy makers in the Global South have acknowledged the vulnerability caused by climate change and adaptation strategies for rural areas have been developed, by and large, these are agricultural-focused. There is a wider need to place the agricultural-focused implications of climate change within the broader settings of peoples' lives. Although understanding specific farming methods to adapt to climate change is critical, it is also essential to consider how farmers are implementing these recommended adaptation strategies. Farmers are often the first frontline actors to be affected by climate change, and they determine how to minimize their exposure to these risks. As a result, simply knowing which methods are the best adaptive strategy for farmers is insufficient. It is critical to understand how they are performing in the actual world and why they have chosen certain choices.

Therefore, it is crucially important to understand how farming households prioritize various factors in the context of addressing climate change issues in their farming. Under this context, it is important to look at climate change from the lens of complex rural livelihoods if effective rural development policies are to be generated.

Therefore, at the heart of this thesis is an aim to disentangle the position of climate change in their livelihood strategies as shown in Figure 1 for the case study region of the Central Dry Zone, and thereby explain why farmers' knowledge and perception of climate change is translating (or not translating) into climate-adaptive behaviour. Using the case of Myanmar's Central Dry Zone, a region that has very high climate risk, the thesis generates an analytical

framework that explains relatively minimal adaptive responses to climate change, even though farmers are fully aware of this issue. The general objective of the study is to find out how climate change is intersecting the daily lives of rural livelihoods. Specifically, in addition to the overall research question posed earlier in this chapter, the study seeks to respond to the following three problems:

1) How do rural households diversify their livelihoods, and what changes are there to the role of agriculture?
2) To what extent can these changes to household livelihoods be explained as a strategy for addressing climate change vulnerability?
3) What does the conclusions about climate change adaptation in the Central Dry Zone reveal about the vulnerability of rural communities in the Global South more generally?

Taken together, the answers to these questions generate a complex narrative about agricultural climate adaptations in agricultural communities. Understanding this complexity is important if policymakers are to appreciate the reasons for patterns of climate adaptation. This thesis will demonstrate that researchers and governments need to understand the local contexts if they are to appreciate climate change's impacts on people.

1.4 Structure of the thesis

This thesis is divided into eight chapters. Chapter One introduces the research and offers the necessary foundation for the study, stressing the research problem. It describes the study's motivation and why it was necessary to conduct it. It also describes the research questions and concepts, as well as the rationale for investigating rural livelihoods and climate change adaptation in Myanmar's Central Dry Zone. Furthermore, it briefly explains the case study area, to illustrate the setting in which this research was carried out and the data collection methods employed. The remainder of this thesis is organised in the structure and organisation described below.

Chapter Two provides a literature review that demonstrates how to understand the role of climate change in rural livelihoods within the wider contexts of a transforming rural economy. It begins with the phenomenon of climate change and the forms of climate change adaptation, particularly the concept of transformative and incremental adaptation. It then critically looks

at the conceptual formulations of climate change literacy in the context of its impacts on adaptation decisions. In addition, it includes the concept of rural livelihoods based on the Sustainable Livelihood Approach (SLA) followed by the concept of how rural livelihoods are changing in the Global South. It also highlights how the importance of agriculture for rural farm households has become less and their livelihoods have diversified into non-farm sectors by describing the evidence of various research conducted in the Global South. Finally, it reveals the intersection of climate change with dynamic rural livelihood settings such as agriculture, non-agriculture, and migration in the Global South by presenting the different arguments and debates from various research.

Chapter Three sets the stage for this research by investigating how climate change issues have been contextualised and mainstreamed in rural livelihoods in Myanmar's Central Dry Zone. It starts with a brief overview of global climate change challenges and their consequences for agriculture. Also, it demonstrates the importance of climate change concerns in the Global South, where agriculture and other associated sectors provide the majority of income. Then, it discusses Myanmar's geographical position, population, and economy. It explores the country's vulnerability to climate change, concentrating on the threats of various hazards and climate stresses based on its geographic position. Furthermore, it gives a more concentrated explanation on why the Central Dry Zone was chosen as the case for this research by highlighting its geographical setting, climate data, and significance on agriculture. The final section of this chapter evaluates the national climate change policy framework and agricultural adaptation practises to highlight the inherent gaps and flawed assumptions in their approach to conceptualising and mainstreaming diverse rural livelihoods in policy formulation and implementation processes.

Chapter Four focuses on the methods used to investigate the research questions. It starts with a critical assessment of quantitative and qualitative approaches to climate change adaptation, which explains why qualitative techniques were chosen for this study. It also gives a brief theoretical backdrop to focus group discussions and interviews as qualitative research methodologies, commenting on their purpose and justification for use in this study. This chapter also describes the process of conducting and reporting the outcomes of focus group discussions and interviews. Furthermore, the chapter describes the sample procedures used to select the research area, such as townships, villages, and households for interviews. The method of qualitative analysis is also discussed, with an emphasis on developing coding for Nvivo. The

ethical considerations behind the study are reviewed in the later part of the chapter, with an emphasis on data collection and data management. Furthermore, the study's limitations are also discussed, particularly in light of the COVID-19 pandemic and political turmoil in Myanmar since the coup of February 2021.

Chapter Five presents findings on the rural livelihood settings of the study villages to support the argument that the social and economic effects of climate change vary between village communities due to the fact that different combinations of livelihoods expose people to climate threats in various ways. This responds to the first of the three research questions of the thesis, above. It begins with a brief socioeconomic, topographical, and environmental profile of the study area. It then emphasises the various village livelihood patterns depending on their geographical environment. Finally, it describes the many agricultural and non-agricultural activities practiced in the communities, as well as migration. This chapter documented the prevailing livelihood arrangements in the study villages.

Chapter Six focuses on the extent to which agricultural adjustments are a reaction to climatic stresses. First, it describes how people perceive climate stresses like irregular rainfall and drought and why they keep doing farming. It then analyses how farmers' decisions about farming activities are related to the climate stresses they have been experiencing. The analysis categorises all farming changes in terms of climatic and non-climatic stresses. The chapter finally argues that farmers' perceptions of climate change are not directly translated into changing farming practices to offset the negative impact of climate change, and that other non-climatic reasons are generally prioritised over climate risks in farmers' decisions for agricultural production.

Chapter Seven focuses on how non-farm activities including migration in the study villages' rural livelihoods are vital for managing climate change risk. The chapter begins by giving a story of one respondent referring to how she allocates her household members in both agricultural and non-agricultural activities in order to sustain the household income when they faced crop loss due to climate stress. The chapter then categorises various types of non-farm livelihoods found in the study villages, as well as domestic and international migration, based on the history of how these livelihoods were developed in the study villages. Then, it depicts farm households' attitudes regarding non-farm activity and migration. Finally, the chapter asserts how non-farm livelihoods are important in rural households, and that the expansion of

non-farm livelihoods across the study villages cannot be attributed solely to adaptation to climate stresses because it is linked to village histories, geographical locations, and cultural norms. Together, chapters six and seven respond to the second of the three research questions, above.

Chapter Eight presents a summary of the most important findings and an interpretation of those findings, as well as the significance of those findings for adaptation research and policy making in the Central Dry Zone, Myanmar and the Global South in general. The chapter also positions the research findings more generally, and hence responds to the third of the research questions, above. It concludes by emphasising the limitations of applying the research findings in light of the present political instability in Myanmar.

2. CHAPTER TWO: CLIMATE CHANGE ADAPTATIONS AND THEIR INTERSECTION WITH RURAL LIVELIHOODS

2.1 Introduction

Rural livelihoods in the Global South are dynamic. Individuals and households are changing from traditional activities focused on agriculture, to more diverse livelihood pathways which include agricultural activities, non-agricultural activities and migration. There are many underlying causes for these shifts. While climate change is certainly one of the causes of livelihood change, because rural farm households need to adjust or change their livelihood activities in order to adapt the changing climatic conditions, it is not the only driver, and its effects are contextualized by other forces. In order to understand the role of climate change in impacting on rural livelihoods, we must firstly examine this wider set of issues.

This chapter sets out the arguments of how to understand the role of climate change in rural livelihoods within the wider contexts of a transforming rural economy. Apart from climate change, other external factors that shape livelihood decision-making include macroeconomic policies, urbanization, market and technology development, and there are also internal factors such as socioeconomic characteristics, cultural norms, and networking. As livelihood arrangements and interactions are complex, to understand the role of climate change on livelihoods, we need to understand the ways that drivers come together to generate outcomes.

This chapter begins by outlining what is meant by climate change adaptation. It then introduces the contemporary contexts of rural livelihood change in the Global South. With these two discussions established, the chapter then examines the interactions between rural livelihoods and climate change. A key argument is that much of the analytical and policy focus on these intersections constitutes what is known as *autonomous* or *incremental* adaptation. That is, they respond to the challenges of a changing climate by facilitating rural households and communities to cope with change. However, taking a broader *livelihoods approach* opens scope to consider these interactions in terms of the possibility for *anticipatory* or *transformative* adaptation; that is, not focusing simply on how to make pre-existing livelihood arrangements more climate sustainable, but altering the very fabric of how rural households and communities go about making a living. This wider framing of climate change adaptation within livelihood

contexts is key to the broader argument of this thesis, including the empirical results discussed in later chapters.

2.2 What is climate change adaptation?

According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the worldwide averaged total surface temperature has increased by 1.5 degrees Celsius over pre-industrial levels, and it is expected to continue to rise in the coming years (IPCC, 2022 [Approved draft]). It is anticipated that the frequency and severity of heat waves, droughts, floods, cyclones, wildfires, hail and storms, as well as the accelerated melting of glaciers and other forms of ice, sea level rise and soil erosion, will all increase over the course of this century. Over the past decade, the number of natural disasters that were caused by climate change has increased around the world. The patterns of precipitation are shifting throughout numerous locations, which is having an effect on hydrological systems. The vulnerability of many different human systems is anticipated to rise as a result of these changes, which constitute a serious danger to ecosystems and the myriad of services they provide (IPCC, 2014). This precarious position affects a wide range of concerns, such as the production of agricultural crops, the safety of food supplies, the health of individuals, and the alleviation of poverty (IPCC, 2014, 2007; FAO, IFAD, UNICEF, WFP and WHO, 2017; FAO, 2016; World Bank, 2014, 2013; Vermeulen et al., 2011).

The manner in which people, households, and society react to these changes will shape their respective futures. The IPCC defines adaptation as a "process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities" (IPCC, 2014, p. 118). Adjustments in socio-ecological systems may need to be made over the medium to long term as a result of this (Smit and Pilifosova, 2001). As a result, adaptation refers to the procedures that civilizations go through in order to make themselves more capable of coping with an unpredictable future. There is already a long history of how cultures adapt and minimise their susceptibility to the effects of disasters such as floods, droughts, and storms. This is because adaptation may have major consequences in lowering vulnerability for both the short term and the long term (UNFCCC, 2007).

These strategies and measures for adaptation have been divided in a variety of different ways. Easterling et al. (2004) classified them into two distinct groups: autonomous adaptation, also referred to as reactive adaptation, and anticipatory adaptation, sometimes referred to as proactive adaptation. Autonomous adaptations are often defined as those that are carried out in an unprompted manner as a normal adjustment to the environment. They are not a deliberate response to climate change but rather are spurred by ecological alterations in natural systems and market or welfare adjustments in human systems. Climate change is not the cause of these changes. For instance, activities with short planning horizons (such as cropping) are constantly subject to the implementation of autonomous adaptations based upon the conditions of the market and the weather. These autonomous adaptations can include the timing of planting and harvesting, switching from cropping to grazing, and other such activities. This kind of decision-making about operations is more tactical than strategic, and it doesn't take into account the incentives given by policies or rules.

In general, autonomous adaptations are focused on risk management in relation to the changing climate, but they do not explicitly acknowledge that the climate is changing. In other words, strategic planning is seen to be enough since the long-term climatic forecast is presumed to remain stable, despite substantial inter-annual fluctuations in circumstances. This assumption leads to the conclusion that tactical planning is adequate. However, given that autonomous adaptations are reactive in nature, they do not impart any advantages; rather, their purpose is to reduce the amount of damage done. In addition, their ability to prevent further losses may be restricted due to the fact that they are frequently implemented only after the first expenses have been spent as a result of pre-existing management practises. Easterling et al. (2004) highlight the fact that autonomous adaptations are, by their very nature, gradual, and, as a result, they may only be partial answers to specific difficulties, which may require ongoing modification that is both time-consuming and expensive. Furthermore, autonomous adjustments that are regarded as effective over the short term may postpone transformative changes to operations that are necessary for long-term sustainability.

The second type of adaptation, known as anticipatory (or proactive) adaptation, is the consequence of a conscious policy decision made because the conditions have changed or are going to change and action is necessary to return to, maintain, or reach a desirable state. These various forms of adaptation are overtly strategic in nature. Typically, they need preparation in advance of potential future situations as well as structural or transformative shifts in the way

operations are carried out. External factors, such as governments and research institutes, frequently play a larger role in facilitating anticipatory adaptation than is initially clear. It has a tendency to be directed towards tasks connected with extended time horizons for planning. As a result, it is particularly significant for decisions on infrastructure, in which investments often have a large initial cost and are maintained for a very long time. To avoid the need to retrofit or modify infrastructure at a later time, it may be more cost-effective to plan ahead for the effects of predicted future climate change and factor them into the design of the necessary infrastructure. These ideas also work well in primary industries, which have room for strategic planning. One example would be the process of restructuring irrigation entitlements and allocations, as well as the planning that goes into large-scale development or contraction of certain production systems.

2.2.1 Incremental vs Transformative Adaptations

The distinction between incremental versus transformative adaptation provides a parallel key classification of this issue (Shikuku et al., 2017; Park et al., 2012; Smit and Skinner, 2002). Incremental adaptation is defined as a continual reaction to climatic risks in an existing system and involves the creation of activities and behaviours that lessen the damage or boost the advantages of natural changes in climate and extreme occurrences (Kates et al., 2012). Transformational adaptation, on the other hand, is a process that results in changes in the biophysical, social, or economic aspects of a system (Park et al., 2012) and entails changing a collection of variables that influence the system's performance. This is different from incremental change, which means making changes so that present aims can still be met under changed circumstances (Robertson and Murray-Prior, 2016).

Incremental adaptation drives minor and small-scale changes to contemporary social-ecological systems (Kates et al., 2012; Adger and Jordan, 2009), for instance adjustment in agricultural and land management practices changes in the number of livestock or land use area, changing the amount of fertilizer and pesticides, or changing crop varieties in order to offset the negative effect of climate change in agricultural production (Nguyen et al., 2013; Ash et al., 2012; Nhemachena and Hassan, 2007). On the other hand, transformative adaptation is a strategy which has the potential to reduce the root cause of vulnerability to climate change by changing the system so that it is removed or protected from undesirable trajectories (Olsson et al., 2014; O'Brien, 2012). It includes broad changes to ecosystem-society relationships and

can be produced by system shifts or the combination of many incremental adaptations (Adger et al., 2011; Kates et al., 2012). Actions that are already reducing losses or increasing benefits due to natural variations in climate and extreme events are incremental adaptation, whereas actions that are implemented on a much wider scale or intensity, novel adaptations, and changing locations are transformative adaptation (Kates et al., 2012). For example, in order to respond to flood, transformative adaptation could entail the rejuvenation of rivers and movement of human activities in flood plains while incremental adaptations could be building channels and dikes. Another example is farmers can develop small irrigation schemes to lessen future risks of crop failure (incremental adaptation), or they can fundamentally modify the features and properties of the land usage by implementing agroforestry or reforestation (transformative adaptation) (Fedele et al., 2019).

Researchers have also claimed that transformational change has a longstanding experience in organisational theory and is typically related with change that is deep and broad, in contrast to incremental change, which is typically pictured as shallow, fragmentary, and sluggish (Termeer et al., 2016). Regardless of definition, these interpretations allude to certain general characteristics of transformation, such as noticeable change in structure or form towards something newer and autonomous or produced change in the system or parts of the system owing to internal or external sources. However, in some circumstances, the distinction between the two approaches may be blurred, and some incremental adaptation may shift towards transformation, focusing more emphasis on the continued transformation process in the adaptive cycles of incremental and transformational adaptation (Kates et al., 2012; Smith et al., 2011; Horrocks and Harvey, 2009). For example, in the case of the re-greening of the Sahel in West Africa, the individual autonomous activities by farmers were aggregated to generate transformative adaptation (Kates et al., 2012).

Nevertheless, the majority of agricultural work has been focused on incremental adjustments that may allow for short-term management of climate risks and opportunities (Vermeulen et al., 2013; Rickards and Howden, 2012). Therefore, the concept of transformation has been extensively discussed as an ultimate necessity in the adaptation literature because of the growing effects of climate change. When the effects of climate change are expected to get much worse quickly and dramatically, transformative adaptation may be a better choice than incremental adaptation (Pelling et al., 2015; Wise et al., 2014). For example, the requirement of transformational adaptation will become more vital when present adaptation measures have

reached their limitations (Dow et al., 2013; Ash et al., 2012), or when profound changes in social or natural systems have already occurred as a result of climate change (Gunderson et al., 2017; Colloff et al., 2016; Pelling et al., 2015). Moreover, some incremental adaptations may make people more vulnerable to climate risks than they were before. For example, giving small-scale farmers drought-resistant maize or crop insurance, may make it less likely that they will make other changes that could be much better in the long run, like growing other crops instead of maize or finding alternative livelihood options (Vermeulen et al., 2013).

However, there are many more challenges to implementing transformational adaptation than incremental adaptation (Kates et al., 2012; Fook, 2017; Rickards and Howden, 2012). Although the distinction between incremental and transformative adaptation is hazy (Kates et al., 2012), the latter involves cultural changes, institutional reforms, and the challenging of assumptions (O'Brien, 2012), and large-scale modifications which are new to a system, which can produce long-term impacts and result in the creation of a new social-ecological system (Kates et al., 2012; Nelson et al., 2007). Dowd et al. (2014) mentioned that transformational adaptation may have very different policy and investment needs than incremental adaptation.

Therefore, transformational adaptation may get less support from society or the government because it may require unusually large amounts of money, people, and time, and the benefits may not show up for a long time (Kuntz and Gomes, 2012; Adger et al., 2005). Because of a lack of familiarity with transformative adaptation, there may be constrained financing arrangement for such kinds of strategies, or narrow objectives of the entities planning these actions. Rather than challenging structures, people often choose more incremental forms of adaptation (Abson et al., 2017; Thornton and Comberti, 2017; Gibson et al., 2016).

Furthermore, transformational adaptation may be less possible as it requires the participation of a large number of diverse persons, groups, sectors, and levels of government, each of which may have various aims (Meadowcroft, 2011; Van den Bergh, 2011). Besides, it may also be necessary to engage in transformative adaptation in order to reconcile future aspirations that are in contradiction with one another, for instance, economic development and reduced carbon emissions. The existence of complex ethical and distributional issues that must be addressed before implementation seems to be another barrier to transformative adaptation. These issues include the deliberate decision to support specified values (Gorddard et al., 2016; Biermann et al., 2012), governance structures (Fazey et al., 2018; Colloff et al., 2017), and special interests

in order to receive the desired results (Wise et al., 2014; Stirling, 2014). These obstacles heighten the risks and uncertainty related with formulating the transformative adaptation (Blythe et al., 2018).

While some types of transformational adaptation are the outcome of activities led by the government in response to climate concerns (O'Brien, 2012; Kates et al., 2012), there are some kinds of adaptation which are driven by the actions of individuals (Park et al., 2012; Fischer, 2019). This latter scenario occurs when a sufficient number of individuals independently adopt creative behaviours that ultimately lead to changes that are long-lasting in the natural and human system. Nevertheless, these changes can only take place when individuals across vast geographical regions participate in coordinated and cooperative behaviours (O'Brien, 2012; Park et al., 2012; Wise et al., 2014). This kind of transformation approach may need a better knowledge of inter and intrapersonal dynamics that drive towards cooperative behaviours as a method of achieving political, technical, and socio-cultural change (Adger et al., 2013, O'Brien, 2012; Gifford, 2011).

However, in the context of climate change, all forms of adaptation are closely linked to vulnerability and resilience. These concepts are interconnected and sometimes, it is difficult to disentangle their relationships. In contrast to adaptation, vulnerability is usually portrayed in negative terms, notably susceptibility to be harmed. Vulnerability is the degree to which a system is sensitive to and incapable of dealing with adverse effects (McCarthy et al., 2001). In other words, vulnerability would seem to have opposing attributes to adaptation. However, the relationship between these concepts is not always oppositional, because vulnerability is made up of components such as exposure and sensitivity to perturbations or external stresses, as well as the ability to adapt. The nature and extent to which a system is subjected to environmental or socio-political stress is referred to as exposure. These stresses' characteristics include their magnitude, frequency, duration, and hazard area (Burton et al., 1993). The degree to which a system is modified or affected by perturbations is defined as sensitivity. The ability of a system to evolve in order to accommodate environmental hazards or policy change and to broaden the range of variability with which it can cope is referred to as adaptive capacity. It depends on a number of factors, such as the availability of technical solutions, the distribution of resources and power to make decisions, social capital, human capital (like education), economic institutions (like property rights), and infrastructure and financial resources (Yohe and Tol, 2002; Engle, 2011; Kelly and Adger, 2000; Bebbington, 1999; Bohle et al., 1994).

Resilience is the capacity of economic, social, and environmental systems to deal with a dangerous occurrence, disturbance, or trend by recognising it or responding in ways that maintain their core function, structure, and identity while also permitting learning, adaptation, and transformation (IPCC, 2014). Thinking in terms of resilience may lead to novel understandings of the coping mechanisms employed by communities undergoing transformation as a result of climate change. Although resilience is difficult to measure, it is a useful concept in climate change adaptation programmes because it can account for how societies can continue to flourish in the face of unexpected change (Boyd et al., 2008).

A major theme of adaptation research has been the attempt to characterise and quantify the opportunities and limits in terms of adaptive capacity, which represents an actor's or system's ability to avoid hazards, plan for, adapt with, and recoup from losses caused by a hazard, and gain from adaptations (Pelling, 2011; Engle, 2011; Smit and Wandel, 2006; Yohe and Tol, 2002; Kelly and Adger, 2000). In the context of climate change, research on adaptation has primarily focused on identifying possible and feasible adaptation strategies in response to future climate impacts, establishing criteria for selecting appropriate strategies, estimating outcomes (such as cost or effectiveness), and investigating responses to current climate variability (Bryant et al., 2000). However, decisions on whether and how to adapt to climate change are occasionally made independent; rather, they are influenced by institutional conditions, social, political and economic structures and community interests and needs (Bassett and Fogelman, 2013; Adger et al., 2005; Adger, 2003; Risbey et al., 1999). As a consequence of this, there is a growing recognition that in order to define appropriate and effective adaptation, research must focus on the actual processes involved in adaptation. This includes investigating how, when, why, and under what conditions adaptation occurs in economic and social systems, as well as social, behavioural, and other impediments to adaptation (Burton et al., 2002).

In rural areas, adaptation methods may change in response to different types of weather events and farm-level adaptations may be different based on gender, ethnicity, or other socioeconomic or cultural factors (Hisali et al., 2011). Individual and household adaptation in Sub-Saharan African rural communities has been associated to common adaptive capacity indicators such as wealth, gender, years of farming experience, land, government support, access to credit, and the strength of social networks, economic opportunities, and knowledge regarding climate

change and adaptation possibilities. (Yegbemey et al., 2013; Brockhaus et al., 2013; Below et al., 2012; Bryan et al., 2009; Deressa et al., 2009; Downing et al., 2009; Ziervogel et al., 2006; Downing et al., 2005; Adger, 2003; Kelly and Adger, 2000). Moreover, traditional knowledge and farming experiences play an important role in adaptation. Mongolian nomads, for instance, have always relied on seasonal mobility strategies; herders travel in search of better pasture and water supplies to ensure the health of their herds. This demonstrates the significance of herders' knowledge of pasture ecosystems and their skills in pasture management for the success of adaptation. Herders with more experience are better able to adjust to new situations than their younger counterparts. While travelling in search of better pasture and water sources for livestock, the elderly focus on how to herd animals and manage livelihoods on resource-limited pastureland (Tugjumba et al., 2021).

These considerations are highly relevant to agriculture, because of its dependence on biophysical systems. In some cases, relying on autonomous, coping, and short-term adaptation strategies may have the unintended consequence of putting an extra burden on agricultural households' ability to withstand future vulnerabilities because it delays anticipatory responses (Brown, 2007), which can lead to maladaptation.

Maladaptation is described as “actions or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future” (Noble et al., 2014; p. 118). Barnett and O'Neill (2010) say that maladaptation can make a population more vulnerable to the impacts of climate change both present and in the future. Agricultural households' adaptive or maladaptive behaviours will be determined by their perceptions of climate change (Maddison, 2007; Deressa et al., 2010). The perspectives that farmers have towards climate change influence not just the sense of urgency with which they perceive the need to implement adaptation techniques, but also the degree to which they actually do so (Mertz et al., 2009; Nhemachena and Hassan, 2007). According to the research conducted by Bryan et al. (2009), the most significant factor that plays a part in deciding how and what kinds of adaptation measures are implemented is people's perspectives on climate change. In addition, the degree of risk that is believed to be associated with the capacity to adapt to climate change has an impact on the likelihood that adaptation strategies will be implemented (Hisali et al., 2011). As a consequence of this, having an awareness of how people perceive climate change is essential for the effective implementation of plans to adapt to climate change (Byg and Salick, 2009).

2.3 Farmers' perceptions of climate change and their impacts on adaptation decisions

Perceptions of climate change are connected to what is known as 'climate change literacy', namely, peoples' understanding of "both climate change and its anthropogenic cause" (Simpson et al., 2021, p.937). The Intergovernmental Panel on Climate Change (IPCC) has recognized climate change literacy as an important key contributing factor for climate change adaptation and mitigation (IPCC, 2022). One key characteristic of climate change literacy is understanding the anthropogenic cause of climate change (Ledley et.al, 2018). It is the ability to recognize the contribution of climate change in meteorological and other environmental changes (Moore et al., 2019; Lee et al., 2015).

Perceptions of climate change are important in developing adaptation practices through its connection to how risk is understood (Evans et al., 2016). Understanding the human causes of climate change has been demonstrated to be a strong predictor of climate change risk perception (Lee et al., 2015), as well as a fundamental skill set that can influence the difference between incremental and transformational adaptation (Andrews and Smirnov, 2020; Mutandwa et al., 2019; Oladipo, 2015; Ugwoke et al., 2013). Enhanced appreciation of the anthropogenic drivers of climate change may be anticipated as being associated with stronger transformative adaptation responses (Steynor et al., 2021; Nkoana, 2020). Without an understanding of the anthropogenic cause of climate change, its impacts and future risks, adaptations may be more likely to be short-term (incremental or autonomous) responses (Guido et al., 2020). That said, there is a lot of confusion about what climate change perception, climate change awareness, and climate change literacy mean. It does not necessarily follow that climate change literacy inevitably leads to the formulation of transformative adaptations (Jamelske et al., 2013). This is because, as discussed above, transformative adaptation requires fundamental changes in social and ecological systems to anticipate the risks of climate change, and although social actors might be aware of this need, may not be in positions to act (Fedele et al., 2020).

Nevertheless, climate change perception is a first step in leading to actions for adaptation. Therefore, the issues of climate change perception are important considerations in the Global South because, according to climate predictions, tropical countries are at the highest risk from climate stress. This makes the issues of climate change perception and climate change literacy important considerations. Also, most people who live in countries of the Global South live in

rural areas and traditionally, agriculture and other activities related to it have been their main source of income. It is anticipated that the effects of climate change will make the risks and uncertainties that farmers currently confront even more severe. It affects food and crop production directly through changes in agro and ecological conditions, as well as indirectly through income development and distribution, and hence demand for agricultural commodities. This is because it has both direct and indirect effects on income (Schmidhuber and Tubiello, 2007). According to Fischer et al. (2007), decreases in agricultural yields or total crop failures can be attributed to the increasing frequency and duration of extreme weather events, as well as increases in the frequency, growth, and emergence of weeds and insects (Rosenzweig et al., 2001). It also has the potential to damage agricultural infrastructure (Rosenzweig et al., 2002). Temperature increases may be beneficial in certain parts of the world, but the overall consequences of climate change on agriculture would be detrimental, particularly in the Global South, posing a danger to the safety of food supplies worldwide (Rosenzweig et al., 2001; Hertel and Rosch, 2010). Recent modelling has shed light on how essential it is for agronomic adaptation to climate change in developing countries located in the Global South. A meta-analysis of crop simulations under various climatic scenarios discovered that adjustments in agricultural management could increase rice, wheat, and maize crop yields by 7-15 percent on average when compared to the non-adaptation scenario (Challinor et al., 2014). Therefore, farm adaptation is essential for agricultural output in the rural Global South, and if failures to perceive the threats of climate change hold this back, it will have wide-ranging implications for people's well-being and livelihoods.

An extensive body of research has explored the relationship between climate change perception among farmers in the Global South, and adaptation processes (Crane et al., 2011; Pelling, 2011; Mortimore, 2010; Below et al., 2010; Smit and Wandel, 2006; Adger and Vincent, 2005; Adger, 2003). The first point to be made is that farmers' climate change perception is built on top of pre-existing systems of agro-ecological and traditional knowledge. For many farmers in the Global South, decisions about agriculture are set within wider spiritual and religious beliefs about care, responsibility and the cycles of life (Smith et al., 2014; Artur and Hilhorst, 2012; Schipper, 2010). For example, a case study from El Salvador shows that religious beliefs are a significant barrier to risk reduction. According to the study, respondents perceived those floods and drought are created by God, and those who believe that preventive measures cannot alter the effects of floods and droughts because they are "God's will" are less likely to adopt preventive measures and rebuild homes in the same high-risk areas where they previously lived

(Schipper, 2010). Similarly, in Mozambique, a priest would generally pray for individuals who had lost their lives and possessions. He would describe God as extremely strong, capable of commanding floods and storms and in charge of deciding who lives and who dies (Artur and Hilhorst, 2012).

Also, perception can lie dormant as an agent for adaptation in times of climate stability, but then become more prominent in times of exposure to extreme events and climate variability (Berrang-Ford et al., 2011; Ostwald and Chen, 2006; Thomas et al., 2007; Bryant et al., 2000). It appears that having firsthand experience with the consequences of climate change, such as flash floods or a straight influence on economic activity, is one of the most important factors in determining how people perceive the situation (Elshirbiny and Abrahamse, 2020). Farming experience, increasing age, and access to extension services are the three factors that are reported most frequently as having a positive influence on perceptions of climate change (Oduniyi and Tekana, 2019; Alemayehu and Bewket, 2017). Also, perception is not just limited to people who grow crops (Liverpool-Tasie et al., 2020). An increasing corpus of literature demonstrates gender differences in climate change perceptions, effects, and responses in the areas of Sub-Saharan Africa (Assan et al., 2020; Schofield and Gubbels, 2019; Wrigley-Asante et al., 2017; Meharet al., 2016; Jost et al., 2016; Fisher and Carr, 2015; Carr and Thompson, 2014; Harmer and Rahman, 2014; Sultana, 2014; Deressa et al., 2009). Gender is frequently a potent sign of adaptive capacity that interacts with other indicators of susceptibility to either limit or facilitate adaptive behaviour (Carr and Thompson, 2014). In many situations, gender affects access to resources like land, labour, money, agricultural supplies and tools, extension services, and adaptation programmes themselves. For example, men and women in rural places of Senegal, usually have separate roles and responsibilities on the farm and also in the family, with women most responsible for domestic work, childcare, and subsistence farm output. Women frequently lack authority in decision-making for on-farm and non-farm related activities; societal norms can also restrict their mobility and hence their capacity to employ adaptive methods outside the boundaries of their community (Djoudi and Brockhaus, 2011). Moreover, as will be elaborated upon below, climate change in any case is just one area of risk facing farmers. Hence, it cannot be assumed that climate change perception of itself will translate directly to decisive and prioritised actions by farmers in order to adapt to the climate change (Tucker et al., 2010; Bryan et al., 2009; Deressa et al., 2009; Bryant et al., 2000).

This is an important point in the context of efforts by scientists and government organizations to enhance farmers' climate change literacy with the goal of implementing adaptation practices. Eitzinger (2018) argues that in the context of farmers' decision-making process about agricultural adaptation, it is important to understand where climate risks are situated within the overall context of farmers' livelihood risks. The attempts of climate change experts to assist farmers in adapting to the effects of climate change are frequently based on the experts' own views of the dangers posed to farmers' means of subsistence. But if farmers and experts have different ideas about how dangerous something is, these methods might not work. For example, in the Cauca region of Colombia, climate-related and other concerns regarding farmers' livelihoods were understood differently by local experts and farmers (Eitzinger, 2018). Farmers ranked failure in agricultural productivity and a lack of access to health and educational facilities as the most significant concerns, while experts listed instability and unpredictable weather conditions as the most significant threats to farmers. This divergence in viewpoint is a reflection of Duflo's (2006) observation that farmers might be considered utility maximizers since they make decisions to maximise nett benefits by minimising probable losses from unpleasant events and maximising gains from new possible outcomes. Land degradation, pests, changes in the market or opportunities outside of agriculture, and climate change are all examples of these types of challenges.

Moreover, Tucker et al. (2010) found that the level of a household's concern about climate stress did not appear to lead to adaptive adjustments for coffee producers in three Central American nations, casting more doubt on any simple relationship between knowledge and practise of adaptation measures. The research points to a complicated interaction between perception, social distinction, and norms, as well as whether and how these transfer into climate adaptation behaviour. Other research shows that the importance of social identity in affecting how the perception of risks on climate stresses is translated into behaviours (Frank et al., 2011). In this example, coffee farmers in Mexico emphasised the impact of their informant's perceived social identity on the adoption of scientific climate change knowledge in connection to their own socio-political identities (Frank et al., 2011).

Therefore, understanding farmers' perceptions and how they influence their decision-making is crucial for effective design and implementation of adaptation solutions for farmers. It needs to address climate change adaptation in the setting of the complex interaction of many other global changes or pressures (Westerhoff and Smit, 2008; Smit and Wandel, 2006; O'Brien et

al., 2004). Adaptations that do not take into account the intricate interplay of climatic and non-climatic stimuli may potentially be detrimental and may even lead to be maladaptive (Westerhoff and Smit, 2008). Also, farmers' views and perceptions about the causes and local implications of climate change have a large impact on their willingness to adapt (Haden et al., 2012). Therefore, effective policies aimed at climate change adaptation must connect climate change concerns to other production risks and stresses.

Climate change policymakers must take into account these variations of how affected people perceive climate stresses. However, perception alone is not enough. Perception without comprehension of the causes of climate change has consequences for climate action with the possibility of short-term responses (Elshirbiny and Abrahamse, 2020), which indicates the necessity of climate change literacy in the context of wider appreciation of livelihood stressors. Focusing on climate change literacy provides a tangible opportunity to integrate climate change into fundamental national and sub-national strategic goals in the Global South (Simpson et al., 2021). Simpson et al. (2021) indicated that education, gender, and mobility were all major positive predictors of climate change literacy in Africa. Policies aimed at these predictors may help to advance sustainable development goals such as gender equality and high-quality education, as well as climate change adaptation and mitigation (Simpson et al., 2021). But even if people know a lot about climate change (high climate change literacy), other problems, like a lack of money, could still make it hard to adapt to and reduce the effects of climate change (Acevedo et al., 2020). These wider contexts are now addressed.

2.4 Rural livelihood diversification

Rural households in the Global South frequently undertake a mix of farm and non-farm livelihood activities. Because decisions to undertake farm and non-farm activities are often interdependent of one another, climate change adaptation crosses over both the farm and non-farm sectors. To understand these processes, Sustainable Livelihoods Analysis (SLA) provides an appropriate an entry point.

According to the original definition of this approach by Chambers and Conway (1992, p. 6), *"a livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide*

sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term". According to this definition, one's capabilities are the options to pursue various activities to create the necessary income for life and to reach full human potential. A person's capabilities are determined by his or her portfolio of assets. In SLA, a conceptual framework is utilized to evaluate households' access to livelihood assets, their activities and reported outcomes, and the contextual factors that impact them (Chambers and Conway, 1992). The basis of this approach is the mapping of people's access to assets as well as their patterns of usage. Natural, physical, human, financial, and social capital are the five basic types of capital that contribute to livelihood assets (Scoones, 1998). Moreover, access to sources of livelihood is influenced by institutions, social interactions, and policies such as changing structures and processes, as well as shocks, trends, and seasons. When they are in such conditions, people who are impoverished participate in a wide variety of actions, decisions, and tactics for their sources of livelihood, in order to attain a wide variety of means of livelihood outcomes (Ellis, 2000). Diversification processes allow rural households with access to agricultural means of production to select between agricultural and non-agricultural economic activity. There are also different ways to adapt to climate change within agriculture, such as extensification, intensification, and leaving agriculture by choosing off- and non-farm activities, migration, and remittance strategies. Therefore, SLA provides a framework for analysing how decisions regarding whether and how to adapt to stressors such as climate risk are influenced by bundles of capital in the contexts of institutional restrictions, social and political and economic systems, and community needs and goals (Bassett and Fogelman, 2013; Adger et al., 2005; Adger, 2003).

When applied to rural households and communities in the Global South, SLA helps explain livelihood pathways between farm and non-farm activities. The majority of the population in the Global South continues to live in rural areas, and agriculture still plays a vital role in rural livelihoods. Therefore, access to land is a vital livelihood asset. It can provide the basis for own consumption of farm products, or cash income generation. Also, land is a fixed asset which can be used as a collateral for credit; performs as a safety net for rural households in response to shocks such as illness or natural disasters, and it is a source of status, pride, identity and comfort. For these reasons, land is a significant determinant for the poverty status of a household. Households that are landless or have only small holdings are typically poorer and more food insecure than households with larger-sized holdings (Rosset, 2006). Because of the

importance of land as a household asset, there is an inverse relationship between incidence of poverty and landholding size (Ali and Pernia, 2003).

However, at the same time, rural livelihoods in the Global South have become increasingly diversified and complex (Smithet al., 2005). The broad parameters of this process have been established in the last few decades by policy reforms that have spurred economic growth in the developing Asian countries by transforming rural areas (Brones, 2017). “A process of comprehensive societal change whereby rural societies diversify their economies and reduce their reliance on agriculture” is one definition of rural transformation (Berdegue, et.al, 2014, p.5). This transformation has resulted in an increase in job opportunities as well as an increase in income from non-farm activities, including remittances, which has led to a decrease in the number of people living in poverty in rural areas (IFAD, 2016; World Bank, 2019).

Household attributes, such as education and family size, can have a significant impact on the pathways utilized to diversify into the non-farm industry. According to Oluwatayo (2005), many socioeconomic factors, such as the education level of the household head, farm families' income from farming, and the country's perceived economic position, all have a role in determining the possibility of income diversification tactics among farmers. In a similar vein, Awoniyi et al. (2011) demonstrate the impact of non-farm income on the living standards of farming households. They cite factors such as age, education level, patriarchal family structure, the family's poverty status, and farm size as major determinants for deciding to diversify their source of income beyond farming. Some studies showed that the cultural or ethnic identities of various groups served as a significant factor to the implementation of certain techniques for the diversification of livelihoods (Crane et al., 2011; Nielson and Reenberg, 2010).

From the perspective of rural households, opportunities to diversify income can represent both a risk-averse technique for securing a steadier income, or as an opportunity-driven plan to better their living conditions (Hagglade et al, 2010). In the language of Ellis (2000), livelihood diversification can offer rural households greater flexibility in allocating their resources among various income generating activities and which can lead to increased resilience to economic and environmental shocks. Low and unstable farm incomes, severe consequences of climatic uncertainty or climate related hazards on crop yield or loss, or land pressures such as restricted lands caused by expanding population are some of the push factors for rural parts of the Global South. (Mulyoutami et al., 2020; Roy et al., 2020; Bacud et al., 2019). The rise of labour-

intensive enterprises and the urban service sector are two examples of the pull factors that might be at play here (Bacud et al., 2019).

Extensive work by Rigg over the past two decades (Rigg, 2006; Rigg, Salamanca and Thompson, 2016; Rigg, 2020) provides a compelling argument that as these processes have advanced, the role of land has become progressively less important in rural livelihoods of the Global South. He argues that rural households are delinking from agriculture. In rural Southeast Asia, Rigg (2020) reports that the proportion of the rural population directly depending on agriculture is in consistent decline in every country. A lesser share of the rural population therefore depends on land for their livelihoods via own-cultivation or as a source of work. The agricultural production that takes place, furthermore, is increasingly destined for market-sale rather than own-consumption. Therefore, land is tending to have a lesser role as an asset for meeting households' food security needs through own production, as households increasingly procure food from market channels. In other words, rural households engage more in non-agricultural activities. Haggblade et al. (2010) found that share of non-farm incomes occupies up to 50 percent of total household incomes in the countries of Global South. Evidence suggests that non-farm activities provide close to 37% of income for African rural households, despite the fact that such activities employ only 9-19% of the rural labour force (Haggblade et al., 2007). Working outside of agriculture is particularly crucial for producing income and job opportunities for the lowest-income members of society, especially women and those with low levels of education or training (Nadvi and Barrientos, 2004). It has been highlighted that the promotion and creation of rural non-farm activities, in addition to chances for earning cash, play an essential role in lowering the level of food insecurity that exists in rural Africa (Barrett et al., 2001). Diversification of livelihoods is common and may be found everywhere, on farms of all sizes and in households of different socioeconomic standings (Ellis, 2000).

Diversification, both inside and beyond the domain of agriculture, is a method that is widely acknowledged for its effectiveness in decreasing risk and enhancing well-being. According to Lohmann and Liefner (2009), non-farm activities have the potential to significantly contribute to the alleviation of poverty by offering households protection from the risk associated with farming and reducing their reliance on the availability of natural resources. Chianu, Ajani and Chianu (2008) pointed out that there are many risks associated with agriculture, and as a result, many rural farm households may be unable to satisfy basic demands, causing members of the

household to look for alternative ways to make a living. Diversification helps contribute to resilient livelihoods through the distribution of risk that it creates. As a result, there is a general pattern observed among rural households to rely on some combination of agricultural and non-agricultural occupations in order to make a livelihood.

These trends are especially important in Southeast Asia. Rural communities and agrarian economies in many parts of Southeast Asia have changed enormously in recent decades. Two decades ago, it was observed that farming was a subsidiary activity for 57% of rural households in the rice growing area of Thailand, which indicates that diversification into non-agricultural activities was an essential component of this transition (Molle et al., 2001). Rigg (2005, 2018) shows that there is evidence of the transformation of peasants in some areas into post-peasants as a result of economic reforms, marketization, and the integration of the country into the larger Greater Mekong Sub-region. These tendencies, which are prevalent in Asia, may also be observed in Africa, where non-agricultural activities were estimated to account for 60 to 80 percent of rural household income, two decades ago (Bryceson, 2002). The examination of rural livelihood diversification needs to take into consideration the fact that, in some circumstances, it is a response to opportunities, while in other circumstances, it is a response to crises and distress. Non-farm activity can give better relative returns, a means of obtaining food when farm output is insufficient, non-farm revenue streams to pay for agricultural inputs, and a means of offsetting the risky returns to farming (Reardon et al., 2000). Therefore, livelihood diversification is used as a risk avoidance strategy in these cases. Crucially important here is that the way that rural households change their livelihood strategies based on the assets they have, their contexts and the internal stresses they face. These situations provide the basis through which they build resilience and maintain sustainability of their livelihoods (Scoones, 2009).

However, rural livelihood diversification also has distress elements, and needs to be contextualised by the emergence of new stresses and risks for rural populations. Distress-induced livelihood diversification occurs when households need to diversify their livelihoods as a strategy to reduce vulnerability due to environmental uncertainty and shocks such as flood and drought (Lohmann and Liefner, 2009). This is more prominent for poor households compared to rich households. Poor households with very few assets are more reliant on low-paying jobs since they are forced to diversify their source of income to minimise risks (Lohmann and Liefner, 2009). For instance, Bouahom et al. (2004) expressed a scenario in

northern Laos in which there was little chance for increased agricultural productivity to bring households out of food insecurity. As a result of this lack of hope, households were forced to become dependent on off-farm or non-farm work out of necessity rather than choice.

While non-farm income has the potential to lessen the reliance of rural livelihoods on natural resources and reduce their susceptibility to environmental hazards (Lemos et al., 2016), the processes through which these changes take place are complex and need to be better understood. Even though non-farm income may reduce their reliance on weather-dependent agricultural activities, it is hard to say how diversifying income and livelihoods affects the vulnerability of rural households because there are so many different stressors at play. Although every decision done by rural households for their livelihoods is not triggered solely by climate change, it plays as an intensifying factor for making decisions. We now consider climate change in these contexts.

2.5 How climate change interacts with complex rural livelihoods

The discussion so far in this chapter has outlined the two themes of climate change adaptation and rural livelihood diversification. Despite the fact that climate change poses a novel threat, farmers are not unfamiliar with the concept of adapting to changing conditions. Various social, political, and environmental factors have interacted to transform and redefine farming practises, thereby establishing the framework for future attempts at adaptation (Burnham and Ma, 2016; Crane et al., 2011; Smit and Wandel, 2006; Adger et al., 2003; Raynaut, 2001). While the primary emphasis of most definitions of adaptation is placed on the process of adjusting one's behaviour in response to the expected or actual effects of climate change (IPCC, 2018), researchers concur that adaptation occurs frequently when the consequences of environmental change, globalisation, and the social pressures that come along with them intersect (O'Brien and Leichenko, 2000; Thomas et al., 2007).

A key point is the observation in the 6th Assessment Report by the IPCC Working Group II (IPCC, 2022 [approved draft]), mentioned in Chapter 1, that most of the adaptation approaches presented to farmers in the Global South fall under the category of 'incremental adaptation', and according to the IPCC, "will not be enough, transformational change is required" (IPCC, 2022 [approved draft], p. 10-106). In these contexts, incremental adaptation relates to changes in the cropping pattern and systems, improved crop varieties and agronomic practices,

irrigation and water management practices and water and soil conservation measures. Farmers who use incremental decision-making to run their farms have less risk because they make changes in a more gradual changes instead of making complex and hard decisions (Nielsen, 2009). Some examples of incremental adaptation are the following: the cultivation of new varieties (Alam, 2015; Chhetri et al., 2012); changes in cultivation timing (Shaffril et al., 2018; Gandure et al., 2013; Finger et al., 2011; Deressa et al., 2009); diversification of production (which includes growing different types of crops and different species of plants); and crop changes (Shaffril et al., 2018; Chhetri et al., 2012). Although these reactions have the potential to generate some advantages for improved yield, they are only incremental in nature and serve to boost crop output in the short run. It is not possible for these practices to change automatically to a kind of adaptation known as transformational adaptation in order to lessen the risks posed by climate change over the longer term. (Fedele et al., 2019; Pelling et al., 2015).

In many rural areas, climate risk reduction interventions have focused on agriculture. More specifically, these interventions have promoted "climate-smart" production technologies such as conservation agriculture, heat and drought-resistant seed varieties, crop and varietal diversification, and institutional support for on-farm management for example, index-based insurance (Hansen et al., 2019). This was done to lessen the effects that climate change has on agricultural production. However, there is little evidence to suggest that these incremental adjustments, which were made with the intention of managing agricultural risks, have led to major gains in household welfare or a reduction in poverty (Hansen et al., 2019). In addition, there is not a great deal of evidence to suggest that recent adjustments made on farms, which are often carried out in a piecemeal approach, are sufficient to guarantee food security and sustainable farm livelihoods in the face of climate change (Thornton et al., 2018).

In these contexts, it is apparent that transformative adaptation is required. But what does this mean for smallholder agriculture in the Global South? Panda (2016) argues that transformational adaptation means going beyond modifications made at the farm level and including those made at higher scales and over larger spaces. Choices for transformational adaptation include less focus on agronomy at the field level and more focus on options related to structure, scale, and location, such as geographical diversification and off-farm investments (Douxchamps et al., 2016). One method for moving from incremental to transformational

adaptation may be to invest incremental adaptation benefits in education and capacity building to increase total adaptable capability (Vermeulen et al., 2018).

At issue here is that scientists, government organizations and extension agencies tend often to be focused on areas of single expertise which leads to incremental rather than transformative adaptation thinking. It is crucial to understand the local context of rural households' livelihoods in order to design effective, transformative adaptation measures. At the community level, transformative adaptation would include both top-down structural measures, like national adaptation plans, financial services, and economic forces, and bottom-up non-structural measures set up by the community itself as part of a group effort to deal with climate change (Girard et al., 2015). Differences in opinion on climate change between agricultural professionals and farmers only contribute to exacerbate the difficulties associated with developing agricultural policy and making climate-relevant decisions. Scientific agreement on the existence, risks, and potential solutions to climate change needs to be connected to farmers' worldviews, to ensure these are not undervalued or misinterpreted (Ding et al., 2011). According to the findings of some research on adaptation in Africa, socioeconomic and market factors are of more relevance to farm households and individuals than climate and weather (Berrang-Ford et al., 2011; Tucker et al., 2010; Mertz et al., 2009; Ostwald and Chen, 2006). In Ghana, it was revealed that a lack of money, which is a non-climatic stressor, was the most prominent stressor driving livelihood vulnerabilities. In this case, a lack of money can be linked to a lack of work opportunities as well as chances for non-farm livelihoods. It can also be attributed to the low profitability of farming, which can at least partially be attributed to limited access to markets (Antwi-Agyei et al., 2014; Antwi-Agyei et al., 2013; Dasgupta and Baschieri, 2010). These all showed that the necessity of situating adaptation strategies for climate change within a wider set of drivers of adaptation and emphasise the need for transformative change.

Hence, the risks posed by climate change are just one of several driving forces that motivate households to diversify their sources of income. As already noted, non-farm rural livelihood diversification is an important process in the Global South. Livelihood diversification in response to climate stress can be understood as a sub-category of this process. It can often take the form of a type of distress diversification because it is an involuntary action deemed necessary to ensure household livelihood survival (Cinner et al., 2010).

These perspectives bring into focus the role of migration. Migration is a type of non-farm livelihood diversification. Migration can occur seasonally, temporarily, or permanently. There is a considerable volume of research that points to the connections between migration and the effects of climate change. In Ghana, the majority of households consider climate uncertainties to be the most significant factor contributing to their need to migrate (Abu et al., 2014). The varying amounts of rainfall in Tanzania was shown to have a strong connection to the migration patterns of farm households (Afifi et al., 2014). Migration is caused by a number of circumstances, with weather-related factors being prominent, including the frequency of droughts and water shortages (Afifi et al., 2014). Moreover, migration patterns can vary greatly due to differences in the amount of precipitation experienced at those different elevations (Afifi et al., 2014). In Guatemala, rural populations are especially vulnerable to environmental and climatic conditions and hazards since their means of agricultural production make them dependent on rain for their food production. Therefore, Milan and Ruano (2014) argue that even though there are other factors that affect migration, such as alternative household income sources or food insecurity, an underlying cause of migration is climate change. In these senses, migration can be considered a type of transformative adaptation (Hadarits et al., 2017). Migration is transformative because it enables households to transition to livelihoods that are less sensitive to environmental change and less dependent on agriculture.

However, transformative pathways associated with migration are not always simple (Pahl-Wostl et al., 2020). It has been shown that the male migration from rural regions has a negative effect on crop productivity. This is due to the fact that farm households are left without enough men to fulfil the gender-related responsibilities of land operation (Sumner et al., 2017). When male members of a household migrate, the remaining female members of the household are responsible for managing the farm and other household chores. Under these contexts, women's labour engagement in the agricultural sector as well as continuous domestic responsibilities has expanded. This has had an effect on time, budgets and the quality of care that is provided to other members of the family. On this basis, Jacobson et al. (2018) argue that migration may be maladaptive action in long term. Their study showed that rural households who use migration as a coping strategy to climate stress is affecting food production system in Cambodia. Migration in Cambodia is mostly temporary, and time of peak migration has in the past coincided with the time of peak rice planting. Therefore, migration affects crop production and contributes to reduced food insecurity in Cambodia. In these cases, migration represents a loss

of critical labour from rural farm communities and make the effect of climate change worse than remedying it.

At the same time, other research points to different outcomes. Choithani (2015) argues that the migration of males has created space for women to participate more actively in decision-making at home while their husbands are away, which has the potential to increase the women's ability to exercise autonomy within their households. In terms of food security, households in which women have the autonomy to decide how to spend remittance money spend a larger percentage of that money on food as compared to households in which males determine how to spend remittance money and women have less authority. Moreover, remittance money also contributed to children's education and health. It is also reported that there is a relationship between school dropout rate and remittances. Migrated households responded they used remittance money to cover school fees and health services (Lacroix, 2011).

In summary, there are diverse pathways that connect climate change with rural livelihood adaptation. Much of the existing efforts in this area are focused on changes to agricultural systems at the farm level and can be considered forms of incremental adaptation. The challenges of climate change however suggest transformative adaptation is required. This points to broader changes in how households construct their livelihoods, and dovetails with pre-existing, and ongoing pathways towards the non-farm economy. In these contexts, migration looms as an increasing option for climate-stressed rural households, but research is mixed on its social and economic implications.

2.6 Conclusions

In summary, agricultural adaptations are not carried out solely in reaction to climate stresses but may be considered as the result of a combination of multiple factors (Smit and Skinner, 2002). People adapt to changes in their external frame conditions in a number of ways and assessing complicated changes in institutional arrangements and determining what can be legitimately assigned to climate change and what can be attributed to other frame condition changes can be challenging. These interactions also complicate how people adapt in both short and long-term situations. Climate change adaptation in agriculture can be accomplished through the adoption of new technologies and a variety of management practices (Smit and Skinner, 2002). However, there is no comprehensive framework for adapting and adopting new

technologies practices and practices. Successful adaptation should be founded on both local, and scientific knowledge, with a view to transformative change, and it should be kept up to date with new research findings.

There is a lot of discussion in the literature on both the level of awareness that farmers have regarding climate change and the connection that exists between that awareness and their action. This is due to the fact that differences in perception have significant repercussions for the actions that are conducted (Raymond and Spoehr, 2013). The discussion that was presented earlier offers a comprehensive and contextually varied overview of the adaptations that have been developed in response to climate change and climatic fluctuation. The strategies range from incremental to more evident agricultural modifications, religious and cultural approaches, and the utilization of local and broader support networks. While there is argument over whether some approaches should be classified as incremental or transformational, the key point is the complexity of how strategies are applied in diverse contexts.

Stresses to agricultural production from climate change can encourage farm-based households to increase their livelihood dependence on non-farm sources of income. However, as discussed earlier in this chapter, rural livelihood diversification is a major theme of change in the Global South that transcends climate change as a single driver. Furthermore, while many of the rural livelihood strategies discussed might be viewed as reactions to natural climatic variability or non-climatic variability or combined, this provides an important insight into possible adaptations to future climate change at the farm level and beyond agricultural contexts across the Global South. While not underestimating the need to minimise the negative effects of climate change on rural livelihoods, this study emphasises the importance of addressing both climatic and non-climatic stressors.

3. CHAPTER THREE: PLACING CLIMATE CHANGE ISSUES IN THE CENTRAL DRY ZONE OF MYANMAR

3.1 Introduction

This chapter highlights the geographical context of the research by situating climate change in Myanmar's Central Dry Zone within global perspectives. The Government of Myanmar's climate change strategy 2018-30 acknowledges that: "Due to its exposure and sensitivity to current and projected weather patterns, Myanmar is extremely vulnerable to the impacts of climate change" (Government of Myanmar, 2019, p 20). Taking this observation as a starting point, this chapter first presents climate change as a global concern with specific impact on agriculture. Then, it addresses its impacts on Myanmar, and finally, the Central Dry Zone (CDZ). The chapter emphasizes the distinctive agricultural and rural livelihood attributes in the CDZ that shape the exposure and vulnerability of its population to specific climate change-related threats, and which make it an appropriate study site for this research.

3.2 Climate change at the global scale

Average global temperatures are slightly more than 1.5 degrees Celsius higher than in pre-industrial times. Many studies have highlighted their rapid increase as being one of the most challenging issues of the 21st century (IPCC, 2022 [Approved Draft]). Recognition of the widespread, destabilising effects of climate change was apparent in the earliest days of international consideration of this issue, with WMO and UNEP (1992) stating that the environment, as well as socioeconomic and related sectors like agriculture and food security water resources, human health, biodiversity and terrestrial ecosystems, and coastal zones, will be significantly impacted by climate change. The main effects of climate change are related to sea-level rise; temperature (variation and mean values); changes in the intensity, timing, and spatial distribution of precipitation; and the number, severity, and length of extreme weather events like floods, droughts, and tropical storms (USAID, 2007). During the past decade, there has been a rise in the number of natural disasters that are caused by the climate. The effects of climate change pose a threat to the social and natural systems of all continents. Higher average temperatures are producing changes in the patterns of precipitation in many different regions, which will have far-reaching implications for hydrological systems (FAO, 2016; IPCC, 2014, 2007).

The extent to which human and biological systems are susceptible to the effects of climate change is directly proportional to their respective levels of exposure, sensitivity, and adaptability (Reidsma et al., 2009). Despite the fact that climate change is a global process, these three components are not consistent across the globe, which results in considerable regional differences (USAID, 2007). However, each of these three contributors to climate change impacts is determined by various factors and measuring these will vary depending on the models used (IPCC, 2007; Schmidhuber and Tubiello, 2007). In Asia, the capability for adaptation differs are based on culture, social structure, economic capacity, location, and the degree to which environmental degradation has occurred. For example, the successful implications of early warning systems for extreme weather events in Bangladesh and the Philippines has contributed to an increase in adaptive capacity for these parts of Asia. However, this capacity is still hindered by a number of obstacles, including inadequate resource bases, income disparities, ineffective institutional governance, and a lack of technological advancement (UNFCCC, 2007).

These differences are especially true for agriculture, which is acknowledged as being highly climate sensitive (Meinke et al., 2009). The World Bank (2006) believes that the effects of climate change on agriculture may be severe in various ways in the region. Nevertheless, the exact extent of the threat cannot be determined because of the complex linkages and feedback processes that occur in both the ecosystem and the economy (World Bank, 2006). However, the scientific data highlight the majority of the negative climatic effects on agriculture can be found in the tropical regions. Assessments on the effects of climate change in the different sectors showed that there are serious impacts on agricultural productivity. Even a slight increase in temperature, for example, one degree Celsius for wheat and maize and two degrees for rice, can have a substantial impact on agricultural production in tropical nations. This is because many plant species have already reached the upper limit of their heat tolerance. Increases in temperatures of more than 3 degrees Celsius are predicted to produce massive yield reductions, therefore, agricultural productivity in the tropical regions is at threat. Even if some farm-level adaptation to higher average temperatures is implemented, it cannot wholly solve those problems. For example, wheat and maize yields in certain regions of Africa, Asia, and Central America may decline by 20 to 40% when temperatures rise by 3 to 4 degrees Celsius although farmers are adjusting their farming practices to offset the effect of climatic stresses. Consequently, these will have detrimental effects on food supply in tropical zones. On the other hand, it is anticipated that there will be some favourable benefits in regions located

at higher latitudes. Overall, increase in temperature would result in lower yields, and the nations in the tropical region, particularly with high population densities would be especially susceptible to increasing food insecurity (FAO, 2016; FAO, IFAD, and WFP, 2015; Elbehri et al., 2015; Rosenzweig et al., 2014; IPCC, 2014).

These issues are very prominent for most of the tropical countries in the Global South because agriculture is the primary livelihood and income generation for households for the vast majority of population. The reduction in agricultural production caused by the adverse consequences of climate change will initially have an impact on these households which rely on farming. In addition, there is the possibility that climate change will have an indirect influence on the income opportunities of rural households that are not involved in agriculture through channels such as the labour market. For example, when climate change has an impact on agricultural productivity and crop prices, the wages for the marketing process and other farming related activities will have impacted. Therefore, this will also have an indirect impact on the earnings of families who do not work in agriculture (IPCC, 2014; Hertel and Bosch 2010). Overall, rising temperatures have a detrimental effect on crop yields in many regions of the world, which creates significant challenges for the global food security, food supply, human health, and the reduction of poverty and these effects are more challenging for agricultural households in the vast majority of developing countries in the Global South (IPCC, 2014; World Bank, 2014; World Bank, 2013).

3.3 Climate change in Myanmar

These issues are particularly true for Myanmar because the country’s economy is predominately agricultural. Myanmar is situated on the mainland of Southeast Asia and over thirty percent of the country's Gross Domestic Product comes from agriculture, with a growth rate of 3.2 percent in 2016 (Government of the Republic of the Union of Myanmar, 2018). Also, agriculture employs approximately 61 percent of the total work force (Government of the Republic of the Union of Myanmar, 2018). This implies that improvements to agricultural practises will benefit the vast majority of the population. The country's agricultural productivity, on the other hand, is becoming increasingly susceptible to the effects of climate change. This is because the country is overly reliant on its agricultural sector and because it does not take significant steps to adapt to or mitigate the effects of climate change (Kreft et al., 2017).

Myanmar has a tropical climate with a dependence on monsoonal rainfall. Its vulnerability to climate change rests on the effects of increased temperatures plus heightened unpredictability of monsoonal cycles, including the effects of storm surges and cyclones, in coastal regions. Myanmar's annual weather pattern consists of three seasons, namely summer (mid-February to mid-May), rainy (mid-May to mid-October), and winter (mid-October to mid-February) (DMO and FD, 2009). There is a large amount of variation in the average precipitation across the country. The coastal areas receive precipitation that ranges from 4,000 millimetres to 5,600 millimetres, while the Central Dry Zone receives precipitation that ranges from 600 millimetres to 1,400 millimetres (DMO and FD, 2009). The mean temperature in Myanmar ranges from 10 to 32 degrees Celsius, with an average mean temperature of 21 degrees Celsius in the northern plains. The temperature in the highlands can drop to -1 or 0 degrees Celsius on occasion, while the average temperature along the coastline can reach 32 degrees Celsius. It is possible for temperatures in the Central Dry Zone to reach 40 degrees Celsius or more during the summer months (NCEA, 2010).

Moreover, Myanmar is also prone to heavy rain, with floods occurring frequently during the mid-monsoon season which is June to August, in areas traversed by rivers or large streams. During the past four decades, Myanmar has been hit by five major cyclones, including the Sittwe Cyclone in 1968, the Pathein Cyclone in 1975, the Gwa Cyclone in 1982, the Maungdaw Cyclone in 1994, Cyclone Mala in 2006, and Cyclone Nargis in 2008. Wind gusts in excess of 200 kilometres per hour were responsible for considerable damage to the Ayeyarwady Delta that was caused by "The Nargis." The majority of the destruction was concentrated in the Delta, the eastern part of Yangon, and the Yangon Division. Moreover, the central region of Myanmar is struck by other kinds of disasters. During the summer, streams are dry and filled with sand, but a sudden flash flood can be caused by the rainy season. This flash flood can have catastrophic consequences, including the displacement of people, animals, and homes (NCEA, 2010).

Myanmar ranks first in Southeast Asia in terms of its economic vulnerability to climate change (ADPC, 2015). There are two components to this vulnerability; its exposure to climatic change and the capability of its institutions and people to adapt to changed climate circumstances. The most comprehensive assessment of Myanmar's vulnerability to climate change is the Government of Myanmar's *Climate Change Strategy 2018-30* (Government of Myanmar, 2019), which sets out the country's key areas of vulnerability. These are drought, cyclones and

strong winds, floods and storm surges, intense rain, extreme daytime temperatures, and rising sea levels (Figure 2). According to Myanmar's Climate Change Strategy, the detailed impacts of these major climate risks are as follows.

Due to the fact that it might have serious repercussions right away, ***drought*** has been singled out as one of the key climate risks that Myanmar faces. The Central Dry Zone and the Rain-shadow Central Belt both have a significant potential for drought. As a result of the drought, farmers witness the failure of their crops and receive lower harvests. A further consequence of dryness is a decline in river flow, which is exacerbated by the fact that rainfall amounts are both decreasing and unpredictable. Because of this, people in the area have had a hard time getting enough water for their homes, farms, and drinking.

Cyclones and severe winds are two types of weather that might pose a threat to people living in coastal areas, such as Rakhine, the Ayeyarwady Delta region, and the state of Mon. These risks can have severe repercussions, as evidenced by the fatalities that Cyclone Nargis brought about in the Ayeyarwady Delta in the year 2008. Crops, land, and infrastructure all suffer immediate harm when a cyclone passes through the area. In addition, farmers have reported encountering intrusions of salty water in their agricultural fields, which has a severe impact on the productivity of their crop production. In addition, the coastal environment as well as the ecological services it provides are negatively impacted by these dangers. In addition, those who live in coastal areas have an increased risk of being killed or injured by storms, which can also threaten their ability to earn a livelihood.

Because it has the potential to cause flash floods, intense surface runoff, and damage to agricultural land, ***intense rainfall*** is categorised as another serious hazard that can occur in Myanmar. In addition, as a result of the higher water levels brought on by La Nina, the issues could be made even worse by an increase in the intensity of the rains. Heavy rains have fallen in the Ayeyarwady river basin, the coastal areas, as well as the mountainous and hilly regions of the Central Dry Zone, the Shan, Mon, and Chin States, the Kayin and Kachin States.

Floods and storm surges provide a significant climate hazard that must be taken very seriously in the upper levels of river systems, coastal areas, and low-lying places, as well as river systems like the Ayeyarwady Delta. River flooding, flash flooding, and urban flooding are the immediate results that this phenomenon creates. In addition, severe land inundation may occur

as a consequence of the storm surge and floods that precede it. These threats have a direct impact on agriculture, causing chaos in crop production as well as on the land and the infrastructure that supports it.

Since temperatures in Myanmar's arid and semi-arid central belt and Central Dry Zone have been steadily climbing for some time now, ***extreme high temperatures*** can be categorised as one of the country's key climate threats. In addition to having a huge influence on people's health, it has the potential to bring about heat waves and urban heat islands. Furthermore, temperatures that are unusually high might reduce the amount of water that is available for usage in both residential and agricultural settings.

The last environmental threat that may be observed in Myanmar is ***sea-level rise***, which can be seen along the coast, most notably in the Rakhine and Ayeyarwady regions. It is possible for cultivated croplands and towns that are surrounded by seawater to suffer damage as a result of seawater intrusion. In addition, increasing sea levels are wreaking havoc on land, infrastructure, and the ecosystems that live along the coast. The rise in sea level has a direct impact not only on the intrusion of salt water but also on the erosion of coastal areas.

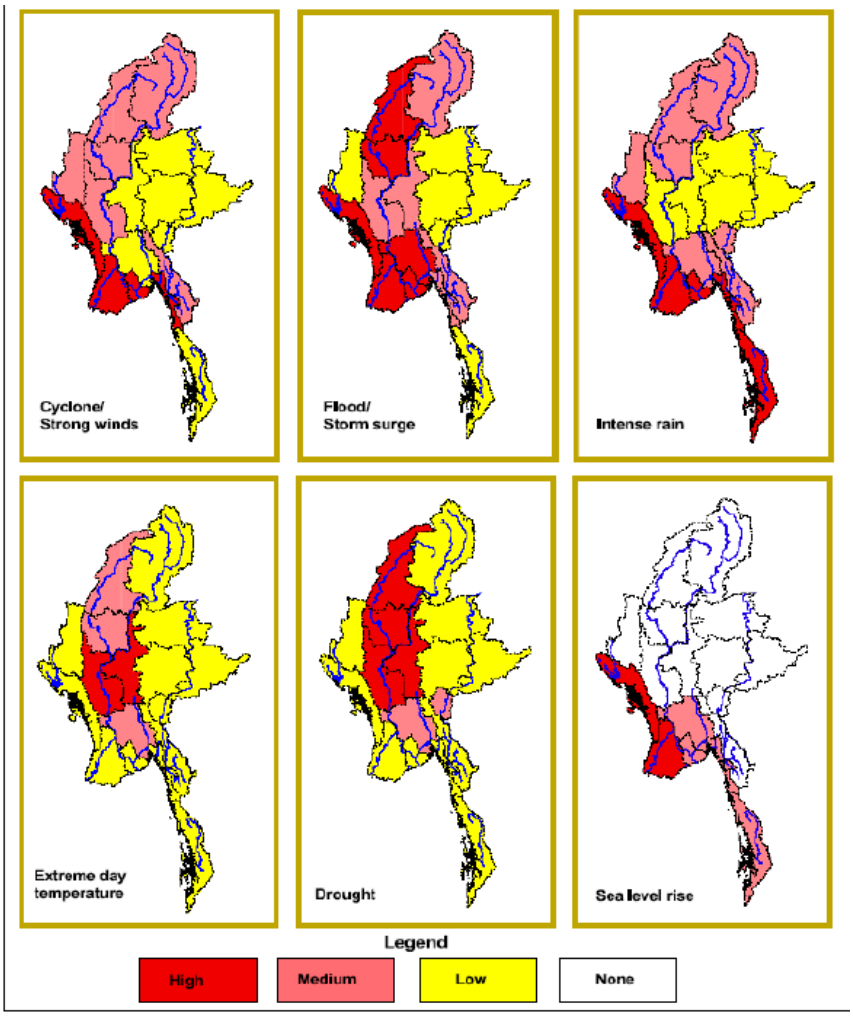

Figure 2: Climate risks levels for potential regions and states of Myanmar

(Source: NAPA, 2012)

Data on Myanmar's climate from the years 1994 to 2013 places the country in second place globally in terms of the frequency of extreme weather events (Kreft et al., 2017). Despite its severity of climate risks in Myanmar, there is still a scarcity of published material on climate change in Myanmar. However, there are some studies related to climate change and the development of climatic patterns that have been conducted in Myanmar by the Department of Meteorology and Hydrology (DMH, 2011). In their research on Myanmar's climate, they found that temperatures have a tendency to increase, but at the same time, there has been a decline in both the length of the rainy season and the intensity of the monsoons.

It is very critical to take account the fact that agriculture is the nation's primary source of income when discussing Myanmar's ability to adapt to the consequences of climate change

(NCEA, 2010). Seventy percent of Myanmar's population calls rural areas their home, and the majority of those people are employed in agriculture, livestock, or fishing. The level of agricultural productivity continues to be strongly dependent on the climatological circumstances, notably the amount of available precipitation. Besides, the vast majority of farmers are those who own very modest plots of land, with the typical size of these plots being about 2 hectares (World Bank, 2013). There is a wide range of climates in Myanmar, which allows for the growth of a vast range of crops. The majority of the farmland has a tropical climate, but some areas, including the hills and plateaus, have a subtropical climate. Rice is the most important crop in terms of food production in this country, but most places also cultivate other types of crops. Rice has traditionally been farmed as a single crop by most farmers but mostly it is rain-fed farming. Oil seeds and other types of cash crops are grown particularly well on the central plain areas including Central Dry Zone. The rainfall that occurs as a result of the activity of monsoons, on the other hand, is notoriously difficult to anticipate, which results in significant variation in annual precipitation. Rainfall associated with the monsoon season can be broken down into five distinct phases: the early monsoon, the late monsoon, a break in the monsoon, the early departure of the monsoon, and the late departure of the monsoon. The activity of these monsoons, which leads to different levels of precipitation in different parts of the country, has an effect on the total agricultural production that may be achieved in any given year (NAPA, 2012).

The effects of climate change are making it more difficult for rural households to earn a living, which in turn is putting strain on their social and economic circumstances. Several studies have shown that changes in climate and water conditions can have an effect on agricultural practises. Because of the negative consequences of climate change, Myanmar's agriculture yields have been erratic (Hallegatte et al., 2016; WFP, 2013; Yi et al., 2012; WFP, 2009). This is especially true in the Central Dry Zone (CDZ), where the majority of farming is done with rainwater (Swe, 2012). Moreover, as discussed above, the Central Dry Zone region is very prone to the country’s major climate risks such as drought, intense rainfall and extremely high temperature.

3.4 Central Dry Zone (CDZ)

Among the three most important agro-ecological zones (the delta zone, the central dry zone, and the hill zone) in Myanmar, the Central Dry Zone is the region that is most susceptible to water stress as a result of extreme weather events such as erratic rainfall and extended dry spells

during the growing season. This is because the Central Dry Zone has the lowest average annual precipitation (Ministry of Agriculture, Livestock and Irrigation, FAO, and LIFT, 2016; Kyi, 2016; McCartney et al., 2015; Paul et al., 2015). The region is characterised by clay and sandy soils, which puts it at an increased risk of being eroded by both wind and water (IWMI, 2015; Anderson Irrigation, 2012; Soe and Kyi, 2016). Rains are absolutely necessary for farming in the Central Dry Zone, which means that crop yields are vulnerable to water stress and drought conditions.

The Central Dry Zone is located in the centre of Myanmar, covering 80,000 km^2 which is about 13 percent of the country's geographical area, and two-thirds of the country's agricultural land (54,390 square kilometres) (JICA, 2013; MLIP, 2016). It lies between the mountain ranges to the North, East, and West and the Ayeyarwady River delta to the South. The Southern section follows the Bago Hills, gains altitude to the North, and ends in Mandalay's South-East. There are two distinct seasons in the Central Dry Zone: (1) the wet season, which takes place from May to October, and (2) the dry season, which takes place from November to April (IWMI, 2015; Irrigation, 2012).

The Central Dry Zone constitutes three regions: Sagaing, Mandalay, and Magwe (Figure 3). A population of over 12 million people, or approximately 23 percent of Myanmar's total population are resident in the Central Dry Zone (MOALI, 2016; Vaughan and Levine, 2015; IWMI, 2015). Over 10 million people live in rural areas of the Central Dry Zone, accounting for roughly 80% of the CDZ's total population (MOALI, 2016; FAO, 2014). A typical village in the Central Dry Zone includes 170 households, with the average household consisting of 4.9 household members and farming constituting 60% of all activities carried out by households (LIFT, 2014). There is significant variation in farm size, ranging from 1 hectare to more than 20 hectares, but the median farm size is 3 to 4 hectares (LIFT, 2012; LIFT, 2014; FAO, 2014).

Even though the climate of the Central Dry Zone is tropical monsoon, the region receives substantially less rainfall than the rest of the country, with an annual average of 700 millimetres and a range of 600-1400 millimetres. This is in comparison to the country's average of between 2,000 and 5,000 millimetres (IWMI, 2015; Tun et al., 2015; FAO, 2009). The majority of annual precipitation falls throughout a period of five to six months, commencing in the middle of May and continuing until late October or the middle of November (McCartney et al., 2013). It is a challenging environment for agricultural production due to the fluctuating length of the

monsoon and the amount of rainfall that it receives, as well as the comparatively low capacity of the soil to hold water (Cornish et al., 2018; Vaughan and Levine, 2015).

The Central Dry Zone is extremely hot all year (temperatures range from 14 to 42 degrees Celsius), with little rainfall and significant evaporation. The precipitation pattern of rainfall is bimodal, with a dry period in July during the rain-fed agricultural growth season. The monsoon season begins in May, and the rains are greater from August through October. Nonetheless, there are distinct dry seasons and unpredictable rainfall patterns (both spatially and temporally). The expected level of risk for drought and high temperatures during the day is set at high (NAPA, 2012; CEDMHA, 2014).

In the Central Dry Zone, climate change forecasts reveal higher temperatures and more variable rainfall, with some studies predicting significant drops in overall quantity of precipitation. (FAO, 2014; ADB, 2016). Moreover, climate modelling indicates there is the change in annual rainfall (ADB, 2016), but more rainfall in the shorter monsoon seasons and less rainfall in the dry seasons. More high rainfall events during the short period which leads to flooding during the wet season, and worse and longer droughts during the dry season. These all would make things even harder for Central Dry Zone farmers, who are already having a hard time.

3.4.1 Impacts of climate change on agriculture in the Central Dry Zone

The Central Dry Zone is capable of producing a substantial quantity of agricultural goods, despite the fact that it is the driest region in the entire country. The vast majority of farm households have the capacity to cultivate a wide variety of crops (Irrigation, 2012). In 2010, the Central Dry Zone was responsible for 22 percent of the country's total rice production, 89 percent of sesame production, 69 percent of groundnut production, 70 percent of sunflower production, 92 percent of pigeon pea production, 97 percent of chickpea production, 52 percent of green gram production, and 95 percent of cotton production (McCartney et al., 2015; JICA, 2010). However, there are many negative impacts of climate stresses on agricultural production of the Central Dry Zone region.

The erratic rainfall patterns and lack of available water in the Central Dry Zone increase the likelihood of crop failure (IWMI, 2015; Irrigation, 2012). All of these elements raise the dangers that are posed to agricultural production, putting at risk the means of livelihoods for

farm households that are dependent on that production. In the years 2010 and 2011, on extended drought caused damage to a total of 129,811 acres of farmland, resulting in the loss of 2844 acres and considerable financial hardship for almost 41 percent of agricultural households (IWMI, 2015; Kyi, 2016). At the same time, the pasture for livestock also decreased accordingly (FAO, 2013).

The Central Dry Zone experiences dry intervals that are frequently prolonged throughout the wet season, with the longest dry periods taking place in late July or early August and having a potential duration of up to 14 days (IWMI, 2015). According to data that was collected on Myanmar's climate throughout its history over the last 60 years, the mean temperature in the Central Dry Zone has been gradually increasing by approximately 0.8 degrees Celsius every decade (IWMI, 2015). Therefore, research done by the World Bank shows that even though Myanmar is working hard to improve its agricultural industry, the country has to deal with the deteriorating effects of climate change every year (World Bank, 2016).

Moreover, rainfed agriculture in Central Dry Zone is a high-risk practice due to the water scarcity generated by strong seasonality and erratic yearly rainfall patterns, which is worsened by sandy and poor soils. These factors combine to create an unfavourable environment for growing crops. Furthermore, soil deterioration occurs in the Central Dry Zone because drought and land degradation are related. According to a global evaluation of the extent and type of land degradation, 57% of the entire area of dry lands in two major Asian countries, India and China, is degraded (UNEP, 1997). Soil fertility reduction owing to water and wind erosion, depletion of soil nutrients, loss of soil humus, secondary salinization, loss of biodiversity, and diminution and deterioration of vegetation cover all have a detrimental impact on agricultural production (FAO, 2013).

Because of the unpredictability of the weather, it is absolutely necessary to have an efficient irrigation system in place in order to safeguard crops and ensure the livelihoods of agricultural labourers and farmers. Unfortunately, a significant number of the Central Dry Zone's irrigation systems were established many years ago and are in poor condition; they need to be restored, updated, and enhanced so that they may continue to meet the ever-evolving requirements and requirements of their utilisation. Farming households no longer cultivate paddy outside of the monsoon season because of dwindling supplies of irrigation water from dams (Belton et al., 2017). Since 2004, an annual decrease in rainfall of 45–65% has been seen, and the withdrawal

of the monsoon in 2009 had a severe impact on 80–90% of sesame and sunflower crops, in addition to severely affecting 50–70% of rice production in sensitive areas (MOALI, 2016; McCartney et al., 2013). As discussed above, the anticipated shifts in rainfall patterns and the increases in temperature would be more severe in the Central Dry Zone of Myanmar.

Moreover, water shortage is not only for crop production and livestock, but the availability of domestic water use is also still a question mark. The vast majority of households in the Central Dry Zone rely on collected rainwater for their drinking, cooking, and cleaning needs. Some rural households in this region make use of the water resources provided by reservoirs, rivers, and groundwater (Slagle, 2014). Rural residents in the Central Dry Zone need to dig deeper wells and travel longer distances to acquire water (Khaing, 2010).

Accordingly, the production of food in Central Dry Zone is especially susceptible to variations in rainfall, and it is anticipated that climate change, in conjunction with a growing population, would worsen the mismatch between the amount of water that is required and the amount that is available. Despite having the second-highest population density in all of Myanmar, it is nevertheless one of the least developed areas. The Central Dry Zone is one of the regions of Myanmar that suffers the most from a lack of food security because severe water scarcity endangers agricultural productivity. As agriculture is the primary source of income in the rural Central Dry Zone, water becomes the key driver of income generation in the agricultural communities that dominate the rural Central Dry Zone. As a result of the lack of rainfall and seasonal shortages, households in the region are trapped in a cycle of poverty and vulnerability. Households in the Central Dry Zone are typically in financial difficulty, with more than 80% having taken out loans in the previous year (LIFT, 2014). Loans were largely utilised for food and agricultural inputs, with rich households spending far more on agricultural inputs than food and poorer families the reverse. Approximately one-third of families reported that their debt was escalating (LIFT, 2014), meaning that they had little room to make investment in innovation or experiment with new technology.

However, according to Myanmar Climate Change Strategy (2019), adjusting crop types and agricultural techniques to adapt the climate change, as well as mitigating the risk of crop loss and disasters, are the primary focuses of the climate-smart agriculture approach. For example, it includes developing drought tolerant crop varieties for the Central Dry Zone. The government's plan for agricultural development in the Central Dry Zone region includes

intensified crop production systems. These include the mixed or multiple cropping methods, in which two or more crops are grown in the same field to increase crop productivity, and act as insurance against crop failure; and sequential cropping systems, in which two or more crops are grown in a time sequence in a year. These types of cropping systems are intended to increase crop yield (Boori et al., 2017). Moreover, Myanmar Agricultural Research Department is conducting research on plant varieties, crop patterns, and irrigation techniques to address issues due to climatic stresses in the Central Dry Zone (MOAI, 2016; Hom et al., 2015). However, the programmes and activities must be reviewed to guarantee their effectiveness in solving the needs of local farmers. These agronomic methods are highly incremental in terms of addressing the long-term climatic issue in the Central Dry Zone region, and they cannot address the long-term climate vulnerability experienced by rural households in the Central Dry Zone.

Figure 3: Central Dry Zone region

(Source: Myanmar Information Management Unit)

3.5 Conclusions

A consistent pattern of increasing temperatures has been documented as having occurred in Central Dry Zone of Myanmar. These trends have been becoming worse over the past few years. Droughts, irregular rainfall, and seasonal water shortages are the key risk factors that threaten farm households, agricultural livelihoods, and food security in the Central Dry Zone. As a large population resides in the rural area of the Central Dry Zone and engage in the agriculture and allied activities, it is crucial to formulate the policies to strengthen the adaptative capacity of rural households in the Central Dry Zone.

However, the climate change strategy and agricultural development planning that is being implemented focuses on incremental agronomic adaptation in order to ease the negative impact of climate stresses which farming households have been experiencing. These implementations are able to address threats in the short term, but their longer-term effectiveness is difficult to predict. As a consequence of this, it is necessary to have an awareness of climatic vulnerability as well as adaptability to climate change is essential for the development of suitable policies (MoSWRR, 2017; Slagle, 2014; NAPA, 2012). As recommended by IPCC (2022 [Approved Draft]), the current adaptation practises in the Central Dry Zone have to be documented and evaluated for better policy recommendations for long term transformative adaptation. Therefore, understanding the implications of climate change and the susceptibility of population, as well as analysing the techniques of adaptation to climate change, are becoming increasingly crucial for Myanmar's national planning and policy action. Therefore, the selection of the `Central Dry Zone region as an area for the case study, sheds light on these important issues.

4. CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

This chapter presents the research methodology on how the data for research was collected and analysed. In this chapter, I detail my fieldwork conducted in Myanmar from April to August 2019. It commences with a critical analysis of quantitative and qualitative approaches to climate change research, explaining why qualitative methodologies were chosen for this study. It also provides a brief theoretical context for focus group discussions and interviews as qualitative research approaches, reflecting on the rationale and explanation for their usage in this study. This chapter also discusses how to conduct focus group discussions and interviews and how to report the outcomes. Furthermore, the chapter discusses the sample processes used to select the research areas for interviews, such as townships, villages, and households. The qualitative analysis method is also described, with a focus on developing coding for Nvivo. The ethical implications of the study are also talked about later in the chapter, with a focus on data collection and management. Then, I discuss the limits of the study, which is particularly relevant considering the pandemic and political unrest in Myanmar.

4.2 Methods

The aim of the research has been to generate a complex narrative about climate change adaptation by rural farm households in Central Dry Zone. In this research, qualitative research methodology was applied to understand the complexity of the diverse range of rural livelihoods. Qualitative methods provide a means to capture greater detail than quantitative methods, such as questionnaire surveys. As such, this research differs from much existing climate change adaptation research that applies quantitative methods characterized by the aim of detecting regularities, patterns, and distinguishing traits of a population, frequently through a sample chosen at random to maximise the likelihood of generalisation to a larger population from which it is derived. These methods are demonstrated statistical relationships of similarity and difference among individuals of a population, but they can be ineffective in explaining how decisions are made in complex settings (Hay, 2005).

4.2.1 Qualitative vs Quantitative research approach

Numerous authors differentiate between quantitative and qualitative studies by highlighting differences in epistemological underpinnings, the nature of the link between theory and research, and ontological concerns (Krauss, 2005; Bryman, 2012). Bryman (2012) defines quantitative research as a research strategy that emphasises quantification in data collection and analysis. Additionally, quantitative research contains deductive reasoning about the relationship between theory and research, with an emphasis on theory testing. In particular, quantitative research has incorporated positivist practises and norms, and it embraces a perspective of social reality as an outer, objective fact. Bryman (2012), on the other hand, defines qualitative research as a research technique that typically emphasises words over quantitative in data collection and interpretation. It predominately places an emphasis on an inductive method to the relation between theory and research, in which the focus is on the creation of theories. It questions the practises and norms of the natural scientific model and of positivism in particular, which presupposes that there is a causal relationship between variables. Also, it represents a vision of social reality as an ever-changing emergent feature of humans' creativity. Neuman and Kreuger (2003) provide a concise explanation of the key distinctions that exist between qualitative and quantitative research approaches. It suggests that quantitative research is more likely to concentrate on testing hypotheses, whereas qualitative research is more likely to attempt to discover the meanings that are buried in the data.

As was noted earlier, the fundamental objective of this research is to determine how the consequences of climate change are interacting with the diverse ways in which rural communities earn their livelihoods. Therefore, it is crucial to understand the intricate process that underlies these interactions. Sourbry et al. (2020) conducted a review of previous research on the topic of climate change and encouraged researchers to employ the qualitative research approach in the course of their investigation into climate change. They emphasised the significance of spending more time and money on qualitative methodologies in order to gain a deeper understanding of the perspectives held by farmers regarding climate change. They are critical of the fact that the majority of the research they analyse is comprised of studies that rely on quantitative data collection methods. As the consequences of this, they stated,

> *"It fails to acknowledge crucial contextual information from farmers which could inform climate and adaptation research and policy, or at the very least provide an*

improved background for understanding farmers' observations". (Sourbry et al., 2020, p.217)

However, the researchers did not intend to imply that quantitative methods were unnecessary for studying climate change. Quantitative and model-based research has been beneficial in the past and will continue to do so in the future in the effort to understand how farmers are interacting with climate change. However, Sourbry et al. (2020) point out that there is an imbalance between quantitative and qualitative research on climate change and that this imbalance must be addressed. They also suggest that future research should take a more qualitative approach, as this seems to be both urgent and necessary.

The use of qualitative research methodologies will require the development of research projects in which the researchers spend more time in the area being studied and cultivate long-term connections with locals who collaborate on the research. Participatory research in general can provide researchers and participants with the opportunity to root their knowledge in the context of the study, thereby facilitating meaningful conversation that sidesteps the power dynamics that are inherent in extractive research (Ashwood et al., 2014). Incorporating these into research on climate change has produced results that are fascinating and helpful for both farmers and academics (Sautier et al., 2017; Mapfumo et al., 2013). Therefore, when it comes to understanding how farmers feel about climate change, qualitative research methods have to gain wider acceptance as tools (Sourbry et al., 2020).

4.2.2 Usage of qualitative methods in climate change related studies

Several earlier studies have demonstrated that qualitative research is superior to quantitative research in terms of its capacity to unearth intricate linkages in the context of climate adaptation. For instance, Smit and Skinner (2002) used qualitative approaches to discern between the agricultural adaptation strategies available to farmers in response to climate change. Additionally, Crane et al. (2011) highlighted the fact that although modelling techniques for climate change assessment are helpful for visualising potential future outcomes and evaluating options for their prospective adaptation, they do not accurately portray and incorporate adaptive human agency. This was one of the main points that the researchers focused on. They have a tendency to leave a very wide gap in the area of adaptive capacities

and practises of farmers, missing one key component in the process of comprehending the connection between changes in the climate and the results of agricultural endeavours.

Antwi-Agyei et al. (2017) used qualitative research methods to gain a better understanding of how different climatic and non-climatic stressors vary and interact at different levels, including district levels household, community, and household, to influence the livelihood vulnerability of small-scale farming households in the Savannah Zone of northern Ghana. They employed key informant interviews, semi-structured interviews, and focus group discussions as the techniques for collecting data in order to figure out the complexity of both non-climatic and climatic stressors, as well as how rural household livelihoods are influenced by either type of stressor. Researchers are also able to acquire information about numerous aspects without having to precondition their responses using these strategies (Bernard, 2000). In a similar vein, Karlsson and Bryceson (2016) use qualitative data collection tools to investigate livelihood adaptations in two coastal villages within the larger context of Belize's colonial and post-colonial environmental history. Researchers make use of qualitative interviews, archival analysis, and observation in order to investigate the dynamics of livelihood change and conduct an in-depth analysis of the various elements that have been impacting alternatives and adaptation throughout the course of time.

In some of the research, comparative analyses of the various groups are derived from the discussions that took place within focus groups. For instance, Gentle and Maraseni (2012) carried out a study in Nepal's remote and mountainous Jumla District in order to investigate how the effects of climate change are having an effect on the means by which local communities support themselves and how various categories of people are being differentially affected. They collected the data from three distinct groups of people using focus groups. Each group was concerned with their own well-being (well-off, medium, and poor). Using this data, the researchers were able to do a comparison of the different vulnerabilities and adaptive techniques that were employed by the different groups. In addition, in order to collect and verify the material, the researchers carried out key informant interviews with various community figures, including village leaders, school instructors, and elderly farmers. The study on the function of social networks in establishing adaptive capacity and resilience to climate change in Ghana that was carried out by Dapilah et al. (2020) is another example of the type of research that makes use of qualitative approaches as the primary data-gathering instruments. The primary methods that were applied were observations, semi-structured interviews, a

survey, and focus group discussions. The people from the community who participated in the semi-structured interviews ranged in age from middle-aged to elderly, and they came from a variety of racial, occupational, and socioeconomic backgrounds. Respondents in that survey were given the opportunity to discuss various aspects of their lives in relation to alterations in the natural environment, local livelihood strategies, and social networks. This resulted in an in-depth awareness of the disparate objectives and perspectives held by older and younger people, as well as the differences that exist between the genders. Additionally, it brought to light issues concerning power dynamics and the availability of the resources necessary to build adaptive capacity, as well as changes in traditional structures and processes, and various segments of the community's climate change adaptation strategies. In the same manner as the previous focus group discussions, those involving men and women separately, as well as others including both men and women, were carried out. The participants in the focus group discussions were asked to identify and describe various resources, such as social networks, a ranking of the risks to their livelihood, a study of trends, a seasonal calendar, and a ranking of coping mechanisms. The study used semi-structured interviews, focus group discussions, and a survey, as well as a variety of other participatory approaches, to investigate how social networks promoted livelihood diversification and resilience in a small rural community in northern Ghana.

In these studies, the use of qualitative approaches was justifiable in order to acquire an in-depth knowledge of complicated interactions. Yiridomoh et al. (2021a) conducted their research on the relationship between climate variability and the sustainability of rural livelihoods in Ghana using a combination of quantitative and qualitative methodologies. After a quantitative survey was completed, the qualitative method of interviews was used to follow up on the issues brought up by climate variability in the communities. The researcher was able to ask questions about alternative means of income in order to supplement the participants' primary sources of income by using the interviews (Rugg and Petre, 2007; Berg, 2007). In this research, interviews were also helpful in determining how the variability of the climate affected the activities that people relied on for their livelihood, and they provided insight into how locals understand climate variability. Using the Livelihood Empowerment Against Poverty (LEAP) programme in rural Ghana, Yiridomoh et al. (2021b) investigated the role of social cash transfers in relation to climate change adaptation. They decided to supplement the data gathering techniques with in-depth interviews so that they could investigate further the nuances of the recipients' encounters with the LEAP and climate change. In conclusion, the validation of the data obtained by quantitative approaches has been an important part of the role that qualitative

approaches have played in climate change research. For instance, Meldrum et al. (2016) used focus group discussions as the data collection method in order to verify the outcomes of the household survey in their research on the role of crop diversity in farmers' adaptation actions in the northern Bolivian Altiplano.

The advantage of using a qualitative approach is that it enables researchers to explore intricate phenomena within the context of their own environments using descriptive data (Sandelowski, 2000; 2010). The respondents are given the opportunity to recount their personal experiences and provide an explanation of how and why they made certain decisions. I used qualitative research methods for this study so that I could gain a better understanding of how farming households decide how they will make a living in the context of the wide variety of agricultural activities that are practised in the villages that served as the case study. The qualitative methods make it possible for me to differentiate between the responses of the households and assist me in gaining an in-depth understanding of the reasons that underlie these responses.

More importantly, the qualitative research approach taken in this investigation may provide a richer understanding of farmers' views on climate change because this strategy allows researchers and participants to ground their expertise in the context of the study, promoting meaningful discourse while avoiding the power dynamics inherent in extractive research. Furthermore, as this approach involves researchers spending more time in the place being examined and forming connections with people who engage in the research, it may provide a clear understanding of the multifaceted process that lies behind these interactions. All of this could result in practical insights on climate change and rural livelihoods research.

4.3 Data collection and data management

When conducting qualitative research, the primary emphasis of the research strategy is placed on the gathering and examination of data in the form of text or images (Neuman and Kreuger, 2003; Bryman, 2012). To put it another way, the focus is more on the written word as opposed to the numerical value. In order to collect these types of qualitative data, this study employ the following qualitative data collection tools.

4.3.1 Review of secondary information

The first step I take before deciding where to conduct the research and selecting the study area was to review the pertinent literature, reports produced by government, non-government, and research organisations, as well as any secondary data that is readily available pertaining to climate change and rural livelihoods in Myanmar. Reviewing secondary sources gave me the opportunity to figure out what was already widely known in the field. It was also helpful to have knowledge of the relevant concepts and ideas about the subject in order to be able to identify the research methods and tactics that have been utilised in the process of researching this field (Bryman, 2012).

Secondary data supported the analysis of interview and focus group data from each village. This included meteorological records of temperatures, rainfall and raining days; soil assessments for agriculture; data on cropping patterns and major crops; water resources for agriculture, irrigation facilities support from governments responding to water scarcity, and the area under irrigation. These data were obtained from various published and/or non-published books, and reports and papers of different government ministries.

A further key secondary source was Pritchard et al. (2018), a household survey of food security and livelihoods in three regions of Myanmar, the Ayeyarwady Delta, Chin State, and the Central Dry Zone. I reviewed the data related to livelihood compositions of the rural households, particularly focusing on their engagement in farm and non-farm activities in Yesagyo Township. Moreover, I also looked at the data related to farmland ownership and migration in order to figure out the linkage between farm households and migration. The study area was then decided upon once I had finished going through these secondary materials.

4.3.2 Study area selection

As climate modelling identified the Central Dry Zone of Myanmar as being extremely susceptible to exacerbated flooding, drought, and increased overall temperatures (Khaing et al., 2016), it was selected as the site for this study. It is also one of the regions in the country where there is the greatest problem with food insecurity (Boori et al., 2017). Rainfall that is erratic and insufficient can cause severe water shortages, which in turn pose a persistent risk to the economic viability of rural methods of living. Poor agricultural yields in the Central Dry Zone

as a result of restricted availability of water when it is required, inadequate levels of food intake, and high levels of indebtedness among the rural poor are all manifestations of the Central Dry Zone's vulnerability (Adaptation Fund, 2012). The conventional dry land agriculture that has traditionally dominated the region's livelihood patterns is being directly impacted by these climate changes (Thein, 2009). Within the Central Dry Zone, Yesagyo Township was identified as an appropriate geographical unit to conduct the study (Figure 4). *(Note that 'Township' here is the terminology of an administrative area in Myanmar. It includes rural areas*). In the Central Dry Zone, there are 13 districts, and the Yesagyo Township is located in the Pakkoku District of the Magway Region. Based on UN data, Yesagyo has a "severe level" of water scarcity, and the situation is expected to get worse over time (Irrigation Department and Water Resources Utilization Department, 2003).

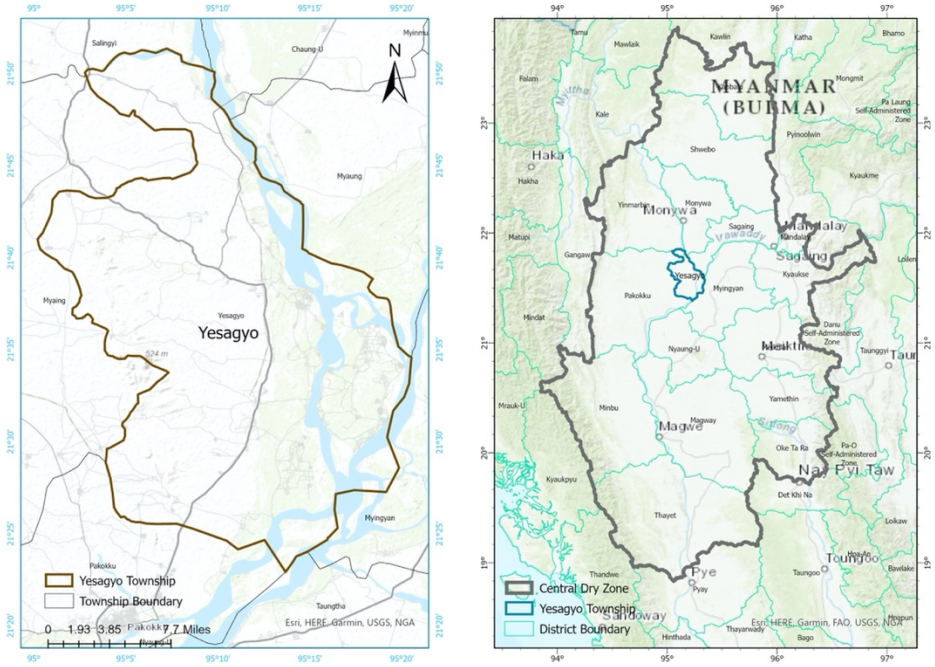

Figure 4: Maps of Yesagyo township and Central Dry Zone region

4.3.3 Pilot Survey

Before conducting the actual fieldwork in the study area, a pilot survey was conducted to test the data collection methods, to determine the sample size and to finalize the research questions. I visited two villages in the Yesagyo Township and conducted focus group discussions in order to get the information related to their livelihood strategies in response to climate stresses.

The initial questions were focused on the role of farming in households' livelihood arrangements, strategies and aspirations and how this is presently changing in contexts of heightened agro-environmental uncertainty associated with climate change. Therefore, the questions were focused mainly on landholdings and their livelihood strategies, including questions on land use changes, types of crops grown and crop production changes in the context of climate change.

The pilot study assisted in fine-tuning some of the questions to ensure that they appropriately reflected the information necessary for the thesis. I also included a few follow-up questions in the process, which allowed me to obtain substantial data on perceived agricultural adaptations to climate change and their livelihoods' strategies in the main survey. According to participants' responses in the pilot study, there are particular livelihood activities, both farm and non-farm in each village. Therefore, I added questions focusing on the non-farm livelihood activities among both landholding and landless households. I put detailed questions for non-farm activities in both focus group discussions and in-depth interviews in order to understand the main non-farm livelihoods at the village level and individual household's perspectives on livelihoods and climate change.

4.3.4 Sampling procedures

After the pilot survey, I was able to finalize the number of sample villages. A purposive sampling approach was used to select the study township and villages. According to Palinkas et al. (2013), purposive sampling is a sampling approach in which the sample is selected based on specific criteria specified by the researcher's interest in order to gather relevant data in connection to the relevance, meaningful comprehension, and depth of the investigated issue.

The approach taken is summarised in Table 1. Yesagyo township was selected purposively because of its "severe" water scarcity level in the Central Dry Zone region. Besides, as the township is located between Ayeyarwady and Chindwin rivers, the villages beside the rivers have been suffering increased flood due to irregular rainfall. The area of the Yesagyo township includes villages which have been suffering both drought and flood due to distance from the major rivers. Therefore, Yesagyo township is well suitable to be selected as the study area for farm adaptations to climate change study.

Then, villages were purposively selected based on their different biophysical environments and livelihood arrangements. This was informed by discussions during the scoping visit and previous research on food security and livelihoods in Yesagyo (Pritchard et al., 2018). Ten villages were selected to conduct 10 interviews and one focus group discussion per village. This sample size was sufficient to capture both a diversity of village types in Yesagyo township, and also, with a total of 100 interviews across the ten villages, an appropriate number of interview narratives about the different intersections between livelihood decision-making and climate change.

Once the villages were identified, stratified random sampling was used to identify the households for in-depth interviews. In order to select the households, I met village heads and explained my study purposes and my selection process. Then, I requested the list of the households from them with their respective household livelihoods (large-scale farmer, small-scaled farmer, the ownership of livestock, engagement in non-farm, etc). The criteria for the stratification of the livelihoods are varied based on the fact that each village is composed of a different combination of livelihood types. With the consultation of village heads, households were stratified based on their livelihood activities in the village and then, 10 different households, which were drawn from different strata, were randomly selected. If the selected households were not able to make the interview (for example, the adult were absent in the household), I requested the village head to choose another household with similar livelihood strategies.

Table 1: Sampling procedures

Step	Sampling techniques	Descriptions	Outcome
1	Purposive sampling	Irregular rainfall, drought, flood	Yesagyo Township
2	Purposive sampling	Villages with different biophysical environments and livelihood arrangements (eg. Migration, rainfed farming, irrigated farming, handicraft, trading, livestock)	10 villages

3	Stratified Random Sampling	Households with different livelihood activities	10 households from each village

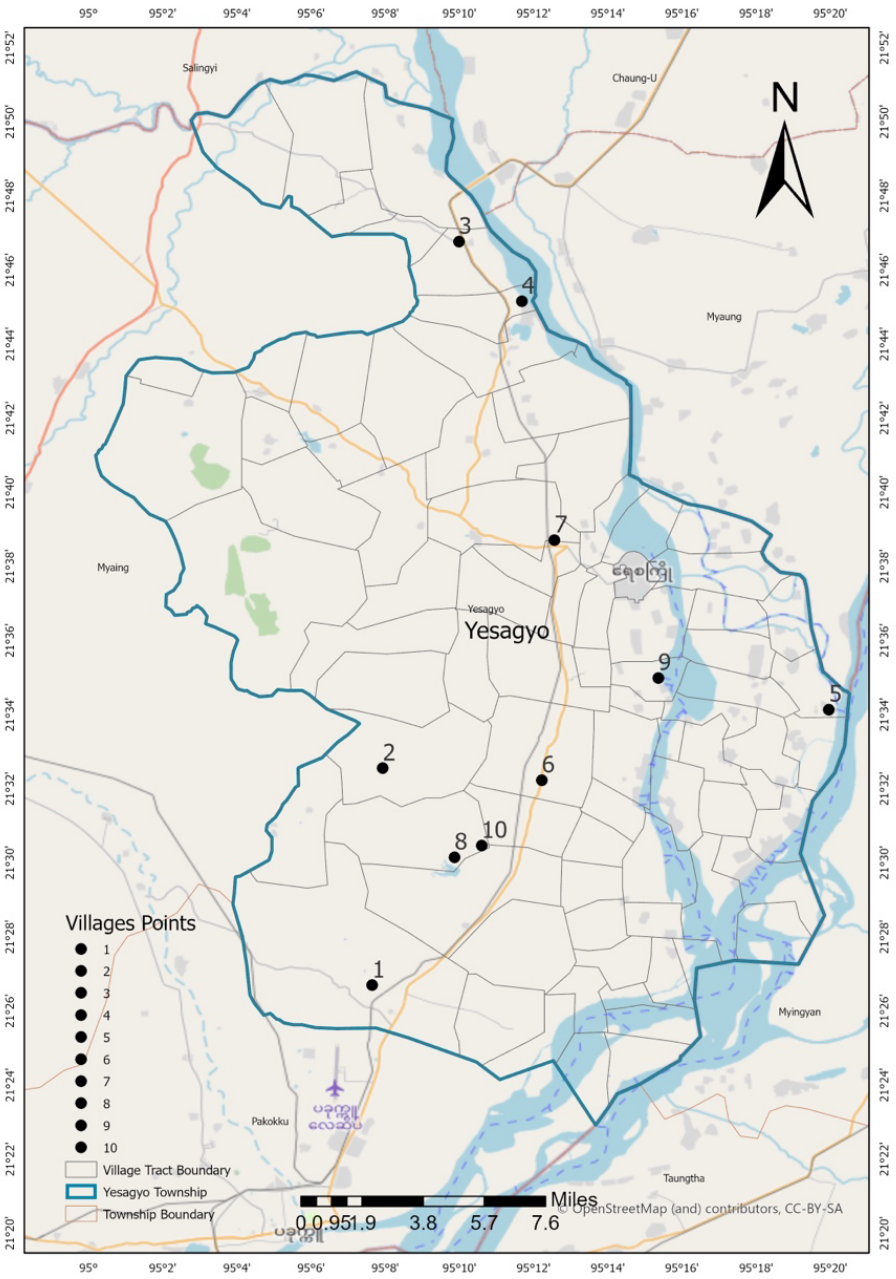

Figure 5: Map of study villages in the Yesagyo township

4.3.5 Focus group discussions

Focus groups are a type of interview in which multiple participants discuss a specific, defined topic and develop meanings under the supervision of a moderator or facilitator (Stewart et al., 2007; Bryman, 2012). One distinctive aspect that distinguishes focus groups from individual interviews is the presence of a moderator or facilitator who fosters interaction and ensures that discussions remain focused on the stated topic (Stewart et al., 2007). Focus group sessions were held with participants in this study to extract qualitative information on perceptions, attitudes, and behaviours about how livelihoods are strategized to shape susceptibility to climate change and how this affects their socioeconomic conditions by village-wise views.

I conducted 10 focus group discussions: one per each village. The aim of the focus groups was to obtain village-wide perspectives on the recent history of livelihood arrangements of people in the village, including changes to the ownership of land, types of agriculture practiced, etc. Focus groups were facilitated by the village head in each village. The village head was asked to convene a focus group of approximately 12 villagers, representing a cross-section of differently positioned people within the village (men and women; landholders and landless; young adults [18 years and over] and older people). As a first step, I requested the assistance of the village heads in arranging meeting venues for the focus group discussions, either within the villages themselves or nearby, as well as other logistical aspects, such as chairs or mats, and the preparation of tea and snacks (paid by me) for the participants. Typically, community buildings such as monasteries, schools, or sometimes areas close to village head houses served as the setting for the focus group discussions. The finding by Stewart et al. (2007) that the participants' likelihood of attendance at a meeting increases in proportion to the distance separating it from their homes provided the impetus for the decision to hold the discussions of the focus groups either within the communities themselves or in close enough proximity to them. Before I conducted the focus group discussion, I started by making some preliminary phone calls to the village head in order to confirm the names of the people who were going to take part in the discussions with the focus group. This call provided information regarding the time of the focus group discussions as well as directions to the location of the gathering.

At the beginning, a briefing about the purpose of the study was given to the participants. This was done in order to encourage them to openly offer their opinions on the topics that were discussed during the subsequent discussions. Every participant was given the opportunity to

discuss or ask questions about the research before they agreed to sign the consent paperwork following my introduction of the objectives of the research. The duration of each focus group was around one to one and a half hours. During the discussion, respondents were encouraged to exercise patience by waiting for the contributions of others to come to a conclusion before offering their own points of view. This was done in an effort to maintain order during the discussions.

The focus group discussions allowed the participants to be free to express their opinions. The diversity of participants' experiences, gender and age was actively employed in the focus groups to encourage differences of opinion to be expressed. Participants were encouraged to disagree or agree with each other on the issues that were critical to perceive, such as awareness of climate change, local livelihoods strategies, histories of non-farm activities in their communities, etc. Focus group discussions enabled me to understand the village-wise perspectives on the research questions and helped analyse the data at the village level. In addition, throughout the focus group discussions, everyone who took part was actually advised to contribute their thoughts. At the end of each of the focus group discussions, the attendees were asked to bring up any concerns they had that they thought were pertinent to the conversation but might have been covered. At the end of each session of the focus group, I thanked the participants for their participation and informed them about the subsequent investigations, which would be in the form of interviews with the individual households residing in the village. After each session with the focus group, I would do some kind of reflection by taking detailed notes about what they said in general.

4.3.6 In-depth interviews

In-depth interviews with a sample of households were conducted to obtain personal narratives of livelihood choices in response to climate change. In regard to the interviews, I made contact with the head of each village and described the purpose of the interviews, as well as the ethical considerations that accompanied them. As described in the table 1, a random sample of 10 households under different livelihood categories per village were selected by using household lists held by the village head. The next step was for me to get in touch with these possible respondents, have a conversation with them about the study, and reassure them that they would not be subjected to any undue amount of pressure to take part. When it was determined that they were interested in taking part, the next step was to have them sign a consent form. The

participants were responsible for deciding when and where to hold the meeting after it was established that they were interested in taking part in the research.

The respondent for interview was an adult man or woman who lives in the household; or sometimes, a group of people from the same household interviewed together. These respondents were advised that their participation was completely voluntary, and they could retract from the interview at any moment. They also had the option to not respond to any particular inquiries or comments that they did not wish to or to deny those responses. In spite of the fact that they had already granted their permission to participate, they were provided with this information anyway. Interviews took approximately 45 minutes to one hour. A semi-structure interview format was used because these questions enabled a focus on the issues of the research, but also allowed the researcher to probe more in-depth answers based on the respondents' answers. This method provided a way of collecting the different stories of individual households' livelihoods and their perceptions on climate change and agriculture.

4.3.7 Data recording and transcribing

I used the audio recorders to record the information during both interviews and focus group discussions with the consent of the participants. The advantage of using recorders is that I could pay more attention to the participants' answers and discussions and also make more interaction. During interviews and focus groups, I noted down comments and observations of key interest, as a way of highlighting issues I then probed further, towards the end of the interviews and discussions. All the recorded data were transcribed with Burmese language first and then translated into English before they were coded and analysed.

4.3.8 Qualitative data analysis

All the qualitative data were grouped based on the villages and data collection tools. Then, I used Nvivo software to categorize the qualitative data and analyse it. I put the data to the software based on the themes that I had identified, for example, adaptation through farm livelihoods, non-farm livelihoods, etc as the parent codes. I created different child codes for response under the parent codes in order to differentiate the different answers under the themes and also to segregate the responses for analysis. I then categorised comparable responses based

on the numerous responses in different codes to produce other emergent themes from the data that support the core point of my research.

Creation of the parent and child codes was shaped by the research questions that formed the basis of the research, in the context of the literature review on rural livelihoods changes in response to climate change in the Global South. The data were first coded and analysed based on the need to generate case/ village-wise descriptive information about different agricultural activities, and other specific non-farm livelihoods. Then, themes relating to adaptation to climate change were applied based on livelihood subsets (various forms of agricultural activities, etc) and the histories of non-farm livelihoods.

Table 2: Descriptions of the codes used in Nvivo software

	Parent codes	**Children codes**	**Descriptions of codes**
Rural Livelihoods Setting	Farmland_utilization	- Land_attachment - Landuse_Abandon - Landuse_crop - Landuse_livestock - Landuse_others - Landuse_Perennial crops - Landuse_rentout	Responses related to farmland utilization such as types of crops grown, the reason for selecting the crops. Farmers' response for management of their land
	Rural_livelihoods	- Farm_men - Farm_women - Farmlabor_men - Farmlabour_women - Men_nowork - Menwork_disappear - Menwork_outside - Menworking_home - Migration_men - Migration_women - Nonfarm_men - Nonfarm_women - Women_nowork - Womenwork_disappear - Womenwork_outside - Womenworking_home - Youngmen_Job - Youngwomen_job	Types of livelihood activities done by male and female and the youth in the farming households; farm activities, non-farm activities and migration. And also, the reason for performing such kinds of livelihoods
	Perception_Climate Change	- Positive - Negative	Perception on the climate stresses

Adaptations to Climate Change	Adaptation_Farm	- Change_ Crops - Change _Varieties - Change_Sowingdates - Change_CultivationPractices - Change_Growing Area - Change_Irrigation - Change_Livestock	Farming detailed adjustments related to climate stresses
	Adaptation_Non-farm	- Male_non-farm - Reasons_malenonfarm - Female_non-farm	Detailed non-farm activities in response to climate stresses
	Adaptation_Migration	- Male_seasonal - Male_temporary - Female_seasaonal - Female_temporary - Male_domesticmigration - Male_internationalmigration - Female_domesticmigration Female_interantionalmigraiton - Reasons_migration	Migration in response to climate stresses

Table 2 describes the different sets of codes used for analysis. To make the descriptive analysis for the village wise perspective on the particular rural livelihoods, “farmland utilization” and “rural livelihoods” were made as the parent codes and then, the different child codes were created to categorise the detailed land use and their attachment to land and the histories of farm work, non-farm work for male and females and which types of livelihoods could be done in the village and which livelihoods disappeared.

Based on the general descriptive analysis, four different parents codes were created to analyse how rural livelihoods were allocated by rural households to response to the climate change. As shown in the table 2, detailed child codes were made to distinguish the different responses under each parent code.

4.4 Ethics application

Before conducting the fieldwork, approval was required from the University of Sydney Human Ethics Research Committee to ensure that procedures were in place for participants in the research to be fully informed and able to give their consent to participate in the research. The participants were only interviewed after they had given their prior informed consent to participate in the study. Before starting the focus group discussions and interviews, each participant was required to sign a consent document and was guided through the information page. Prior to data collection, I described my position as a student and highlighted that it was an academic research project in which they had the option to accept or deny participation. In every instance in which audio recordings or photographs were obtained, I first gained the participants' consent.

Confidentiality was stressed throughout the permission process, and I informed responders that the study was only for academic purposes. I further told them that the material would not be made public without their permission, and that the respondents would remain anonymous during my analysis and report-writing. Therefore, in order to guarantee that the research complied with these ethical norms, the real names of the participants were changed before it was published. During the phase in which the data was being collected, participants were given assurance that their personal information would be kept confidential, and this promise was kept. All the information collected wasstored securely on the computer, and only the researcher and research supervisor are allowed to access it. To prevent inadvertently disclosing names and raising suspicions, the specific villages were not revealed during data collection or in the thesis. I further informed the participants that the findings would not be publicized for any other purpose apart from academic ones. Moreover, participants were not compensated monetarily for their time, but I did provide them with tokens of appreciation in the form of little presents like towels and detergent boxes, because it is customary or cultural for visitors to the village to show respect in some way. Also, during the time that they spent participating in the focus group discussions, participants were offered tea and refreshments.

4.5 Limitations

There were two fieldwork limitations that restricted aspects of the study. First, the research initially intended to include interviews with working children aged from 14-17 years old in the

households to get the better understanding for the future livelihood scenario of the area. However, additional ethical requirements were needed for interviewing people under 18 years of age, that were difficult to implement in rural Myanmar. The University of Sydney Human Research Ethics Committee required approval from Myanmar authorities in the form of an equivalent 'Working with Children' check, but there is no such kind of document in Myanmar. Because of the ethical uncertainty that would arise in this absence, it was decided to not proceed with this aspect of the study.

Second, after the coding and analysis was completed, it was intended to carry out follow-up surveys in order to validate the results. This was intended on an important part of the study, because it would enable a revisiting of sites and a re-interviewing of respondents following analysis and reflection on the initial round of focus groups and interviews. However, because of the travel restrictions imposed by COVID-19, this particular component of the study had to be scrapped. Due to the ongoing political unrest in Myanmar, a potential workaround that involved conducting interviews via phone was ultimately scrapped as well. My study villages either did not have phone connections or it was deemed improper to contact respondents because of the much larger urgent political concerns they were dealing with.

5. CHAPTER FIVE: RURAL LIVELIHOOD DIVERSIFICATION

5.1 Introduction

The social and economic effects of climate change differ between village communities because different mixes of livelihoods expose people in varying ways to climate threats. Therefore, to understand the social and economic implications of climate change on our studied villages, it is first necessary to document their prevailing livelihood arrangements. The purpose of this chapter is to undertake this task.

The chapter starts with the obvious, but profound, observation that livelihood arrangements differ greatly between the studied villages. Key aspects of these differences are outlined in Table 3. These differences can be conceptualised within three themes: (1) differences in the extent of dependence on agriculture across villages (2) differences in the type of agricultural activities practiced across villages, and (3) differences in the type and extent of non-agricultural activities across villages.

Setting out these differences in these ways emphasises the complex character of rural livelihoods in Myanmar, and by extension, the Global South. It corresponds to key arguments discussed earlier in this thesis, about the importance of conceptualising rural livelihoods in terms of combinations of agricultural and non-agricultural activities. Appreciation of this point is a crucial foundation for the examination of climate change vulnerability and adaptation in the following chapter. Clearly, different agricultural practices are exposed in different ways to climate change. However, the impacts these will have on villages depends upon the agricultural dependence of villages on agriculture, and also, the ways in which climate change may affect non-agricultural industries.

To assess agricultural and non-agricultural livelihoods, this chapter firstly considers patterns of agricultural dependence between studied villages. This is done by referring to focus group data collected as part of the fieldwork for this thesis as well quantitative survey data produced in village surveys undertaken in 2016 and 2017. Then, agricultural, and non-agricultural activities are outlined. Finally, the conclusion summarises the key points made in this chapter.

Table 3: List of villages and livelihood characteristics

Village number	Summary of characteristics
1	• Dryland farming (no irrigation) • Small-scale trading is an important non-agricultural livelihood
2	• Few rice cultivation area in low-lying lands with some irrigation • Diverse non-agricultural livelihoods including trading, goat rearing, cattle rearing, weaving and carpenters
3	• Toddy palm farming • Dryland areas used for chickpeas, abandoned, or rented out for melon cultivation • Goat rearing
4	• Extensive rice cultivation through irrigation; also some land rented out for melon cultivation • Dryland used for pulses or limited uses • Brick-making is the most important non-agricultural livelihood, although masonry and carpentry also present
5	• Located on the island between rivers; • Fertile alluvial land with access to irrigation water from tube wells CP corn grown as a major crop
6	• Farming on both dryland and few alluvial land • Initiated wild almond trees cultivation
7	• Dryland farming; Partially irrigated rice land; Irrigation water from river pump irrigation project • Number of carpenter groups working outside village
8	• Major goat rearing village in Central Dry Zone • Crop productions are abandoned
9	• Less land area; very good fertile soil • CP corn growing area • Large number of seasonal migrations to China
10	• Dry land farming without irrigation water • Weaving as a major non-agricultural livelihood

5.2 Patterns of agricultural dependence

As suggested by Table 3, although agriculture is still an important activity in the studied villages (all villages undertake agriculture of some kind), its role varies considerably. To further consider these variations, reference is made to the results of village surveys undertaken in 2016 and 2017 as part of the Australian Research Council research project discussed earlier in this thesis (Pritchard et al., 2018). That survey generated land and livelihood data for 30 randomly sampled households per village. As earlier discussed, the villages selected for this thesis were drawn from the results of that survey.

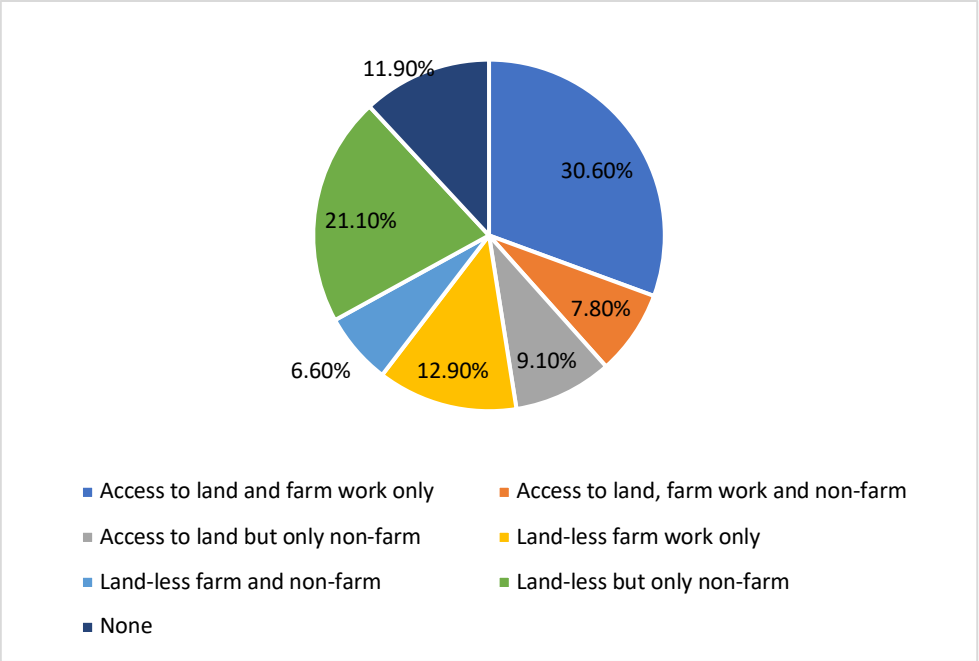

Figure 6: Household livelihood composition of rural villages in Yesagyo Township

Source: Pritchard et al. (2018)

According to Pritchard et al. (2018) survey data, the livelihood composition of rural households in Yesagyo Township is very diverse although engaging in farm work is still their main livelihood (Figure 6). When the data are disaggregated into village level, households' landholding sizes are varied depending on the location of the villages. The villages with dry land area have larger landholding sizes (Village 1, Village 2) while the villages located near rivers where there is alluvial land have smaller sizes (Village 5, Village 9). Regardless of the landholding size, migration can be found in all villages (Table 4).

Table 5 presents how households' members engaged in different livelihood activities. The data show that each village has their own major livelihoods although they are all are located in the same township. For instance, Village 1 has highest percentage of household members who work in shop type petty business among all the villages. According to primary data from focus group discussions and interviews, the main livelihood of Village 1 is trading household commodities. In contrast to the traditional livelihood patterns, less than 30% of household members are engaging in farm related activities, particularly in agricultural labour sector in all villages.

Table 4:Average Land holding size and Migration by Villages

Number of households in survey	**Average landholding size**	**Percentage of households with migrated person**	**Percentage of households who received remittances**	**Average migrated person per household**
Village 1 (n=25)	5.5	76.0	60.0	2.3
Village 2 (n=20)	7.5	80.0	45.0	2.3
Village 3 (n=27)	3.2	81.5	40.7	2.3
Village 4 (n=22)	2.5	56.0	28.0	3.1
Village 5 (n=28)	1.3	58.6	31.0	2.2
Village 6 (n=21)	4.3	38.1	19.0	3.0
Village 7 (n=21)	2.5	81.0	47.6	3.1
Village 9 (n=30)	3.7	63.3	30.0	2.3
Village 10 (n=30)	6.0	56.7	26.7	2.3

Source: Pritchard et al. (2018)

Note: Village 8 in this study was not surveyed by Pritchard et al. (2018). It was added for this thesis due to its distinct livelihood which there is no crop farming.

Table 5: Occupations of household members by villages in 2017

Occupations	Percentage of household members in 2017								
	Village 1 (N=148)	Village 2 (N=115)	Village 3 (N=147)	Village 4 (N=147)	Village 5 (N=142)	Village 6 (N=107)	Village 7 (N=130)	Village 9 (N=171)	Village 10 (N=147)
Farmer or working on family agri land	7.8	23.3	11.0	9.1	9.0	5.5	6.9	23.4	17.4
Agri wage labourer	2.6	1.7	12.2	5.7	21.8	10.9	1.4	4.7	20.9
Shop-type petty business	18.2	3.3	7.3	13.6	10.3	12.7	11.1	3.7	4.7
Household industry petty business	3.9	3.3	4.9	10.2	2.6	10.9	4.2	15.9	9.3
Non-agri laborer	2.6	3.3	2.4	5.7	9.0	1.8	0.0	3.7	1.2
Non-agri manual self-employment	5.2	0.0	13.4	2.3	5.1	1.8	11.1	9.3	11.6
Salaried employment	2.6	0.0	2.4	4.5	5.1	10.9	6.9	0.9	1.2
Family chores	26.0	40.0	13.4	15.9	15.4	16.4	27.8	13.1	11.6
Non-working adult	13.0	3.3	12.2	11.4	7.7	5.5	5.6	7.5	8.1
At school	9.1	10.0	13.4	15.9	12.8	12.7	19.4	10.3	11.6
At college or university	1.3	0.0	1.2	1.1	1.3	0.0	1.4	1.9	0.0
Other	7.8	11.7	6.1	4.5	0.0	10.9	4.2	5.6	2.3

Source: Pritchard et al. (2018)

5.3 Agricultural Livelihoods

Before discussing agricultural activities in the study villages, it is critical to comprehend the various types of farmlands across the study region because it has a significant impact on the agricultural livelihood activities of rural households. The Central Dry Zone's agricultural systems are complex and diverse, with different crops and traditional land patterns. *Le*-paddy land, *Ya*-dry land, and *Kaing-kyun* (alluvial land) are observed in the study villages.

Le Farming: This type of lowland is often known as paddy land. It is situated on dense, impermeable soils on flat, impermeable ground. Paddy farming, along with other forms of agriculture such as oilseeds and pulses, flourish in this area.

Ya Farming: This is referred to as dry land farming. It is not prone to flooding and lacks irrigation. Major crops include oilseed crops, and legumes. Generally, farmers who grow the crops on *Le* and *Ya* lands start their land preparation between February and May, then grow the crops between mid-May and mid-June, when the moisture content of the soil is optimal.

Kaing-kyun Farming: This is known alluvial farming. It occurs near rivers, including riverbeds, and crops are grown during the dry season after the water has drained. The major crops in the study villages are CP corns and very few cultivated area of oil seeds crops, legumes, vegetables (CP corn is a hybrid corn grown with seeds produced by the Thai Charoen Pokphand company).

In the study villages, there are two types of alluvial land. The first type of land is alluvial land with certified plots, which implies farmers have “Form No.7” for land ownership. This provides permanent title to land. Seasonal alluvial land is another. The latter's area is not fixed and is entirely dependent on river flow. Lower precipitation levels or dry periods reduce the discharge of river and promote the building of sandbars on the riverbed. Moreover, logging of forest and changes in land use have a further impact on sedimentation loads in the river and produce new fertile flood plains. There is no land ownership for seasonal alluvial land; it is common property for the nearby villages, and the heads of village tracts and village leaders distribute it to the households on a yearly basis. However, these alluvial lands are the most fertile land for agricultural production.

Study villages were selected to include different biophysical conditions with different farmland types in order to analyse these different agricultural patterns. Local biophysical conditions influenced considerable diversity among villages in terms of major agricultural practices. Irrigation, and the lack thereof, was an important defining factor shaping patterns of agriculture among villages. For villages without irrigation there is dependence on dryland cropping, or an absence of cropping at all, with livestock grazing being a dominant or sole agricultural activity. This diversity is summarised in Table 6. The information in this table 6 was compiled from village interviews and focus groups, with the aim of displaying major agricultural activities. The discussion of each activity that follows elaborates upon this information, highlighting a further set of place-specific, village-by-village differences in the grounded character of these agricultural practices.

Table 6**:** Summary of agricultural activities detailed in fieldwork in studied villages

Agricultural activity	1	2	3	4	5	6	7	8	9	10
Irrigated land for monsoon season paddy cultivation		X	X		X		X			
Irrigated land for two seasons of paddy cultivation				X						
Irrigated land rented out for melon cultivation			X	X						
CP corn cultivation on alluvial/irrigated land in non-monsoon months					X				X	
Alluvial land used for seasonal cropping					X				X	
Less emphasis on dryland crop production	X		X	X		X		X		X
Dryland area extension		X								
Goat Rearing		X	X	X		X		X		X
Farm mechanization and cattle rearing	X	X	X	X	X	X	X		X	X
Perennial Crops	X	X	X	X	X	X	X	X	X	X

5.3.1 Irrigated land for monsoon-season paddy

Villages 2, 3 and 5, 7 are adjacent to low-lying irrigated areas used by villagers for paddy (rice) cultivation. In Village 2, most local agricultural land is low-lying and potentially suitable to water-intensive paddy cultivation, but constraints limited the take up of these activities. Of the 100 acres of low-lying potentially suitable for growing rice in Village 2, only 70 acres is serviced by irrigation from the local dam, and in the rest of the area, dependent on rain, farmers often opted for maize with its lesser water requirements (see below). In any case, even for land with access to irrigation, this only served to supplement monsoon rains and there was no possibility to grow summer rice. Constraints to rice cultivation were expressed more significantly in fieldwork in Village 3, where although some rice cultivation continues, the more important narrative was that a number of farmers had recently abandoned rice farming and instead opted to rent out their land for melon cultivators (see below). Fieldwork in Village 5 provided a further variant to the problems and constraints of paddy cultivation because of monsoonal unpredictability. This village lies in between two rivers meaning that during normal monsoonal conditions there were no problems of water shortages for the cultivation season of July-September, but delays to the monsoon created dependence on tube wells, which tap underground water down to 80-100 feet, and this creates additional production costs that erode the viability of paddy cultivation.

5.3.2 Irrigated land for two seasons of rice cultivation

In one studied village (Village 4), post-monsoon rice cultivation is possible for this village because of an embankment that stored monsoon waters in the post-monsoon season. That embankment is also used as the main village road, especially for students who go to the school during the rainy season. A water gate is used to manage water flows on either side of the embankment. It was built approximately 10 years ago, and staff are maintained to control the water gate. This infrastructure allows rice to dominate agricultural livelihoods in this village to a degree unlike that in the other studied villages with alluvial or irrigated lands suitable to rice.

5.3.3 Irrigated land rented out for melon cultivation

As noted above, in Village 3, some landholders of low-lying land that could otherwise be used for monsoon rice have opted to rent out their low land to melon cultivators on a seasonal basis.

Melon cultivators are typically rich Burmese farmers from Sagaing District to the north, where melon cultivation is more entrenched as an agricultural activity. As the industry has grown, it moved into Pakokku. Melons are grown for export to China. Farmers can get MMK 200,000 (approximately US$140 based on the exchange rate in the time of data collection, 2019) per year and rent out their land for a three-year basis. This is a relatively recent phenomena in the village, starting from approximately 2016. In focus groups, these decisions were explained because of the uncertainty of making a profit growing rice. However, the intensive water demands of melons means that not all low-lying land is attractive for renting out, and melon cultivators usually want areas of at least 3 acres per rental agreement for commercial viability. The melon cultivators bring labour and support temporary shelter (tents) for them, and it would be economic only if they stay in one place instead of scattering in many places. Farmers in the village cannot grow melon because it needs large investment, in piping and cultivation infrastructure, which they cannot afford.

5.3.4 CP corn cultivation on irrigated land in non-monsoon months

Interviews in villages 9 and 5 emphasised the role of CP corn cultivation on irrigated land outside of monsoon paddy production. In Village 5, fieldwork identified CP corn to be cultivated by 90% of farmers. Corn is normally planted in September and October (just after paddy) and harvested in February and March. In some cases, a second season is then potentially available for harvest just prior to the monsoon. The cultivation of CP corn in this area originates from the introduction of the CP variety 888 from Thailand in 1998. The variety was introduced in this village by staff from the Department of Agriculture (Yesagyo Township) who gave one tin of corn seed to each household. By 2004-05, the vast majority of farmers in this village were cultivating CP corn. Prices have fluctuated and farmers' abilities to negotiate better prices has been difficult, according to villagers. With increased prices for fertilizers and deteriorating soil quality, CP corn was described in this village as beset by problems, although it still remains a dominant agricultural activity.

5.3.5 Seasonal alluvial land used for seasonal cropping

In Village 5, the area of seasonal alluvial land suitable for seasonal cropping within the village boundaries is increasing because of an embankment that was built in the past decade. Because this is alluvial land it is not available for a permanent occupation and the granting of a land

titling certificate known as either a Form 105 or a Form 7. Accordingly, this seasonally available additional land is distributed by the village head through a lottery system to all households of the village. The total area of new alluvial land is approximately 100 acres which is allocated to around 300 households meaning each household receives 0.2-0.3 acres of alluvial land. If they do not want to cultivate crops on the alluvial land, the household can sell their allocation to other farmers. Farmers can cultivate 2 crops per year on these seasonal alluvial lands, which is more productive than in other areas, but also carries with it a higher risk as these areas are prone to water bank erosion.

5.3.6 Less emphasis on dryland crop production

Although dryland farming is the major farming activity in the Central Dry Zone, farmers in Villages 1, 4 and 6 emphasized that they are moving away from these traditional dryland family farming activities. The main reason for this is the need to rely on rainfall in a context of greater irregularity. These villages have a lack of irrigation access for dryland farming. Farmers are not wholly abandoning dryland crops such as pulses and sesame, but they invest little time and resources into them. They typically only broadcast the seeds after ploughing the land and go to the field again only at the harvest time. Therefore, they keep their dryland farming largely to maintain a family tradition with little expectation of profit. They minimize their dryland farming activities just to cover livestock feed needs when the weather does not favour (Village 4, Village 6). For example, in Village 6 farmers advised they had stopped summer ploughing, a traditional farming practice, for dryland farming. Furthermore, some farmers in Village 4 said that they have completely abandoned their dry lands with poor soil quality, keeping it fallow. Because of other job opportunities which can be done in the village, farming households are clearly paying less attention in dryland farming. For instance, female family labour in Village 10 prefer weaving than working in the fields. In Village 8, almost all the farmers have abandoned their dryland farming as their livelihood shifted to the goat rearing, from which they can earn much more money.

5.3.7 Dryland area extension

In contrast to other villages, farmers in Village 2 have been increasing the area of dryland in their village. While they also accept that rainfall patterns have become more irregular and that dryland farming gives low agricultural returns, farmers in this village still want to keep

extending their dry land. The motivation behind this is that farmers in Village 2 perceive that farming is their identity and they will do farming at the time of monsoon even though they realize that their returns from crop production are low. Therefore, farmers perceive their fortunes to be better if they have more dry land. Farmers extend their dryland by clearing virgin land to which they do not have a land certificate, even though that process is illegal. However, there is no conflict among farmers because farmers extend their land simply by widening the field embankment into lower-lying land. This is a traditional agricultural practice that enables water to be captured as it flows downhill. Farmers usually grow pulses in the new land because they can be grown with little rainwater.

5.3.8 Goat rearing

The climate conditions of the Central Dry Zone are favourable for rearing goats, and this has become an increasingly important rural livelihood activity. In the past, goat rearing was mainly a subsistence activity. But in the past few years, goat rearing has become commercial because of the opening of trade to the Chinese market. The trade of goats to China was illegal until the last few years. In Village 8, goat rearing has now replaced crop production which previously was the village's traditional livelihood. Farmers can rear goats by their own investment or share-rearing between owners and labourers. Also, goat rearing can create job opportunities for both male and female landless labour by allowing them to work in trading and grazing. Although farmers in the villages with dryland farming rear the goats, the number of households who rear goats and the size of goat herds are very different from village to village. In some villages, only three to 10 households keep the goats (Village 4, Village 6), and farmers are rearing goats for household extra income together with cropping (Village 2, Village 3, Village 10). In contrast, goat rearing is the major household livelihood activity in Village 8. However, because this livelihood is totally reliant on the China market, farmers reported that they faced the potential of losses each year due to goat price uncertainty, and in such cases, they have to find other livelihood opportunities.

5.3.9 Chicken rearing

Chicken is reared as a subsistence item in the households in all survey villages. It is a tradition that households in the Central Dry Zone villages use their chicken when they need to cook a meal for their guests. Some commercial production of chicken was undertaken in the past in

Village 4; however, this was stopped because of some chicken disease infestation. The fear of this repeating means they don't dare to rear chicken again. Additionally, chicken rearing outside of the village is problematic because of water shortages. Some microfinance organizations are encouraging households to rear chicken as a part of their project activities (Village 1 and Village 3). However, rural households cannot rear chickens for commercial purposes because the amount of loans they receive from microfinance organisations allows them to rear the chickens only for subsistence with the purpose of household consumption and meagre supplemental revenue.

5.3.10 Farm mechanization and cattle rearing

Farmers in all villages reported that the number of cattle has been decreasing since the last 10 years. The main purpose of rearing cattle traditionally was to keep them as draught animals for crop production. When farm machines are introduced, farmers prefer to use machines because of their effectiveness in saving time. Farm mechanization in the Central Dry Zone is used mostly for land preparation such as clearing, ploughing and harrowing. However, some farmers still keep their cattle not only for draught animals but also for household extra income by selling them. However, increased difficulty to obtain cattle feed had led some farmers to give up cattle rearing. This is less the case however for farmers in the villages where rice can be grown (Village 2, Village 6, Village 4) who can use straw and rice residuals for cattle feed. However, some dryland farmers also keep cattle by grazing them in their fallow land or growing maize for cattle fodders.

5.3.11 Toddy palms

The changing fortunes of toddy palms within village economies illustrates the changing role of agricultural activities within village livelihoods. Jaggery (toddy sweet) is a prominent traditional business for the Central Dry Zone. However, it was reported that fewer and fewer households are doing jaggery production. Toddy farms are located on dry land and traditionally, landless households do this business. It is a very hard work which includes climbing toddy trees, harvesting the toddy juice and making the toddy sweet. Therefore, it requires a whole landless family to stay at the farm for the whole season. The main reason for why this livelihood disappeared in Village 1 is the opening of non-farm opportunities, such as local trading of clothes, blankets and other utensils in other townships (discussed later in this

chapter). As there is no work for toddy workers during the winter season, the landless households in Village 3 migrate to other township or other countries for seasonal work, for example in watermelon and melon cultivation in Chaung U Township. This has left toddy production an activity that is now only attractive to older people who have difficulties getting jobs in other areas (Village 3).

Moreover, the financial benefits from the jaggery business are comparatively very low and offers few attractions for farmers and landless households as a livelihood activity. In the past, when population was lower, every household had crops cultivation in their backyard. Therefore, they did not need to buy vegetables for cooking and also, shared crops or vegetables with each other. At that time, a household's expenditure needs could be covered by the toddy palm business. However, household expenditures now cannot be covered by this business. Therefore, if there are many working members in the family, they separate household members to different types of work such as labour in the village, wage labour in watermelon and melon farming, migration to China, etc. Toddy farming has proportionately declined, and toddy trees are often kept only because of the use of toddy woods and leaves for the buildings.

5.3.12 Perennial crop production

Some perennial plantations can be found in the study villages. Apart from the toddy farm, *Thanakha* which is a famous crop for traditional cosmetics, is planted as a perennial crop, particularly in the very dry land. Because of a large area of *Thanakha* is growing in the Yesagyo Township, there are some joss stick factories which they use *Thanakha* stems as raw materials for creating joss sticks. Farmers are growing *Thanakha* not just for commercial income. It is also used in the home, particularly by female family members who frequently use it as a present for relatives in another township or for well-known guests.

Another new perennial crop in the Central Dry Zone during these years is wild almond trees. In the study villages, it was introduced by a businessman, and now farmers are motivated to grow the wild almond trees because the market price of wild almond latex is much better than *Thanakha.* Other sorts of trees, such as tamarinds and plum trees, are also cultivated on many farm's perimeters. Farm households typically pick plum fruits and sell them to broker houses in Pakokku or Yesagyo town. Although the amount of revenue they can earn is little, farm households continue to do so in order to supplement their household income, which can cover

the cost of some household spending or children's pocket money. They also used to gather tamarind leaves and fruits for largely domestic consumption. Because young tamarind leaves and fruits are seasonal, rural people typically preserve them for use throughout the year.

5.4 Role of land

As described earlier, the agricultural activities in the study villages are very diverse and their importance for household livelihoods is not the same. Consequently, it is important to review the role of farmland, which is the vital fixed asset for farming households. Although land is still an important asset for rural households in the Central Dry Zone, it plays different roles in different villages, even within the same township. With access to irrigation, land plays a very important role for crop production in more than one season (Village 2, Village 4, Village 5, Village 7, Village 9). Its value for crop production is highest in fertile alluvial land located near rivers (Village 5, Village 9). In dry land areas, where there is no irrigation access, it performs as an identity for farmers rather than an asset for crop production (Village 1, Village 2, Village 4, Village 6, Village 10). Also, farmers use their dryland by growing perennial crops such as *Thanakha*, toddy palms, wild almond trees and plum trees. However, in Village 8, agricultural land is abandoned for crop production, and it is used only for grazing the goats. In Village 4, land is used for non-agricultural purposes in which the top layer of soil is used for making bricks.

However, most of the population in every village are landholders except Village 9 where there is very limited alluvial fertile land. Although the average landholding sizes are varied based on the villages, the landholding size for dry land is much larger than irrigated land and alluvial land. It is very rare to sell or buy land for crop production. Demand for dry land is low because of its low crop productivity, and farmers don’t want to sell fertile alluvial land because it can give very good crop yields. However, small areas of land which are located near villages or main roads are sold out for buildings. The price of land has also fluctuated depending on where it is sited. In Villages 3 and 4, farmers rent out their land to melon cultivators which can make them assure to get income from the land.

Therefore, the monetary value of land can vary greatly depending on the type of land and whether or not it has access to irrigation. Despite the fact that Yesagyo is a relatively small township, the value of land varies greatly throughout the area for a variety of reasons related

to its topography. For instance, fertile alluvial land that has access to irrigation at Village 9 has the highest economic value, and the price ranges from 1.5 million MMK to 3 million MMK per acre, depending on the location of the farm, which can either be close to the village or have access to a good farm road and irrigation. On the other hand, the value of the dry land farm that does not have access to irrigation was approximately 200,000 MMK per acre in Village 1 at the time that the data was collected (2019). However, the value of land can increase regardless of the type of land when it is converted to another use, such as residential or commercial usage. This is true even if the land was originally used for agriculture, for example, some dry land in Village 1 was sold to the petroleum station for 20,000,000 MMK for 1.8 acres because it is located next to the main highway.

5.5 Non-agricultural livelihoods

Although agriculture is a traditional livelihood for rural areas in Central Dry Zone, there are different types of non-agricultural activities in rural areas based on the mix of resources and job opportunities in the villages. Table 7 shows the list of different non-agricultural activities in the surveyed villages. Beyond the data in Table 7, there are some non-farm activities such as groceries, traditional snacks sellers, vendors, and government jobs in every village.

Table 7: Summary of non-agricultural activities detailed in fieldwork in studied villages

Non-agricultural activity	1	2	3	4	5	6	7	8	9	10
Trading household commodities	X	X						X		
Weaving		X				X				X
Carpentry and masonry		X		X	X		X			X
Brick making				X						
Joss stick making						X	X		X	
Labour for waterway transportation									X	

5.5.1 Trading household commodities

Trading household commodities has long been a part of rural livelihoods in some villages, particularly those dominated by dryland farming. In the past, traders carried household items

such as blankets, clothes and other utensils to rural areas by foot and sold these items in the off season. Nowadays, they also work with village-based trading groups. For example, in the trading group of one of the studied villages (Village 1), one trade leader worked with 15-20 trade workers. The trade workers are supplied with items from the trader and then sell them to people in other villages. Trade leaders also act as informal credit providers, with trade workers being allowed to borrow money from trade leaders when they need it for household expenditure, especially for daily household consumption. The trade leader usually buys items from Mandalay by his own investment. Then, he sends items to targeted destinations. The trade workers go there with motor bikes if it is close. If it is far, they have to take their motor bikes on the car/truck to their respective destination. They are allocated three villages each year for selling their items. In each place they need to spend around 2-3 months, and so need to rent accommodation. The trade leader pays for this accommodation, and the profit from the sale of items is shared between trade leader and trade workers. However, this works to the overall advantage of the trade leader because trade workers also pay interest on the items invested by the trade leader.

This model however does not exist in all villages. In Village 2 and Village 10 for example, people are still trading individually and not forming the trading group. This seems to be the case because trading is only a minor part of their overall livelihoods. Trading was stopped in Village 8 a few years ago because their livelihood moved entirely to goat rearing. Importantly, there is a highly gendered division of labour in trading. It is an activity traditionally only undertaken by men. There is no opportunity for women to work in it, because of the need to travel and stay for lengthy periods in other villages, which contravenes gender norms. In any case, improved road transport across the region is increasing the overall mobility of village people and it was reported in field work that it is expected that the trading business will decline as people go directly to large towns to make purchases.

5.5.2 Weaving

In the villages where cotton has traditionally been grown, there has been a long tradition of weaving for their own clothing. However, in recent years this has taken on a more commercial orientation, even in villages where cotton is grown no longer. For example, in Village 10, female villagers were sent to Kachin State to learn how to weave different designs. The traditional Kachin garment has become very popular in Myanmar and as a consequence,

weaving has become a main livelihood for some villages in the Central Dry Zone area. The group of female workers who worked in Kachin state came back to the villages and started weaving and taught these skills to other females in their village. Weaving can be done by households regardless of whether they grow cotton or not and is a large source of livelihood activity for young females who can earn regular income from weaving. Although there are some households weaving as a part of their livelihoods in Village 2 and Village 6, it was concentrated in Village 10.

5.5.3 Carpentry and masonry

Carpentry and masonry are also non-farm work which allows income earning opportunities to both farmers and landless people because it occurs during the off-growing season. It was reported that villagers can easily get the jobs to earn money from carpentry and masonry during the off-season because of high demand for new buildings and repairing houses. Only males work in carpentry but both males and females work in masonry. Both carpentry and masonry are done by groups. There is a group leader and workers in each group and the size of the groups depends on jobs they are offered. Although there are carpenters in many villages, most of them are followers/workers in the group. Village 7 is famous for their carpenter groups and there are more than 100 carpenters in that village. The leaders from Village 7 find the workers from their village and also other villages. The carpenter groups need to travel around different regions and their working destinations depend on the group leader's social network. However, these jobs are not permanent, and the workers are free to decide to join the groups depending on their availability.

In Village 6, young men are working both as farmers and masons. They can earn 6500 MMK per day working as a mason. There are mason groups, and each group has a leader. Each group has 6-7 persons. There are 5-6 mason group leaders in the village. They work in surrounding villages, building cement houses. The number of mason groups is increasing and becoming popular because villages in the area are becoming developed. People in these areas work abroad in countries including Korea, Thailand or Malaysia. When they return, they use their money saved to build or repair their houses. Masons and carpenters from Village 6 work mainly in local villages. This is an attractive livelihood activity even from farm households, where one household member can join the mason group to get extra money. Mostly, while the eldest son is taking care of farming, the younger brother works in the mason group. Then, the next year,

this is reversed, and the eldest son works in a mason group and younger brother works for farming. In that way, households can learn skills in both activities. Another alternative is for younger household members to work as masons during the off-growing season. For example, one man can take leave for two days from a mason group during the green gram harvesting time. In this way, household can earn money from both farm and non-farm.

5.5.4 Brick making

In Village 4, the brick making business is a popular livelihood. This is despite the fact that there is fertile soil for crop production in that village. The brick making business was initiated by outsiders in that village 30 years ago, however currently, only local landholders are doing the brick making. The alluvial soil after flood provides the best quality for brick making (not too much clay or sandy). The land of the village is located near rivers and people can get alluvial soil after flood every year.

The brick business is seasonal, and it starts from October until March-April. (Brick business cannot be done during the rainy season.) During the time of brick making, it consumes much effort, therefore, people cannot do other livelihoods such as masonry or carpentry. When the brick making season is over, people revert to those other jobs. Brick making can employ many people, both male and female regardless of their landownership and they can earn better money than working in farming. Farmers can still keep their farming activities while they are working in brick making because of the time feasibility. Brick making starts 3 am and ends at 10 am and then, they can go to the field for farm work such as fertilizer application, or to manage irrigation. There are 10 brick businesses in the village. There are 2-3 persons per household who work in each. The brick workers need to work in groups, including both males and females. Each group consists of 5 persons, and they can produce 2000 bricks per day. There are five people in each brick making group: 2 females and 3 males. Also, the tasks are gender segregated; females roll the mud and dry the bricks in the sun, while males carry mud, do watering, dig mud and other heavy works. However, both males and females get the same wage. One group can earn 180,000 MMK for 10,000 bricks. Not all households are able to participate in this activity, because baking bricks demands much fuel wood, which is expensive. Business owners try to buy rice hulks, toddy trees and the wood that is carried by floodwaters, for sale to brick making groups.

Additionally, some farmers have started selling their topsoil to the brick businessmen recently with the purpose of getting household extra income and renewing and levelling their land. Some other farmers in the village sell their topsoil with the purpose of repairing their soil condition. Farmers need to use a lot of chemicals for crop production. Then, when they feel their soil in a particular plot needs to be changed, they sell the topsoil (1-1.5 feet) to brick business owners. Landholders don't need to do anything in the process of selling. The brick business owners take all the responsibilities for hiring labour to dig the soil and carrying it to the trucks for transportation. The measurement for selling soil is the number of trucks. Digging the topsoil does not affect crop production because flooding carries all the good soil and sediment onto the land as alluvial deposits. Farmers will not sell the topsoil from same plot in every year. Some farmers sell the topsoil from the land which is located in higher elevation so that they can make their land level. These activities provide a very real example of the interacting of farm and non-farm livelihoods.

5.5.5 Joss stick making

Thanakha is a wild tree in the Central Dry Zone and has been grown for commercial joss stick production for many years. Yesagyo township is famous across Myanmar for joss stick production. The most famous joss stick manufacturer, *Kan Pwint*, is located in Yesagyo town and supports many jobs for villages in the township. People make joss sticks in their homes. The manufacturer supports ingredients such as bamboo sticks, paper and *Thanakha* incense paste, and village homeworkers roll the paste to the stick and dry it under the sun. Then, the representatives from the manufacturer collect and pay for the finished quantity. Both males and females can work for this type of job but mostly, this is women's work because the payment is very low, and men prefer to work on other jobs outside. In Village 9, landless households do joss stick work as a replacement for weaving bamboo baskets which was their traditional handicraft. The reason for disappearance of weaving bamboo baskets is connected to the demise of jaggery production (jaggery was used to put in bamboo baskets for trading and also, it is replaced with bags now). Joss stick making is attractive for women because it allows them to earn regular income without working outside their homes and that income can contribute their daily food expenditure (Village 6 and Village 7). However, this work cannot support livelihoods year-round because during the rainy season home-based drying cannot occur unless it is supported with a large house owned by representatives.

5.5.6 Labour for waterway transportation

Village 9 is located beside the junction of two famous rivers, Ayeyarwady and Chindwin where cargo ships have traditionally been used for trading or transportation. Therefore, working in the ships is a part of male villagers' livelihoods. The number of men who work in the ships has been increasing and now, it is almost 70 persons from this village. This employment is attractive because men can earn better income, at least 500,000 MMK per month. Most of these ships transport petroleum fuel, which is imported from foreign countries to the places along the rivers. With the increasing number of ships, there is more demand for workers, and this has meant men are leaving farm labour and consequently, farmers are facing labour scarcity. Although most of them are landless, household members from landholdings also work for the ships as it can earn more money and they can gain more experience outside the village.

5.6 Migration

Migration has been reported in the study villages. The majority of migration discovered is seasonal and temporary, rather than permanent. The majority of seasonal migrants work as farm labourers, which includes both domestic and international migration. However, the majority of international migration is temporary.

5.6.1 Domestic migration

Government and other salaried workers in the study villages migrated regularly to other townships and regions to advance their professions. Individuals such as doctors, teachers, nurses, and accountants, as well as certain employees working for telecommunications companies, are required to serve in a variety of duty stations. Based on the findings of the household interviews conducted with these types of household members, even though job rotations are meant to be for a short period of time, sometimes this becomes permanent.

There are some instances of seasonal domestic migration to work as farm labourers in other villages or townships. In particular, the conversation that took place during the focus group at Village 3 brought up the fact that some small-scale farmers and dry land farmers require employment in the Chaung U township during the growing season for melons so that they can work as farm labour. Other forms of temporary domestic migration are associated with non-

agricultural jobs, including as carpentry and trading; also, there are some women who work in textile factories in Yangon. Despite the fact that they participate in a variety of different types of domestic migration, the respondents highlighted the fact that they typically return to the village during festival times, such as the water festival (*Thingyan*) in April and the lantern festival (*Thatingyut/Thasaungtaing*) in October-November. This is because festival times are the traditional time for family gatherings.

5.6.2 International migration

International migration has become a part of rural household livelihoods in the Central Dry Zone for 10-15 years. Although there was some illegal migration in the past, international migration now takes place legally by connecting to agents in Yangon (Village 2). The main reason for working in foreign countries is to earn better income and obtain this in a lump sum. For example, a manual worker can get 5000-10,000 MMK per day in the village, but this is insufficient for a household to save money after spending on necessary foods, education and health. But abroad, they can earn more money and can save it. If one household member works abroad, she/he can support 5 family members in the village. However, some parents don't want to send their children to work abroad because they will need to stay there at least two to three years. Therefore, not all households have people working abroad (Village 2).

In the past, most of the people migrating for work travelled to Malaysia, Thailand and Singapore. In recent years, people are also travelling to Korea and China. Usually, all types of international migration are temporary such as two to three years working there. But, as a new trend, it was found that many migrant workers are doing seasonal migration to China. They work in eggplant and melon cultivation to do tasks such as planting bed preparation. Although there are only 2-8 persons per village who migrated to other countries such as Malaysia, Singapore, Thailand and Korea, the flows of people to China are much larger. It was found that there are a large number of seasonal migrants to China (50-100 people) in Village 3 and Village 9. As a consequence, farmers are facing farm labour scarcity, particularly in Village 9 where there is more fertile alluvial land with tube well irrigation system. Mostly, men do international migration but in China case, women do more because of opportunities in nursery plantation work.

5.7 Conclusions

The rural population of the study villages is diversifying their livelihoods. The geographic location of villages has a very important influence on the patterns of diversification of livelihoods, notably in the activities associated with agricultural production. Only with access to irrigation and land that is rich in fertility does agricultural performance appear to be good. However, the reason for less emphasis on crop production and more engagement in other non-farm livelihoods by farming households is not primarily the irregular rainfall pattern and drought in the Central Dry Zone and its low crop productivity. Diversification into non-farm activities is also occurring in the villages where there are good crop production areas (Village 4, Village 5, and Village 9). It is dependent on the opportunities available to as well as the social network that they have.

While new livelihood opportunities entice the rural population, certain traditional livelihoods, such as jaggery production, are gradually disappearing. The majority of dryland farming is managed by family labour in order to preserve the so-called "farming household identity." Hence, farmland continues to play an important role in rural landholding households, not just for its agricultural productive value, but also for its social and economic value related to other land uses.

Since livelihood activities in the study villages have become increasingly diverse and location-specific, the vulnerability to climatic stresses takes different paths. As previously stated, there are numerous other aspects that influence household livelihood decisions in both agriculture and non-agriculture activities. In the next chapters, I will go into greater depth about how various livelihood settings are addressing the climate change concerns that farmers in the Central Dry Zone have been confronting.

6. CHAPTER SIX: CLIMATE CHANGE AND AGIRICULTURAL LIVELIHOODS

6.1 Introduction

In the previous chapter, the diversity of livelihood arrangements in the case study sites of the Central Dry Zone was revealed. There is an array of different agricultural activities across the villages and an important role of the non-agricultural economy. The livelihood mixes in different villages vary significantly, dependent on local biophysical factors, cultural traditions, and the ebb and flow of individual entrepreneurship.

In this chapter, this very location-specific character of livelihood arrangements in the study villages is shown to create a complex landscape of climate change adaptation. As a starting point, I document how farming households have already experienced the adverse effects of climate change, especially in the villages with dryland areas. Therefore, awareness of climatic issues in their region is widespread. Nevertheless, awareness of the negative impacts of climate stresses does not always translate into adaptation practices. Although climate change is one of the factors in changing farming practices, there are other influencing factors that compete for attention when farmers make livelihood decisions. It is vital to understand this wider set of perceptions in order to comprehend farmers' behaviour in response to climate stresses. Framing these issues within this wider set of perspectives shows how "climate change issues" need to be carefully positioned in rural social worlds. It demonstrates that climate change is not always the central role in allocating rural households' assets and labour for their livelihood choices, even in climate-sensitive areas like Central Dry Zone.

This chapter will focus on how farmers relate climate change adaptation behaviours with their perception of climate risks. First, it will discuss farmers' perception of climate change, and second, it will describe farming behaviours in response to climate and non-climate stresses. Finally, it will explain the allocation of climate change issues, emphasizing the importance of different biophysical settings.

6.2 Farmers' perception of climate change

Farmers' awareness of climate stresses is a critical first step for adaptation. Based on the data collected from focus group discussions and semi-structured interviews, it was clear that there was widespread awareness of climate change issues among respondents in the study villages. This was the case even though direct questions relating to climate change were not included in both data collection methods. When asked about agriculture and livelihoods, respondents independently brought up climate change as an issue of concern.

Respondents were aware of climate change based on a range of experiences. Respondents described climate change issues such as higher temperature, longer drought duration, irregular rainfall patterns, lesser rainfall precipitation, and increased rainfall intensity in a short time, leading to floods. Elderly interviewees highlighted climate change by comparing the present day with the time in their younger lives, for example:

> *"It feels like it is getting hotter and hotter year after year and the signs of raining days cannot be predicted (based on local knowledge) like when I was young" (62 years old male respondent from Village 1).*

Less anecdotally, some respondents used the water level of wells as symptoms of longer drought duration at the current time. For example, a 59-year-old female respondent from Village 10 said:

> *"The water from the drinking well in the village is gone in TaPaung (March) now, but we were able to access the water year-round when I was young."*

Most respondents were able to link climate stresses to problems in crop production, such as decreased crop quality, lower crop productivity, incidences of pests and diseases, soil fertility depletion and crop failure. For example, one interviewee shared his experience of losing his crops:

> *"I broadcasted sesame in my two acres of land, I thought I could harvest a good yield, but unexpectedly, there was a heavy rain just before the harvesting period, and my crop was failed."*

Some respondents also complained about the lesser availability of animal feed in recent years. Every focus group discussion made references to the climate issues they have witnessed in the recent past.

Nevertheless, farmers perceived climate risks in mixed ways. Many farmers who owned dry land perceived climate stress as the enemy of crop production, for example:

> *"The drought encourages the farmers to give up the farming and leaving our land vacant, and we become just so-called farmers" (39 years old male respondent from Village 3).*

On the other hand, some perceived climate change as creating greater unpredictability, but not a reason to abandon farming. These farmers said they would like to keep cropping in the hope of getting benefits in more favourable times. A further theme revealed in interviews and focus groups was that farmers could cope with climate change because they were resigned to the ups and downs of good and bad seasons. These narratives touched on farming as a tradition. The sense of climate change aggravating the unpredictability and hard times of farming was normalised, at least by one respondent (a 56-year-old female) by explaining decreased crop yield due to the drought in religious terms:

> *"I think my karma was bad in that year, so the weather was not favourable to my crop production."*

Another respondent also mentioned that:

> *"It is all about ThaKyarMin (based on the traditional belief, he is the head of the gods, and he can manage some climatic conditions such as rain, thunder). We shall only get what he offers us. I have no idea whether my crops will succeed or fail*."

The complex ways that climate change was understood to have impacts on farming was also highlighted in the surprising suggestion by some respondents with alluvial land that the lengthening of drought duration was favourable. For example, one farmer from Village 5 said: *"I got the longer growing season when the onset of monsoon was late."* Similarly, a 23-year-

old female respondent from Village 8 mentioned, *"I prefer the drier climate because it makes less disease for my goats and rain makes the grazing time difficult."*

However, farmers' attitudes toward climate change were consistent in that it was acknowledged as being "out of control", it is something they cannot adjust or manage. The male respondent in the focus group discussion of Village 2 elaborated his feeling towards these changing climatic conditions, particularly for irregular rainfall patterns,

> *"We usually estimate the amount of rain by evaluating the time of the onset of the monsoon. We guess the amount of rainfall for the post monsoon will be high or low. But, during these years, these methods have not worked very well. Therefore, we lost our crops during these years. The only thing we can say about these weather conditions is that they have become hotter and hotter year after year. We don't like these hotter and drier climates, but what else can we do? Sometimes, I curse the rain when it comes just before the harvest".*

All of the interviewees and focus group participants identified the climatic situation as an issue beyond their control. In this case, it raises the question of why farmers, particularly dry land farmers, continue to farm since it is so unprofitable for them. They are displaying some sort of devotion to being farmers and it is closely tied to their attachment to their farmland.

6.3 Attachment to agriculture and farmland

Because of the effects of climate change, dryland crops are failing year after year. The majority of farmers in dryland farming with no irrigation access earn very little or no profit from agricultural production. However, based on focus group discussions and interviews with farming households, farmers continue to farm despite their dissatisfaction with the farming situation.

The first reason the farming households continue to engage in farming activities is that these are traditional jobs. This gives some indication as to the importance of farming for the identities of households that are residents in the villages. Additionally, it demonstrates that they are the part of the community. It is ingrained in them to carry out each step of the farming process in accordance with the time of year. If the farmers in the surrounding area started

ploughing, then the other farmers would also want to do land cleaning on their farm and would like to go to the farm to participate in the ploughing operations there if they saw it happening. It has become something of a routine for them, and it demonstrates that they are not slothful. Whether it was a formal or informal community meeting, such as spending the Sabbath at the monastery, volunteering at the donation house, or participating in the festival, they regularly discussed activities related to crop production, such as the price of seeds and fertiliser or the condition of the weather. Due to the fact that farming is an integral part of their community, landholding households still desired to engage in the activity. During the focus group discussion in the Village 10, farmers who were more experienced, brought this up.

> *"Farmers and village dwellers are inextricably linked. We'd like to get our cattle ready for farming around the same time we start hearing the cowbells from neighbouring farms before the monsoon season. We'd want to discuss the success of our farming efforts throughout harvest. If you own farmland, there's no point in resting while others work for their land. It is important for us to remember our farming roots".*

The second reason is that they believe the price of land will rise in the future. Farmers in Myanmar highlighted the rise in land price in relation to wider inflation rate of money. Despite the fact that their farmland is dry, sandy, and not irrigated, which results in unsatisfactory crop production, it might be sold for other reasons. Some farmers who own land that is close to a village or road or that is located alongside highways are keeping their fingers crossed that they will be able to sell their land for uses other than agriculture, such as residential or commercial development. Farmers whose land is extremely arid, sandy, and lacking in soil fertility are aware that no other farmer will purchase their land because of its low agricultural productivity. Some farmers would prefer to maintain their land in the hopes that they will be able to sell it at a higher price in the future, despite the fact that the process of changing land use from farming to residential is not particularly straightforward or simple. Farmers provided the case of land that was purchased by a petroleum shop as an explanation.

> *"Maung Win have the farmland adjacent to the main road. The land isn't suitable for farming at all. Typically, he broadcasts maize in that area to feed his cattle. Without expecting a return on his investment, he planted that crop in the field. However, a business group spent two hundred lakhs on the plot of land a year ago with the intention of constructing a petrol station on it. He received almost 200 lakhs MMK for only about*

1.8 acres, although the going rate for such land is between three and four lakhs. Although we believe there are procedures for altering land use, we assume that this is typically handled privately by the company's owner due to their extensive network. Landowner farmers along the main road are now defining the boundaries of their allotments very seriously."

Regarding the future hope of rising land prices, farmers would prefer to maintain their land for their generation and pass it along as a family inheritance. They consider the land to be a fixed asset and typically harbour the hope that one of their children will carry on the family business of farming. In the future, when their generation is confronted with any kind of difficulty, they will be able to sell the land in order to acquire the cash. Therefore, rather than giving up on the land, they want to continue cultivating it. At the very least, they have access to the agricultural loans that the government offers during every growing season, and the amount of money that they can borrow is proportional to the amount of land that they own. To receive the loans, they must present the certificate of land ownership (No.7 form) to the Agricultural Development Bank. Despite the fact that dry land farmers are aware of the detrimental effects that climate stressors might have, the majority of them are adamant on retaining ownership of their farmland in order to preserve their households' identity as landholding households for future generations. One interviewee of Village 6 who owns farmland shared her thoughts on whether or not she should continue farming.

" *In my ideal world, all of them would stop farming and instead pursue higher-paying careers in decent works. However, I have no idea what will happen to them in the future. Because of this, I intend to hold on to my farmland for them. To help us realise our dreams for the future, my in-laws gave me this piece of land as a gift. I feel a responsibility to preserve it for the future generations of my family, therefore I will. They can sell their assets or obtain loans from private money lenders if they have an immediate need for funds, such as medical care or higher education. If you use farmland as collateral for a loan, the interest rate is drastically altered. If I'm being completely honest, I'd rather not have my kids called "landless." Given that their grandparents are large- scaled farmers, it is reasonable to assume that they will inherit at least some land*."

Another reason why dry land farmers continue to farm is the expectation of future agricultural development assistance from the government and non-governmental organisations. Because of the significant climatic challenges that they have been experiencing, namely erratic rainfall and drought, it is anticipated that they would receive support for the agricultural irrigation. Some farmlands in the study villages have access to government-supported dam or river pump irrigation. Therefore, farmland that has access to irrigation has the potential to cultivate crops for two seasons. Some of the farmers who own dry land that does not have access to any type of irrigation have mentioned that the problems that they are having with their agricultural crop production will be resolved once the government or non-government organisations have a plan for irrigation development projects that will be located around their villages. According to the conversation that took place in a focus group in Village 6, the participants provided instances of the farming conditions that were present in other communities that had access to irrigation from Chindwin River pumping project.

> *"Farmers in that village have access to irrigation water from the Chindwin River pumping, allowing them to grow rice. So, neither the crops nor the cattle are thirsty in there. At the very least, they can grow rice for their own consumption. I wish the government would fund irrigation projects in our village as well. If we can have access to irrigation, not only will we agriculturally benefit, but land prices would rise as well. I heard the rumours in the town that such projects would be funded in the future. So, we must continue to grow crops year after year. If we abandon the farmland, other wild vegetations, such as wild cactus, will flourish and ruin the agriculture."*

Some of the respondents in the household interviews answered the question "why do you maintain doing farming if it is not profitable for the household?" by referring to the ups and downs of seasonal conditions. They believed that they would be able to make a profit off of the crop production in the years that had favourable precipitation levels and ride out the others. Therefore, they must continue to work on crop production every year. One interviewee who own 3.5 acres of dry land in Village 2 explained her motivation for engaging in farming despite the risk of a loss.

> "*Yeah, I realise my sesame might be "Tasinluat" (a farmer's idiom of expression for saying she doesn't need to harden the harvesting gear because all crops have failed). However, who knows? I can earn when the monsoon favours the farmers. Farmers are*

hoping for adequate rainfall for the crops this year. So, all we have to do is grow something on our land with minimal input. Farming can sometimes provide us with compensation for our investment even if we do not make a profit. I would also like to make a good profit from crop production but really upset the prolonged drought during these years. However, I am satisfied if I am reimbursed for the cost of seeds and ploughing and other costs at the time of harvesting."

Regardless of their reason for keeping on farming under these climatic stresses, there are certain farm adjustments they are making in order to improve their profitability from farming. The testimony from focus group respondents clearly indicates an awareness of climate change and consideration of how it is impacting upon farming. Farmers interpret these processes based on their worldviews, indigenous knowledge, local norms, and experiences of past climate stresses. As a result, they vary from showing severe concern for their farming to being very optimistic. It is crucial to understand how these climate stresses are situated within rural households' wider livelihood arrangements. In the following section, I will classify farming activities based on whether they are influenced by climatic or non-climatic factors.

6.4 Farmers' behaviour in response to climate and non-climate stresses

How farmers translate their perception of climate change into their farming behaviour is essential. As per interview and focus group discussions, farmers regularly alter the ways they manage farming activities in various ways, including changing sowing dates, altering their use of farm machines, changing crops, and making changes to irrigation. These are motivated by an array of factors. Drought and irregular rainfall are essential drivers of change, but so are factors such as labour availability, the introduction of new technology, prices for inputs and outputs, etc. Hence, although farmers understand climate change and the need for adaptation in their farming, its influence on farmer behaviour is contextualized within a broader set of factors. That said, as climate stress is intensifying, evidence from focus groups suggests its influence is an accelerating factor of change, both directly and indirectly.

6.4.1 Land preparation

Land preparation is the first important step for crop production. Farmers in the Central Dry Zone prepare their land by cattle plough or motor plough. Farmers usually practice two types of tillage; primary tillage called ploughing, and secondary tillage called harrowing. It was found that farmers did tills in all three stages of the growing season in study villages. The first time was at land preparation when the farmers did the ploughing to remove the stubbles from the field and break down the hardpan of the soil. And they harrowed land to make the soil loose and porous, which is suitable for soil moisture conservation and increases the infiltration rate. Land preparation is usually done in the early monsoon time, for seed growing to get the proper germination and plant growth rate. After that, farmers usually practice tilling during crop growing time, also called the inter cultivation tillage system. It is done to make the soil more aerated and to prevent the soil cracking because of high evaporation in the top layer. At the same time, it helps to destroy the weeds and thins the crops. At this cultivation period, farmers only ploughed, not harrowed.

According to their traditional knowledge, farmers know that tillage in the fallow time enables the soil to absorb more water when it starts to rain. Therefore, Central Dry Zone farmers usually plough during the fallow time before monsoon, called “summer plough”. For example, respondents told how they preserved the moisture from summer ploughing and acknowledged it is their traditional method in dryland farming villages, such as Village 1. The respondent from Village 10 commented on that practice, *“Summer plough is our traditional method used for many years to absorb more rainwater in the onset of monsoon.”*

6.4.2 Irrigation

In the eyes of farmer respondents, drought is the major symptom of climate change stress. Therefore, access to water is an increasingly important issue for maintaining farm viability. In the Central Dry Zone, most farmers depend on rainwater for crop growing. Although there are some government-support irrigation schemes such as pumping irrigation water from the river, dams and reservoirs for agriculture, only very few areas of land are supported and mainly for paddy production. Therefore, the majority of the land area in the study villages needs to rely on rainwater for agricultural production.

However, villages with alluvial lands, such as Village 5, have become increasingly reliant on the use of tube wells for irrigation as a response to water scarcity. They have used tube wells to extract groundwater for more than ten years. Moreover, collective responses are linked to the use of tube wells, as farmers usually share the irrigation water with other neighbouring farms for corn cultivation.

Tube wells have been widely used in the alluvial (*Kaing-kyun*) CP corn growing areas in Village 5 and Village 9. This is because fertile alluvial land makes it easy to dig tube wells. Interestingly, respondents indicated little concern for the sustainability of water reserves from tube wells – they assumed that water availability would continue. Expansion of tube well use in alluvial villages is connected to wider processes of farm mechanisation. One participant from the focus group discussion in Village 5 explained:

> "*First, we used tube wells only for household water, and we usually use open wells and hand pull irrigation for the farm. The number of wells was very few in the beginning. Since we can access water pumps and hand motors for pumping water from the tube wells to irrigate crops, the number of tube wells has been increasing, and it is approximately around 50 tube wells now".*

In contrast, dry land villages cannot afford the tube wells for their crop cultivation because the soil is so hard, and the groundwater level is lower. Therefore, the farmers in the dry land villages are limited in their agricultural options.

6.4.3 Sowing time and practices

Timely sowing is the most common adaptation practice in the Central Dry Zone, especially in rainfed agriculture. Farmers participating in one focus group discussion mentioned that

> "*We, farmers have to grow the crops once the first monsoon rain comes to use moisture even from very first rainfall if first rainfall is enough for crop germination. Therefore, farmers need to prepare the land for crop sowing at the time of early monsoon. Now, irregular patterns for the onset of monsoon are usual for the Central Dry Zone area. So, we do not fix the date of sowing crops, and it is adjusted based on the onset of*

monsoon rainfall. Therefore, early or late sowing crops depends on the time of monsoon rainfall".

Farmers also adjusted their sowing times to catch moisture and avoid drought during the peak water requirement time of crops. Sowing very early in the season may not be an advantage for all crops; for example, growing green gram or groundnut early may fail crops under rainfed cultivation if there are prolonged dry spells in July. Therefore, farmers in focus group discussions pointed out,

"We have never fixed the sowing date for our crops, and we usually sow based on the onset of rainfall and the amount of rainfall we predicted."

Rice cultivation provides a further example of how changes to sowing practices were used as an adaptive response to climatic unpredictability. There are two sowing practices for growing rice in the Central Dry Zone: direct seeding by broadcasting and transplanting based on water availability. Farmers used to only apply the transplanting method for rice sowing many years ago. However, farmers who participated in focus group discussions in Village 2, Village 4 and Village 7 mentioned that

"*the transplanting method produces a higher yield than broadcasting, but it takes time to move from the transplanting bed to the field. We frequently confront the problem of insufficient moisture in the soil during transplanting owing to a lack of rain, and as a result, seedlings must stay longer in seedbeds, resulting in crop productivity losses. So, paddy farmers used the broadcasting method to make optimal use of rainwater.*"

One male interviewee from Village 2 added benefits of broadcasting in rice sowing in terms of production cost.

"*Broadcasting can get rice seeds to germinate in the field using monsoon rain. Following that, rice plants can stay to receive the next rain on the field, avoiding the risks associated with a shortage of rain at the stage of transplanting. Likewise, it helps reduce transplant labour costs."*

6.4.4 Fertilizer application

Both organic and chemical fertilizer application was found in the crop production of study villages. In the Central Dry Zone, farmers use cow dung as the organic fertilizer for their crop growing. They usually apply cow dung during land preparation time together with crop residue by ploughing. Farmers believe that cow dung and crop residues can improve soil structure to maintain moisture. The amount of cow dung used for crop cultivation is related to number of cattle a farmer owns or number of the cattle the village owns. But farmers cannot apply cow dung in their farm every year, so they apply it alternatively on their farm every second year. Interestingly, farmers involved in goat rearing do not use goat manure for their farming, but usually sell it.

However, during the past decade, farmers have increasingly made extensive use of chemical fertilizer for their crop production. They usually use compound and complete fertilizers, as these kinds best increase the yield. But farmers participating in focus group discussions highlighted that the use of these fertilizers is dependent on weather conditions, especially rainfall. Fertilizers such as potash, which is included in compound fertilizer, were seen as highly effective in increasing plant strength, particularly during drought periods. Therefore, farmers apply these chemical fertilizers to get vigorous growth that helps compensate for crop yield decrease due to water shortages during drought. However, this function works best when there is enough moisture is in the soil. In focus groups, farmers told of how crops could be damaged if fertilizer is applied with no moisture in the soil. As a result, farmers apply fertiliser in two applications, one before and one after the drought period, depending on the wetness of the rainfall and stage of crops' growing.

Fertilizer use, however, was not universal in villages, especially dry land villages. Focus groups revealed that farm households with financial vulnerability, such as female-headed households dependent on the flow of remittances from males working elsewhere, used lesser amounts of fertilizer because of the risk implications. For these households, the upfront cost of chemical fertilizer use had to weighed against the risk of crop failure due to unfavourable climatic conditions. One female respondent from Village 10 explained her management for fertilizer application:

"I cannot waste my money on costs for labours and chemical fertilizer under the condition of unpredictable rain".

In contrast, farmers who possess alluvial land need to use a higher amount of chemical fertilizer despite their land being very fertile because they grow crop after crop, mainly corn known as a heavy feeder.

6.4.5 Short-lived crop varieties

In the focus group discussions, I observed how many farmers described using suitable varieties as a good practice to get a better yield. Short-lived varieties are suitable for drought and irregular rainfall conditions because farmers can harvest early and face fewer risks. For example, farmers prefer a 3-month sesame variety to their traditional 4.5-month variety. Farmers discussed that they received short-lived varieties of sesame, pulses, and rice from the township agricultural department more than a decade ago. At that time, not all the farmers accessed it, therefore, they left some of their crops as the seed for the next season. Later, farmers accessed the seeds from the traders or fellow farmers. One paddy farmer from Village 2 highlighted his choice of shorter varieties as

"I have 0.5 acres of Le (paddy land) and I grew Ma Naw (name of short-lived rice variety) last year for my household consumption. Based on my experience, I can still harvest in case I don't get enough irrigation water".

6.4.6 Mechanization

Access to farm machinery is an important factor in determining adaptive capabilities to climate change. Since the last ten years, the use of farm machinery in the Central Dry Zone has been increasing. The most common farm machines used in the study area are motor ploughs for land preparation, and pumps for tube well irrigation. According to focus group discussions and interviews, the primary purpose for the usage of the motor plough is to save labour and time. Traditionally, Central Dry Zone farmers used cattle ploughs for their land preparation, but in recent years, the number of cattle has been decreasing and the incidence of farm labour shortage has been higher. Timing of the plough is crucial for rainfed farmers as they need to grow their crops with the correct timing of the rain. The efficiency of the motor plough is much higher

than the cattle plough when this time-sensitive factor is taken into account. Therefore, farmers use farm machines not only to save the farm labour but also to save time at the onset of the monsoon to capture the rainwater most in their farmland. This shows mechanization to be linked directly to climate uncertainty. With heightened concern about the timeliness of the monsoon, farmers are more inclined to reduce the risks of not getting their fields ploughed by investing in mechanical ploughs. One female respondent from Village 1 highlighted,

> "I *don't need to wait for my husband returns to the village for land preparation to grow the crops at the time of monsoon. I can easily hire motor plough to prepare my land to be ready when the monsoon arrives"*.

This comment from a female respondent highlights the historic gender standard in running the farming activities, and it does so not only for the purpose of saving time and labour. Because, according to the customs of the village cultures, women are not permitted to operate farm machines or cattle ploughs used to prepare land.

6.4.7 Farm labour utilization

Farm labour arrangements are an important issue for crop production as farmers in the study villages face significant farm labour shortages at the current time, particularly in the peak times such as sowing and harvesting. There are three types of farm labour that have been observed in the Central Dry Zone: family labour, hired labour and exchange labour. In the alluvial farming areas with irrigated paddy growing, farmers use both family labour and hired labour for their farming activities. However, the farmers in the dry land villages tend to use hired labour more sparingly. They rely on family labour and the exchange of labour with relatives or friends, in order to minimise monetary costs. One female respondent from Village 10 told how her family arranged the farm labour in the peak time:

> *"I need to stop my weaving in the green gram harvesting time as I need to help my parents in the crops harvesting, carrying, and threshing activities"*.

Farmers clearly stated their awareness and concerns about climate change, and they tried to offset its adverse impacts on their crop production as far as they could. However, most of these practices were based on their traditional knowledge and the availability of resources at their

disposal. Abilities to change agricultural practices in response to climate uncertainty were socially stratified, with some categories of farmers being more able than others. Overall, however, changes to agricultural production practices in response to climate change could go only so far to avoid the losses due to climate stresses. In the next section, I place these responses in a broader context, but also looking at the non-climate drivers that also shaped farmer behaviour.

6.5 Non-climate drivers of changes to farming practices

The change to sowing dates and implementation of shifting agricultural practices, described above, provide examples for how farmer respondents in the Central Dry Zone are adapting to climate change. However, as suggested in the introduction of this chapter, such changes jostle against other alterations to farming, driven by other factors. These factors can be either narrowly responsive to market conditions or more widely strategic in securing farm household income. In this section, two types of responses are outlined. First, the rise of cash crops in recent years in response to new market opportunities. As a general rule, these cash crops are less climate resilient than traditional crops yet have expanded due to farmers' desires to capture increased income. Second, there has been a trend among farmers in some villages to secure income through agricultural changes that move away from cropping. This has included investment in wild almond trees and goats. In both cases, decisions about moving into these sectors responds to perceptions by farmers that although climate change is out of their control, they have agency still about their own choices for what they grow.

6.5.1. Market responsiveness and cash crops

It should come to no great surprise that short-term market conditions continue to exercise considerable influence on farmer decision-making. Farmers in all interviews and focus groups indicated they placed high priority on the market price of crops in the decision-making of process of "what to grow." This was the case both for dry land or fertile alluvial land.

Sesame

> *"I own 4.5 acres of land. My wife's family gave it to me as a family heirloom. However, our family cannot earn a good money through farming because my farm does not have*

access to irrigation water. This year, I intend to produce sesame because the market price is favourable. I grew sesame, pigeon pea, and green gram last year. However, the weather did not go along with us. So, even if the market price of sesame was higher, I could only earn 90,000 MMK from it. I believe the sesame market price will remain high this year, as I have heard that brokers from Korean factories would also visit the village to purchase our sesame. We used to have to go to the Pakokku market to sell the sesame. The broker has been coming to the community to buy sesame since last year. During the monsoon season, I normally grow pigeon pea and sesame for intercropping. I attended intercropping system training at the Department of Agriculture. I discovered that if crop residues are left in the soil, there is no need for fertiliser. In addition, when I lost sesame, we can acquire crop yield from pigeon pea. Because there has been no rain this year yet, I am unable to grow any crops yet. But this year, in the monsoon or late monsoon, I will grow sesame alone on all of my acreage. If the weather gave us the favour, I expect to gather about 7 baskets per acre. However, it is commonly known that sesame is quite risky. Sesame performance can be superb throughout the entire growing season, but just one time of rain before harvesting can damage the entire field. If the weather does not cooperate, we can harvest 1.5 baskets of crop to none of the crop. But I will cultivate the sesame because there are only two options; if we fail, we will just lose the cost of seed and the rental charge for ploughing. If the weather is doing good, we will make a lot of money. If the market price of sesame remains high, as it has this year, I intend to continue growing it. If I lose this year, I may make a good profit the following years."

The story from a farmer from Village 10 above, explains why he has decided to grow sesame on all of his land plots for the coming year. Sesame became a popular crop for dry land farmers when a processing factory, owned by Korean interests, opened nearby in Magway, in 2017. The key point about this is that sesame is very climate-sensitive, known locally as a gambling crop (*Laung Ka Sar Thee Hnan*). So, at the same time that farmers were becoming increasingly aware and concerned about climate change, they were also placing increasing reliance on a crop characterised by high climate vulnerability.

Sesame was initially grown intercropped with pigeon peas, a traditional pulse crop of the region. Pigeon peas are suitable to grow in the Central Dry Zone because it is a drought-resistant crop that needs relatively lesser water than many other crops. For 20 years, agricultural

extensionists from both government and non-government organizations have recommended pigeon peas, and these recommendations have had strong uptake from farmers in the Central Dry Zone. Pigeon peas have been often grown in rotation with other crops. As a legume, pigeon peas have beneficial agricultural properties in terms of retaining moisture and fixing nitrogen in fields. Its rotation with other crops therefore helps to use land efficiently. In addition, the residues of pigeon pea can be used as animal feeds and fuel wood for cooking.

Despite the merits of pigeon peas in terms of climate resilience and broader agronomic effects, interviews and focus groups revealed that the better market returns provided by sesame caused pigeon pea cultivation to lose favour. Pigeon peas have a lower net profit than sesame and have been affected by some unease in trading with India, the main market for pigeon peas. Further aggravating these problems, farmers expressed concern with labour scarcity. Pigeon peas have large labour requirements during the land clearing process because of the need to dig the crop residues to make ploughing possible for the next season. As farmers have been facing farm labour scarcity, they have become increasingly disinclined to opt for pigeon pea cultivation. One female respondent from Village 1 complained the difficulty of land clearance after harvesting pigeon peas:

> "*Digging out the roots of pigeon pea is a heavy task and kinds of tiresome for me and my very young children when my husband is going for trading, and I cannot afford to hire the human labour".*

As a result, sesame has increasingly been cultivated on its own. Evidently, farmers have been swayed by the market prices on offer for sesame and moved away from cropping practices that in purely agricultural terms are better suited to climatic uncertainty. Rainfed dryland farmers in the focus group discussions gave the following explanations for solely growing sesame in their farms:

> *"We prepare the land and broadcast the sesame alone. If rain didn't favour us, we will lose only cost of seeds and hiring machines for motor plough. If rain makes best for sesame cultivation, we can get more yields from our land by sowing sesame only. As sesame market price is not bad in these years, it is worth to grow more".*

Sesame has become a lucrative cash crop grown in rainfed conditions. But although farmers have been keen to take up opportunities to grow sesame, they are equally aware it is a "gambling crop" because the crop would fail if there were no rain during the critical period when water is needed.

CP corn production

CP corn production provides a second example of a cash crop. As there are different biophysical features in the Central Dry Zone, such as dryland, lowland, and alluvial land, the choices of crops by farmers are different based on their resources. Among the different types of land in the Central Dry Zone, alluvial land is the most fertile and high valued land. Therefore, villages near rivers with alluvial land have more productive agricultural sectors than villages in dryland areas. Traditionally, farmers who own alluvial land grew pulses, sesame, and vegetables but, in 1996, the government introduced CP corn to grow in alluvial land. At first, farmers were not willing to change from their traditional crops into CP corn. However, two years after introducing CP corn, it was cultivated by almost every farmer. This is because the market price of CP corn is much higher than traditional crops. This is the case even though initial subsidisation of CP corn has ended. In the early years, farmers could buy seeds (the '888' varieties) from the Department of Agriculture in the township at a subsidised price. After a few years, there were a lot of farmers who cultivated CP corn, so the government decided it couldn't distribute enough seeds to cover everyone. Since then, farmers have had to buy seeds from private companies at full price.

The following are the story of one CP corn farmer from Village 5 and he explained why he chose the CP corn for his farmland.

> *"My parents still own the 5 acres of land that I work on. I grow CP corn since my parents have done it for many years. Other farmers in my village have been producing CP corn for many years. We traditionally produce chickpeas, green gram, sesame, and other vegetables before cultivating CP corn. We grow CP corn since it has a higher market price and is ideal for our farmland. For inputs for CP corn production, I can rely on the agro-chemical company. They frequently visit villages before the growing season to sell seeds, fertiliser, and pesticides. I chose the seed from the most reputable company to ensure a high yield. However, the cost of agricultural chemicals increases*

year after year. In order to achieve a high yield, we must use high-quality fertiliser. We, the farmers in the village, were aware that CP corn might devastate the land. Therefore, if the soil becomes too sandy, I sometimes fallow one plot of land. However, I want to use all of my lands to cultivate crops in order to maximise profits because I must spend input and labour expenses while producing CP corn. I cannot handle CP corn cultivation just with family labour because it requires irrigation at critical times and labour, particularly during sowing and harvesting. I have my own tube well for irrigation, but I must employ labour to irrigate it. However, I will cultivate CP corn again this year because it is appropriate for my agricultural land and has a decent market price. I may get 7000 MMK for each basket of CP corn, and the average crop production per land area is 100 baskets. I can easily get information about the market price via brokers, radio, farmers' media, and Facebook. Why do I have to grow peas, sesame, and other traditional vegetables when the prices of CP corn on the market are much higher than the prices of these crops?"

Although farmers have received better financial returns from CP corn, this crop was described by focus group participants as generating negative impacts on their soil because corn is a heavy feeder, and it can deplete the soil. Therefore, some farmers practice rotating cropping with pulses but mostly grow only corn. Famers have little ability to negotiate selling prices, as the buyers (trader houses in the township) control pricing arrangements. Farmers cannot hoard the crops to capitalise on price movements, and so all sell their crops within a brief time window after harvesting with relatively lower prices. This is because they buy fertilizer and seeds on credit from agrochemical companies and have to repay them at the time of harvesting. Also, they have to prepare their land for next season's crop production and need cash directly after harvest. As they are able to access irrigation, they can grow crops year-round.

Melon Production

"I am the owner of 5.5 acres of farmland. There are 3 acres of irrigated low land and 2.5 acres of dry land among them. I decided to rent my irrigated acreage to melon producers. They are not from my village. They are from the township of Chaung U. Before renting out the low land, I used to grow paddy and chickpeas there. The agricultural production was not so awful because my lowland is fertile and able to get irrigation. However, the income from farming is highly unreliable. Farmers may have

high crop yields one year, but the market price is relatively low in that year. So, it is better to rent out if I have the chance. I am fortunate that my low land has access to irrigation and is located on a flat. Otherwise, I will be unable to rent out my land. I received a rental fee of 300,000 MMK for one season for one acre of land. I received that money with no investment in farming. I grew rice and chickpeas for two seasons before renting out that land. It is not the same as a dryland crop. Farming lowland crops such as rice necessitates more inputs such as fertiliser, labour for harvesting, weeding, and fuel costs for irrigation, yet market prices are not always predictable enough to generate a profit from these crops. Besides, I can work for my carpentry jobs because dryland crops only grow for one season and require little care. In addition, my daughter can work in China for 8 months. So, not only will I be able to preserve money for crop production, but I will also be able to earn more money. If the melon growers want it, I am happy to rent out my land for the next few years. If they don't want to rent my land, I have no alternative but to take it back and cultivate rice again". (57 years old male farmer from Village 3)

Melons have been a boom crop in northern Myanmar, including the Central Dry Zone, due to opportunities for trade with China. Because this form of agriculture is capital-intensive, and is dependent on connections with brokers and traders, local farmers are not always well-positioned to move into melon cultivation. Consequently, renting out land to melon farmers has become an increasingly attractive livelihood option for dry zone farmers. Usually, the land they rent out for melon is land used previously for rice, which is flat and irrigated, known as *le* land in Burmese, which translates as 'low land'. This land, which is suitable for growing crops and because it is irrigated, is less vulnerable to climate stress. But the primary reason for renting out their land to melon farmers is landowners want to secure their income through renting out their land at a fixed price, instead of growing crops and facing market uncertainty. In the words of farmers from Village 3 participating in focus group discussions:

"If we grew the crops, it is not certain to get 200,000 MMK per acre to profit from the crops but, we can certainly earn 200,000-600,000 MMK per acre depending on the land conditions by renting out our land to melon farmers".

In general, the Chinese farmers or rich Burmese farmers involved in melon cultivation are interested only in the highest quality land. They will approach farmers and offer to pay for only

that land which meets their needs, and this may leave farmers with poor land only. The land demanded by renters is often that used for rice, and with good water access. Renters will typically invest in water access and storage facilities, but these are dismantled upon completion of the lease, which is usually three years. The melon cultivators don't want to rent land plot by plot but seek to aggregate a number of fields owned by several different persons into a large holding. With greater size, the cultivators can bring in labour and raise support temporary shelter (tents) for them. This produces economies of scale for the cultivators.

However, renting out land to melon farmers is controversial because of its negative longer term environmental and productive impacts (Kubo, Pritchard and Phyo, 2020). Primarily, melon farmers do not rent land for more than three consecutive years because they know the nutrients in the soil are depleted after that time. Therefore, they will give back less fertile land to the landowners. Moreover, melon production needs to use plastic sheets to mulch/cover the soil. After harvesting the fruits, they leave the plastic in the soil, which impacts the land. However, landowners are still willing to rent out their land for the secure income it will provide for three years rather than grow some crops with uncertain market prices.

6.5.2. Moving away from cropping

The case of landowners renting out their land for melon cultivation, described above, segues into a wider set of issues in terms of farmers moving away form own-account cropping. In these cases, farmers still use their land for agricultural income, but not in through traditional cropping.

Wild almond trees

Perennial crops such as toddy tree, plum tree and *Thanakha* (which is used as traditional cosmetics) are grown in the Central Dry Zone area as all these types of trees are very resistant to drought. In recent years, wild almond trees have also been introduced to the Central Dry Zone, and farmers, mainly those who can invest more in agriculture, have been actively developing this sector due to its potential market to China. The gum from wild almond trees can be used as latex.

Many interviews mentioned the acquisition of large land areas to grow wild almond trees. Wild almond trees can be grown in all types of soil, but they cannot give revenue in the early years; therefore, farmers must invest money to cultivate. For example, one businessman from Monywa bought 26 acres for wild almond tree cultivation near Village 3. This was successful, and so after three years he bought more land. The success of this businessman's investment had a demonstration effect on the village, with one farmer (not a wealthy farmer) in Village 3 planting wild almond trees on his 3 acres of *Thanakha* land. He mentioned that the likelihood of changing the entirety of his perennial crop from *Thanakha* to wild almond trees is very high because he believes the latter has a better market price. He also explained his decision for growing the new plant by calculating the cost and benefits.

> *"I own 5.2 acres of Thanaka which is located on the dry land. Last year, I dug out around three acres of Thanakha to plant wild almond trees. A neighbouring farming household informed me about it. She and her husband were quite helpful in obtaining seedlings of wild almond trees and demonstrating planting techniques. I'll have to wait three years for the earnings from the wild almond trees, but I feel it will be a better market price than Thanaka. In normal conditions, the price of Thanakha increases by 1000 MMK per year, and I can obtain 7000-8000 MMK for a 7-year-old Thanakha tree. Because the area is remote from the village, I must pay labour to care for the tree. Security costs 50,000 MMK every month. It didn't seem worthwhile to me. So, I decided to attempt a couple acres of wild almond trees. The price of a wild almond tree is not bad this year. A viss of wild almond latex can get 50,000 MMK. The farming of Monywa man produce 20 visses every day from his one orchard. As a result, the total return from this wild almond latex is rather amazing. My parents have already grown Thanakha on their dry land because they are unable to grow food crops due to the agricultural area being exceedingly dry and infertile. Therefore, I have no plans to produce dryland crops there. But I have 4.5 acres of dry land plot, and currently I grew sesame and green gram there. After waiting for the return of my three acres of wild almond trees, I will most likely shift all acres of my dryland to the wild almond trees".*

Farmers have on occasion been exposed to the concept of switching from traditional food crops to new perennial trees through the course of social networking activities. According to an interview with a local large-scale farmer in Village 7, the area of wild almond tree cultivation is progressively expanding year after year. She grows many annual and perennial crops,

including 10 acres of wild almond trees. She was enticed to move into this sector because of advice from a friend of her husband, a civil servant in the agricultural department. They grew wild almond trees on land used previously for pulses and was vacant, used only firewood collection. She also mentioned the price of latex from wild almond trees is excellent, and she sold 46,000 MMK per viss, and she can harvest ten visses a day in the harvesting season. The brokers she deals with are representatives of Chinese businessmen, and they travel to the village on a regular basis to buy the latex.

This farmer has become an advocate for wild almond trees. During the interview, she told how she encouraged other farmers to grow wild almond trees based on the comparative crop prices. She argued that farmers have been losing labour costs when they grow mung bean or paddy when the market price or rain is unfavourable. She also grew paddy and mung bean last year and received less income than for wild almond trees. Therefore, she plans to extend wild almond trees in both paddy and dry areas as wild almond trees are resistant to drought.

Figure 7: Wild almond trees orchard at Village 7

Goat rearing

Goat rearing has become an attractive livelihood option in the move away from traditional crop production. In interviews and focus groups, farmers explained their reasons for this shift. Although climate stress is one of the reasons, they gave greater weight to the better prices and profits available from goat rearing. The goat market was developed after the Myanmar and Chinese Governments agreed to allow goat trade through their common border. One interviewee from Village 8 shared his experience about how he transitioned from farming crops to raising goats.

> *"I own 70 goats. I've been raising goats for four years. I used to work in crop farming. I am the owner of 4.5 acres of farmland. My parents gave me the land as a family inheritance. My parents were farmers as well. We used to grow sesame, pigeon peas, and maize. If the weather is bad, we can harvest about 10 baskets of pigeon peas from 4 acres of land, but if the weather is good, we can harvest 40 baskets from my land. However, since last decade, in my village, people have begun to breed goats, and they may earn a lot of money from it. So, I'd like to raise goats as well. But I don't have the money to buy the goats at that time. So, I began by sharing goat rearing with other households in the village. They made the investment to purchase the goats, and I contribute to daily care. I started with 20 goats. I was still doing crop cultivation and farming at that time. I was unable to leave the farmland since it is customary. I'd like to plough and distribute seeds when the monsoon arrives. However, the income from agricultural selling and goat sales is vastly different. I merely grazed the goats and took care of their food and drink because I did share rearing, but I can earn a lot more money than selling crops. Then, I tried to save money and buy my own goats so that I wouldn't have to share rearing and could get the entire profit. I can readily learn about market prices from my fellow livestock owners in the village because they have a link with goat trade in Muse. It's been four years since I've not done any cropping and fallow on my land. I was stressed out about predicting the monsoon while I was cropping, and now I'm stressed out about predicting goat prices. Anyway, for the time being, I'll be rearing goats. I haven't decided whether or not to grow crops on my farmland in the near future".*

Farmers indicated in interviews and focus groups that goat rearing generated five times higher income than crop production on an equivalent area of land. Of course, goat rearing tends to occur on dry and more marginal lands where cropping potential is less. However, the superior rate of financial return makes this sector highly attractive. Against this, goat rearing also possesses additional risks associated with access to the Chinese market. Prices can fluctuate substantially due to conditions at the border markets. During the survey (2019), some farmers complained about temporarily lower goat prices, and they could not decide whether they should continue to hold their goats until higher prices were on offer. However, this option was constrained for small farmers, who were less able to afford fodder and hence more at the mercy of prices in the short term.

6.6 Summary of how climate change is positioned within agricultural changes among case study villages

This chapter has used evidence from focus groups and key informant interviews to flesh out how local biophysical variation plays a crucial role in explaining the role of climate change in farm adjustments in the Central Dry Zone. A summary of the diversity of responses by farmers is in Table 8. As emphasised throughout the chapter, farm adjustments are driven by a combination of climate and non-climate factors, which operate differently in varying contexts.

Table 8: Farm adjustments done by farmers based on different land types

Farm Adjustments	Dry Land Farming		Alluvial land Farming		Irrigated Paddy Farming	
	Climate	Non-climate	Climate	Non-climate	Climate	Non-climate
Tillage	*		*		*	
Sowing Time	*		*		*	
Fertilizer application	*			*		*
Short-lived variety	*				*	
Irrigation			*	*	*	
Mechanization	*		*	*	*	
Labour Utilization	*			*	*	

Crop Selection		*		*	*	
Investing in perennial crops		*				
Land Rental				*		*
Goat Rearing		*				

For all the farmers in the study villages, adjusting the sowing date is an important response to climate change. Timing of sowing depends crucially on climatic conditions. Therefore, adjusting the sowing date can be considered a pure response to changing climate. All farmers across all sectors have reviewed their sowing dates, practices regardless of what kind of land they possess.

For many dryland farmers wedded to traditional crops such as oilseed crops and pulses, a key adjustment to climate change is to practice more tillage to absorb additional rainwater. Because of this heightened importance of tillage, mechanisation becomes more important. Farmers, regardless of their land types, apply machine ploughing for land preparation in order to save time and therefore be more adaptable to the uncertainty of the monsoon. Importantly, not all farmers are equally able to invest in these technologies, with richer farm households more able to adapt in this way. Also, in focus groups and interviews with farm households, the point was made that the wider use of farm machinery responds not only to the imperative to saving time as a response to irregular rainfall patterns, but also in response to farm labour shortages due to rural people joining in the non-farm sector. I address this issue in greater detail in the next chapter.

For farmers on alluvial land, the use of tube well irrigation can offset drought and water shortages in the cropping season. However, again, this adaptation to climate change is also implicated with non-climate factors, in this case the financial returns available from CP corn production. Farmers who observed the benefits of CP corn in other farms were motivated by incentives to capture the comparable benefits of market prices of CP corn. These higher financial returns from CP corn encouraged farmers to change out of their traditional pulses and vegetable production. But because CP corn production needs irrigation for successful production, it encouraged investment in tube well irrigation by alluvial farmers. Therefore, digging tube wells and pumping water for irrigation is jointly a response to changing market

conditions and an adaption to climate uncertainty as part of this transition. However, it needs noting that not all the farmers in the Central Dry Zone are able to move into CP corn. Within the study area, only a few villages had the biophysical attributes to move into CP corn.

The importance of local biophysical conditions in shaping adaptation is emphasised also in the case of villages able to access river water using pump irrigation. This is dependent on village location with respect to the Irrawaddy and Chindwin Rivers and canals from it. However, even in villages with river access, not all the farmers are able to access water because of local variations in landscape and infrastructure. For farmers with access, they are able to cultivate rice and chickpea. These issues show how local variations in biophysical conditions are critically important for farm adaptation.

Approaches to fertilizer usage are also implicated in how farmers adapt to climate uncertainty. Fertilizer application has grown rapidly in alluvial farming because it is seen to increase the vigour of the crops if they face the incidence of pests and disease due to unstable climatic conditions. However, this agro-technological response is rooted to deeper social and economic climate and non-climate processes. As described in the previous chapter, villages with paddy land raise more cattle than dryland villages, and hence have more ability to apply manure utilization to their land. But with the shift to mechanised ploughing, described above, cattle numbers have fallen, and this is linked to a shift to the use of chemical fertilizer. Chemical fertilizer effectiveness is however connected to weather conditions (represented in soil moisture) and hence provides another example of the linking of climate and non-climate factors in farm adjustments. For dryland farmers, use of chemical fertilizers is generally lower because of lower financial returns making it more difficult to justify these upfront expenses. Cattle manure continues to be used, although again, lower numbers of cattle pose issues for application. Farmers engaged in goat rearing, have a commercial market for goat manure and farmers tend to sell it rather than using it in crop production. Therefore, decisions about arrangements for fertilizer application are connected to a range of both climate and non-climate stresses and incentives.

Land and labour are also elements of farmer responsiveness to climate change. Increased reliance on family labour, especially for dry land cultivators, can be understood as a climate change adaptation strategy because it reduces labour costs and the risks of relying on external labour in contexts of local labour shortages and the need to respond with more agility in

contexts of climate uncertainty. In some dry land parts of the Central Dry Zone, labour issues and climate uncertainty reduce the viability of traditional cultivation, and this has encouraged wholesale shifts into goat rearing and tree crop cultivation. In the case of goat rearing, this opportunity has arisen due to opportunities from the Chinese market, also emphasising the role of geopolitical factors in reshaping farmer decision-making. Farmers who own alluvial land and cultivate higher yielding crops with higher financial returns still need to hire farm labour and have been struggling with the farm labour shortage.

Farmers also try to avoid the risk of climate and crop market price uncertainty by renting out their land to others, although their land is fertile enough and able to access irrigation. These practices have been most prominent in melon cultivation connected to the Chinese market. For example, villages located near Chuang U township are highly engaged in the rental of farmland to Chinese and middle-class Burmese melon growers. Only farmers who own irrigated land can do this practice.

Farmers' decisions on their farming practices are closely connected to their biophysical environments and the shifting commercial environments in which they operate, in contexts of their social networks and market prices. For dryland farmers who have difficulty accessing irrigation, the key response to climate stress is implementing crop sowing date changes and changing other farming practices to capture the rainwater and save the moisture. Even though alluvial farming and irrigated rice farming have fewer risks to crop losses due to irregular rainfall and drought, farmers' decisions on their crop choices are still based on the potential market prices or secure benefit.

6.7 Conclusions

As its name indicates, the Central Dry Zone is a region where drought, high temperatures, and rainfall volatility are familiar for rural households. Although households understand that these risks are being heightened by climate change, this familiarity conditions acceptance. Even though they are well aware of the climate impacts on agricultural production, dry land farmers want to continue farming and value their land and status as landholders. The negative impacts of climate change on crop production in the Central Dry Zone and farmers' struggle to respond to it cannot be denied. However, climate stress is not the only stress farmers in the study villages have been faced for years, and there are other stresses such as instability of crop market

prices. Farmers make adaptations in their cultivation practices to protect crop losses due to climate changes based on their own traditional knowledge and available resources. However, as seen in the cases of study villages, the priority for farm households is to obtain better income, and this may lead to behaviour that pays lesser regard to the need to deal with climate change risks. In contrast, when agricultural or trade policies are changed, it has drawn local people's attention because of the very immediate impact on their rural livelihoods of the Central Dry Zone region. According to these changes, rural households can grasp huge benefits or suffer losses. Therefore, they pay more intentions to such kinds of market changes.

It is true that farmers in the Central Dry Zone responds to climate changes in their farming, but this is implicated and intertwined with other factors, notably financial returns from different forms of agriculture although all the responses are very incremental. Farmers are willing to take risks in crop selection if they think they can get a better income. On the other hand, they can rent out their land although they know it could affect their farm in the long term, and they can even completely change their traditional crop production to livestock production or tree crops. Therefore, we can see more prominent farm adjustments in response to better market prices and better income. The literature related to climate change adaptation mostly spotlights on-farm adjustments in linkage with climate change. However, farmers are making their decisions on their farm arrangements not only in response to climate stresses, but also, they are changing their farming activities to maximize the benefits from the farming based on the resources they have. Farmers respond to multiple factors simultaneously as the livelihood of rural farm households are very dynamic. Therefore, it is necessary to situate climate change as a factor in farming adjustment within the wider contexts of how farmers are grasping new market and technological opportunities.

7. CHAPTER SEVEN: CLIMATE CHANGE AND NON-AGRICULTURAL LIVELIHOODS

7.1 Introduction

As discussed earlier in this thesis, farm households can adapt to climate change through actions taken in either farm or non-farm sectors. Livelihood diversification into the non-farm economy provides a potentially important adaptation pathway for rural households in the Central Dry Zone. This is especially relevant for rainfed dry land farmers who have been highly vulnerable to climate uncertainty, as described in the previous chapter. These farming households have suffered declines in crop yield or faced crop failure due to climate stresses such as drought and irregular rainfall. The aim of this chapter is to focus on the extent to which farm households respond to these pressures by engaging in non-farm livelihood activities.

The discussion in this chapter builds on that from the previous chapter, where I discussed how for farming households, the immediate cash benefits from market opportunities often lead to farming decisions that prioritise these incentives above farm adaptations to climate stresses. Although it is clear that farmers are aware of climate stresses such as drought and irregular rainfall patterns, for various reasons described in the previous chapter, these do not always convert to on-farm adaptation practices. In these contexts, livelihood diversification into non-agricultural activities may become a heightened risk reduction strategy. These changes make farmers able to be less reliant on farming because of their access to non-farm opportunities.

The non-farm economy is a pathway for farming households to adapt to adverse climate because non-farm livelihoods provide rural people with greater flexibility in allocating resources across income-generating activities and therefore can lead to increased resilience to economic and environmental crises (Ellis, 2000). Nonfarm employment in developing-country agricultural communities has attracted a lot of attention. Its importance in implementing climate change adaptation methods, however, is rarely discussed. Some studies in the literature characterize non-farm activities as an alternative new pathway for rural farm households when agricultural productivity has failed. Studies have been unable to adequately account for the essential role of socio-cultural variables such as social capital or local culture in the formation of the rural non-farm industry.

As this chapter will argue, non-farm livelihoods are a key strategy for farming households to increase their adaptive capability to climate stresses. It will present what non-agricultural livelihoods mean for rural households in the Central Dry Zone and how non-farm livelihoods are linked to the village traditions. First, I bring this issue into focus by describing the role of non-farm activities of farming household members, using an exemplary testimony of one of my informants. Then, I will evaluate the types of non-farm livelihoods (including migration) found in the study villages. Finally, local perception of the undesirable impact of these types of non-farm work and migration will be presented.

7.2 How farming households respond to crop failures: Daw Mya's story

> *"I can guess the success of my crops by observing the onset of monsoon. If the onset of monsoon is bad for the crop, the monsoon crops will fail. I knew there was not much left to harvest from my farm. So, I planned to work as a farm labour in another township. My son has already worked in a stone-carrying truck for two years. My younger daughter is still in primary school, and I do not need to worry about her school fee because she is still in the village school, but if she is in high school in the nearest town, I will have to think of her school fee. My husband focuses more on his carpenter work rather than farming. He contributes only to the ploughing and harrowing times. Sometimes, my son helps in these jobs. Usually, his job needs him to travel and stay in the destination where there is construction for months. It would be good if we could harvest more yield from the crops. If not, we lose only the costs of seeds and hiring machines for ploughing and harrowing. Our family would like to keep farming as the family tradition, and I never think of giving up the land. At the time of monsoon, when other farmers are doing ploughing, I also would like to do it even though it is uncertain about getting the crop yields. Work outside agriculture depends on where you live in society. For example, my husband has many friends in the carpenter's circle, and he can get the jobs."*
>
> *Daw Mya, 39 years old female respondent from Village 2*

The story of *Daw Mya* highlights how rural farm households allocate household members to farm and non-farm activities. Her story is characteristic of how male household members are more likely to initially engage in non-farm activities, while female members stay at home to focus on farm management. However, facing crop failure, female household members make plans to find job opportunities. Her story tells of how her husband and son join non-agricultural work, and the importance of social networks to get non-farm jobs.

The responses exemplified by Daw Mya are contextualised by the fact that farmers in the Central Dry Zone region mostly grow crops for the market rather than for household consumption. Most respondents explained that they need to buy rice and other foods for household consumption. According to the region's biophysical conditions, very few areas of land are used for paddy cultivation, and even in these cases, paddy is grown with a view to sell surplus. Farmers growing oilseed crops and pulses mostly they sell all of their products and then, they buy cheap oils from the market for household consumption. Therefore, when climate stress hits their crops, this is first and foremost an *income problem*. Their chief intention is to find alternative income sources.

7.3 Types of non-farm work in the study villages

The information collected by household interviews and focus group discussions are analysed based on the theme of "what are the reasons for working in the respective non-agricultural activities". Generally, non-farm work can be categorized into two, individual and village wide. Individual non-farm work means the work which can be done based on individual's skills and qualifications. Village-wide non-farm work means the work or activities which are related to village resources, culture, or tradition. People undertaking this work may be highly skilled, but not through any formal education or qualifications.

7.3.1 Individual non-farm livelihoods

One of the most important individual influences in people's ability to work in the non-farm work is education. As confirmed in my fieldwork data, there are only very few rural farming household members who have college or university graduate-level education. This level of education is vital to work as waged labour in professional roles in the government or non-government or private sectors, such as teachers, doctors, or accountants. Based on my

observations during household visits for interviews, rural households with graduates put graduation photos prominently in the living rooms or guest visit places. Rural families are very proud when their children join these kinds of waged jobs. One female respondent from village 7 proudly shared her thoughts on her son who works in a telecommunication company:

> *"I have noticed the education performance of my son since he was young. Therefore, I supported him to send to the school in the Pakokku city for his high school. He got the entrance to the Engineering University (Technological University, Pakokku) and then, finally he graduated and got a job in a company. I feel like he got the ticket for his livelihood. He cannot send money to us every month, but it is not a problem. He usually comes back to the village at the Thadingyut festival and Thingyan (water festival)".*

Although farming households accept the fact that to gain professional employment family members need to move out from their village, sometimes, they try to find opportunities to keep their children local. This is especially the case with female household members. For example, one male farmer from village 6 explained how he attempted to get his daughter a work transfer to his village:

> *"My daughter works as a teacher in the village school. At first, she needed to serve in a village primary school in Shan State. When she worked in Shan State, we could not communicate very well because the phone connection is not good in that village. I worried a lot for her health and security. After three years of working in there, I suggested that she apply to our village back [Although unsaid in the interview, he made it known he used some kind of bribe to make this happen.] Finally, she got her transfer, and I am so happy as she is under our eyes. People in the village and neighbouring villages pay respect to her as she is a teaching staff for the village. Besides, my wife can also sell some traditional snacks at the school for the kids".*

According to face-to-face household interviews, the respondents wanted their children to have better education so they could get the kinds of skills required for professional jobs, rather than working in agriculture. There was a strong emphasis in focus group and interview narratives about their hopes for their children to get a good education in order to grasp decent jobs in the cities. One female respondent from Village 2 shared how she scolds her children when she feels they are lazy in their study:

"if you don't want to graze the goats, you have to try hard in your school lessons. Otherwise, you will have to work hard under the sun like me. You can only get the good jobs if you passed the exams smoothly."

These sentiments highlight a paradox in the relationship between the farm and non-farm economies. Although all respondents indicated that they wanted their children to become educated persons and work in decent waged jobs, they also said they want to keep their farmland for the future generation. Although they don't want their children to take up the agriculture work, they still want to handover their land to their generation as the family heritage asset:

"*Farming is our tradition, and nothing is wrong for keeping the farmland for our generation. Maybe, one of the children will keep the agricultural work. At least, they can use it as an asset to get money when they faced difficulty in the future" (39 years old male respondent from Village 2).*

7.3.2 Village-wide non-farm livelihoods

As noted above, individuals with graduate level education are the exception rather than the rule in the case study villages. Hence, most non-farm livelihoods tend to be in non-professional employment. This work may involve manual work or craftsmanship involving high levels of skills but is not associated with any need for educational qualifications. Activities can be subcategorized into tradition based, location based, and local resource based non-farm work.

Traditional based non-farm livelihoods

Like agriculture, some kinds of non-farm work in rural areas play an important role in terms of traditional livelihood identities. These are kinds of activities in which village members have worked generation after generation. Weaving in Village 10 is a good example of these traditional livelihood practices. Farm households grew cotton many years ago and this led to an expansion of weaving at the village scale. This activity then became more formal after sending a group of female workers to Kachin state and learning the popular Kachin garment patterns. Hence, from informal and opportunistic beginnings, weaving has now established

itself in Village 10 as an important livelihood activity from which village members draw identity and purpose. One young female respondent from Village 10 describes this transition:

> *"In my grandparent's times, they grew cotton and weaved the garments. In our times, we don't grow cotton anymore, but we modified our weaving machines and changed the weaving style. Every household with young females does weaving in the village. The merchants collect the garments in the village, and we can earn household income better than farming. All the young females can do weaving, and the household with more women can earn more stable money from weaving. We don't have to work outside the village or on the farm, and we can work in our home."*

Females in Village 10 have a strong sense of pride about weaving because they identify it as skilful work and highly regarded by their families. The fact they can work at their home, described by some respondents as "under the shade", highlights its preferred status compared to farming work, which needs to be done 'under the sunlight' of the harsh climate of the Central Dry Zone. Additionally, the gendered norms around weaving provide scope for female members to feel they are the main income earners in households, further building their pride and social status.

It is interesting to compare the fieldwork insights from Village 8 to Village 10, because these two villages are located close each other, and they share the same biophysical conditions. These two villages have similar agricultural cropping patterns. However, unlike Village 10 which moved into weaving, Village 8 moved from cropping into goat rearing in response to opportunities to trade goats to China over the border. Comparing the two villages, goat rearing can provide a more financially lucrative option for households than weaving. But in Village 10, the take-up of goat rearing has been relatively small, due to the way that weaving has been inserted into village identity and tradition. In Village 10, interviews and focus groups emphasised how the weaving business is preferred because girls and women can work at their home. There is now a strong history of sending village girls to Kachin state to learn new garment patterns. Therefore, their pride in weaving seems to act as the paramount consideration in shaping their non-farm livelihood pathways. This is summarised in the following quotes:

> *"I know goat rearing and trading can earn better money, but my daughter doesn't want to deal with goat management. She prefers weaving to grazing goats. She helps me at*

weeding, harvesting and threshing times at the farm." (56 years old male farmer at Village 10)

"[Talking about another household…] *They have four daughters, so they can establish four looms. You can calculate the money they can earn. As we can access the electricity in the village, they can do weaving day and night. Since my daughter got married and pregnant, the loom in our house has stopped."*

The move into weaving however provides opportunities only for some village members. Elderly females cannot work in weaving due to their eyesight issues commonly encountered by older people which impacts upon the detailed work in formatting garment patterns:

"As I am old already, I cannot do weaving due to my eyesight. I don't want to find the jobs outside the village, and I better find the farm labour jobs in my village or neighbouring villages" (58 years old female respondent).

Also, male household members are excluded due to gendered norms and expectations that define weaving as a traditionally female job. In the focus group discussion in Village 10, female participants strongly resisted the idea of men working in weaving:

"[men] can work for other jobs such as farming or carpenter or trading. They cannot sit down for the long time in the home and do weaving. They prefer to work outside and get the exposure."

Like weaving, "trading household commodities" is another form of village-level traditional non-farm work. Focus groups and interviews in Village 1 highlighted the history and current arrangements of this activity. In past years, households in this village earned income from carrying tradeable commodities by foot to sell other rural areas in the dry season. Nowadays, they use the motor bikes and cars to transport tradeable goods to the other regions. The trading is usually organised at a village level and Village 1 has leaders who organize the labour for traveling and selling the commodities. The critical asset that allows Village 1 to generate income from this activity is its knowledge network. Because Village 1 has been involved in trading for many years, the village possesses skills and trust that enables this activity to occur. Other villages accept the role of Village 1 as the leader in this activity.

At the focus group discussion at Village 1, the conduct of this activity was discussed. Participants acknowledged that trading was their main non-farm livelihood:

> *"Men in the village usually work for trading with their respective trade leaders. They usually take the advance money from the leader to spend the household expenditures of their families during their leave. Female and other household members can manage household chores and farming activities. So, generally in the village we have income only from trading and farming" (Focus group discussion at Village 1)*.

Although the work demands leaving the village and spending extended periods away from home, household members accept this reality. One couple interviewed in Village 1 simply acknowledged that absence was part of their livelihood circumstances:

> *Husband: "I joined the group since I was single. I just know how to work with trading group and farming. So, I have to find money for my family by doing what I can do". (26 years old male household member)*

> *Wife: "I do not feel any difficulty as my husband goes to other regions for his work. I have nothing to be scared for being alone with my kids due to my husband's absence as my parents and my relatives also live in the village. They take care of me". (23 years old female household member)*

Unlike weaving in Village 10, which is an income-earning activity for females, trading is a traditional male activity. One female interviewee responded the questions of "would you like to work in the trading?" by laughing:

> "*What do I suppose to do among the male groups? Only men do that job in our villages. They need to travel village after village with their motor bikes and sometimes, their accommodation is very rough. We, females need to take care of kids and households in the village."*

A third example of village-wide traditional non-farm livelihoods is the carpentry work in Village 7. For as long as any respondent could remember, Village 7 was known as "the name of carpentry village." People from this village have a long tradition of working to build houses

and other community structures such as monasteries. They began these activities during the off-season in their own and neighbouring villages, but nowadays, they are working with groups year-round in the township and other regions such as Shan state. A 47-year-old male respondent shared his thought about how his village name is vital for his work:

> *"I have been working as a lead carpenter for ten years. I have farmland, and I received the land from my parents as the family heritage. I also grow the crops, rice and chickpeas. I joined as the young carpenter in my uncle's group when I got married. My uncle trained me in the working group. Our group got some connection to work in Mandalay, and these people from Mandalay know our group is good at that work. We have got more linkages in these years, and the youth not only from my village but also neighbouring villages would like to join in my group. My wife manages the farming, and it is not difficult for her. I would like to focus on my carpenter work to be better because the client trust in the capacity of our village carpenter's group."*

Although the work demands to travel outside villages, the workers in the carpenter groups are flexible in adjusting their timeline. They can only join in the off season, or they can take leave when their family needs the farm labour at the peak season:

> *"I can make an agreement with the leaders for the duration of work before I join the group. For example, I can tell my leader I will work till Thingyan (water festival)" (22 years old male worker).*

Again, there is a strong set of gendered norms around this work. The carpentry work is traditionally for men; therefore, only male household members are allowed to join the groups. At the focus group discussion, the thought of females doing this work was dismissed without question:

> "*It is impossible! Carpenters need to work with a group of men and the work is not for females such as climbing the height for building the roof."*

In addition to this, a 60-year-old male group leader mentioned that the position of carpenter is too risky for women.

Resource based non-farm livelihoods

Like agriculture, available biophysical resources are very important in defining the non-farm livelihood opportunities available for rural people. A good example of this is brick production in Village 4. Farming households use the soil from their cropping land to bake the brick. The brick making industry was formed in their village 30 years ago and it was initiated by outsiders. Then, local households learnt the new businesses and wealthy households built the businesses of brick making. Based on these resources, Village 4 has become a production place for bricks and many farm household members are taking the opportunity to work in the brick making:

> *"The quality of soil used to make the bricks is very important. We are able to access the good quality alluvial soil for the brick because most of our village farmland is flooded in the monsoon season and leaves good soil for baking the bricks. We (the village) are lucky to have such kinds of land which allow us to earn the good money in the offseason". (A female brick worker at Focus Group Discussion in Village 4)*

This non-farm work can support the job opportunities for the whole village. Farm households' members who used to work only in farming can now work as the labour for brick making and earn higher incomes than possible in farming. Moreover, the timing of the work can be adjusted with the crop management activities. The brick making workers operate as a group in which both male and female members are included. The payment is based on a piecemeal rate based on the amount of work finished. Upon completion of a job, labourers get paid lumpsum. Participants in the focus group discussions in the Village 4 discussed feasibility of working in the brick production:

> *"A labour group for making bricks is usually composed of family members, friends or relatives because it is easy to adjust the activities each other. For example, female members can go and work for their parent's farming activities such as weeding or harvesting crops after finishing her work of rolling the mud for baking the bricks. As we stay at the same village and we know each other since we are born, it is not difficult to get the understanding on the time management. It is also the same for the sharing the payment. No one doesn't dare to make the uneven payment. As long as you can work in the group, your family don't need to worry for daily consumption".*

A second income flow related to this industry is in how farmers can generate extra money by selling topsoil of their farmland to the brick business owners. This occurs during fallow times and would seem to impair future productivity. However, as per an interview with a farmer who sold topsoil from his land, crop production was not said to be affected. This was because he decided to sell only one plot out of total six plots. He again added why he decided to sell the topsoil of that plot:

> "*That plot is located near the river. At the monsoon time, it will be full of flood and after the flood there will be fresh alluvial soil. So, I don't need to worry for losing the topsoil because it can be refilled naturally."*

Location-based non-farm livelihoods

Location-based non-farm activities are those dependent on their village's geographical location. Working on the water-borne transportation is a good example because rural households get those opportunities from being in the village located beside the junction of two of the main rivers of the country. Village 9 is located near the junction of Ayeyarwady and Chindwin rivers, which is a famous transportation route for cargo ships. For example, petroleum fuel is typically transported along the rivers. Since Village 9 is located near the main junction, household members have had extensive opportunities to participate in these activities for many years.

Despite the agricultural productivity of Village 9 being high due to fertile alluvial land, family members of farming households still undertake extensive work in water-borne transportation because they can earn better money. Being a resident of that village allows them to obtain that kind of non-farm work relatively easily. At the focus group discussions at Village 9, the participants elaborated on these issues:

> *"As our village is near the river junction, we have the good connection with the cargo ship owners. Since we have been working for the cargo ship for generations, the experienced workers can recommend the younger ones to get the jobs there."*

The skills required to undertake these tasks are embedded in the history of the village. Particular skills are needed to work on the cargo ships such as understanding river flow. In this village, this knowledge has been passed on generation to generation:

> *"When my son was 16 years old and he failed matriculation exam, I asked my uncle to take him to work in the ship in order to get the experience. My uncle works as a worker in the cargo ship for his whole life. Not only my son, but other young males also approach him to get a job on there". (47 years old female respondent at Village 9).*

Yet again, gendered work norms play a key role in shaping access to this form of non-farm livelihood. Only male household members are allowed to work for water-borne transportation. As per focus group discussions, this was described as a tradition that only male household members undertake because the nature of work is very hard and inappropriate for female and it also asks the workers to move along the rivers, spending considerable time away from home:

> "*Workers for water-borne transportation need to stay overnight on the ships along the rivers. It is hard work. Moreover, the workers on the ships usually drink alcohol and we don't think it is a suitable job for the female." (Focus Group Discussion at Village 9)*

Another example of location-based non-farm work is joss stick making. The *Thanakha* tree is the main source for joss sticks, and this is naturally abundant in Yesagyo township. Therefore, the whole Myanmar knows that Yesagyo is a place for producing joss sticks. There is a famous joss stick factory, *Kan Pwint,* in Yesagyo town. That factory demands the labour from the villages around the town for making joss sticks. The rural households near the town have opportunity to obtain jobs to work for the joss stick factory. Moreover, they can work at home, and receive money on the basis of pieces they finish. One female respondent from Village 7 described her participation in this industry:

> *"Since Kan Pwint factory was established in Yesagyo, many households in the village take the portion of work from the factory. The broker of the factory distributes the required materials and collects it back in every week. I can easily earn money just staying at home without any disruption of cooking and taking care of my kids".*

Nevertheless, although it is convenient work, income earned from joss stick making cannot support a household. The women working in this sector do it just for household extra income which can be used for household daily consumption. One female respondent from Village 6 talked about the contribution of money earned by her working for joss stick making:

> *"The work for making joss stick and drying them is easy and I can earn around 10,000 MMK per week. So, I don't have to worry for the cost of oil and salt (se pho sar pho: direct translation is cost of oil and salt for cooking, but it represents the amount of money which can cover the miscellaneous use of kitchen)".*

7.4 Migration

Remittances are also an important source of household incomes in the study villages. Both domestic and international migration have been found in the study villages. Most of domestic migration is related to the non-farm work such as trading, carpentry, and water way transportation. Therefore, it is mostly male migration. Apart from that, in the case study villages, very few females moved to the cities to work in factories or markets. Some female labour works in other townships as farm labour, particularly in Chaung U township for a very short period. However, male migration is much more prominent than female migration in the study villages.

International migration is not new for the Central Dry Zone. In the last 10-15 years ago, farming households in the study villages have been sending their household members abroad to work for better income. Rural households place their hope in international migration as a strategy to receive remittance money as a lump sum after one or two years. Monies from remittances from international migration are often invested on fixed assets such as repairing the family house. A female respondent from Village 6 told her plan to allocate the remittance money from her son:

> *"My eldest son went to Korea for 2 years already. After paying the loan for his company (the agent who linked to Korea for work), I will repair my house with bricks. So, he doesn't need to worry for the house when he marries."*

Moreover, remittances are also used for traditional and religious ceremonies that cost a lot of money.

"I bought the gold by using the remittance money and I will sell it back when my husband is back in order to use for my son's novitiation ceremony (Shinbyu)". (24 years old female respondent at Village 2)

The story that is presented below was obtained from a farming household that had a household member who currently works in Korea. The interviewee discussed the process through which her son moved to Korea to work as well as the significance of remittance money for her family's finances.

"Because of my son's work in Korea, our household economy has improved this year. We can't breathe because of the losses in farming and caring for elderly parents in recent years. During his undergraduate years, my son had the desire to work in Korea. His friends intend to take the exam to work in Korea. He wants to work because he knows our family's financial situation is not good. He unexpectedly passed the exam and was given the opportunity to work in Korea. The key incentive to working in Korea is the higher income compared to Myanmar. He actually has no work experience. He went to college in Pakokku. Even though he travelled with his friends, I am concerned for him because he is too young. He has been working there for roughly nine months. However, we did spend 67 lakhs to send him there. We originally had loans of roughly 30 lakhs for household expenses, children's education, and parental health care. We are unable to make good money from the farm as well. My husband works so hard all year, yet the expenses are so expensive that we had to take out loans from private money lenders. As my son sends money back from Korea, we will be debt-free by the end of this month. According to his contract, he must work there for four years and ten months. I want my other children to work for the government as teachers or doctors. I want their lives to improve and become more pleasant. I'm not sure how I'll feel if they all leave the village. I feel terrible for my son, who travelled to Korea. He is a highly intelligent son; he understands how hard his father works for the entire household, as well as the cost of his younger brothers and sisters' schooling".

In the past, rural households migrated mostly to Malaysia, Thailand and Singapore. But, in the time of interviews (2019), most of them were trying to work in Korea because of higher wages

available. However, migration to Korea has more initial expenses, such as attending language training.

> *"I would like to send my son to Korea, but I cannot afford the initial costs. The agent asked him 4,000,000 MMK to link with the company in Korea. My son is a graduate person and cannot find the jobs. So, he is very willing to work there. Maybe I need to sell my goat herds in the next year for the initial cost." (52 years old female household member at Village 1).*

Most of the international migration from the study villages is temporary migration and it is usually a male dominant migration pattern. But, at the time of data collection, seasonal migration to China was observed as a new migration trend in the Central Dry Zone. There is labour demand to work as the farm workers in the eggplant and melon cultivation sectors. In these cases, female migration outnumbers make migration because female workers are seen as being more skilful in nursery plantation. In the focus group discussion at Village 3, the participants revealed the reason for more female worker joining in the seasonal migration to China.

> *"The income of one female labour can earn 1,500,000-2,000,000 MMK per season from watermelon or cucumber farms in the China border area. The number of migrated people to China is increasing as they can easily join the work with the help of previous Burmese workers who worked in China. Farm labour prefer to work in China as they can earn much more than working in the village. They can even earn till 2,500,000 MMK per season if she worked hard. So, most of young people in the village would like to work there."*

They also claimed that seasonal timing allows them to work as farm labour in the village and then to China.

> *"The peak crop season is different in our village and China. So, they can work back in the village farm work too. Small-scaled landholders can also work in the China as they have less land to manage." (Focus group discussion at Village 3)*

Seasonal migration to China has attracted most of the farm labour from the study villages. Landless farm labour households try to allocate their household members to work in there. The interview with one farm labourer (19 years old female) who usually works in the agricultural farming in her village as well as another township, revealed her family member's experience who worked in China the previous year.

> *"My sister and I are daily wage farm labourers. We also work for all types of jobs. We work in farming if there is a job for it. We are currently working in melon fields in this village, as well as melon cultivation in the eastern portion of another township. Last year, my sister went to China to work. I cannot join her to work there because I have to take care of my family here too. But she had never been to China before. Working in China seems good. She stayed there for eight months. She made almost 16 lakhs in eight months. This year her health is not very well. If her health improves, she plans to return to China. The most important factor for life is one's health. There are three dependent households' member in my family. Only the two of us can work in my family. Working in the village for all types of jobs cannot cover our household's expenditure and creates a financial problem. So, my sister went to China for a year of working. However, she did not stay the entire year because when there was no job, she had to cover her own bills if she continued to stay there. She received her work wage in the form of a daily wage. There are two types of wage payment system: daily wage payment and monthly wage payment. My sister worked as a daily labourer. They used their currency to pay labour. That is something I do not really understand how they manage in exchange. She only stayed for eight months. There are currently only a few works in the village. Farms are also completed farming activity. Farming activities in China begin in September. I think there will be a lot of people from my village will go and work there next year. They must account for their own expenses to travel to the border of Myanmar and China. I don't know what the route they use to go to China."*

Farm households in the study villages are open to work in China on a seasonal basis due to its higher payment and flexible timing. One female labourer who organized a labour gang to work in China explained why China demanded increased numbers of Burmese workers:

> *"There are around 50 persons in my group, who went to work in China last time. I guess the number will be increased next time. The work for the farm labour is common*

agricultural work such as nursery bed preparation, cover the plastic on planting bed and making the hole with stick for eggplant cultivation but Burmese labour are much cheaper than Chinese labour. They pay Burmese labour only half of the wage of Chinese labour".

Moreover, migration to China to work as a farm labourer has become popular and lucrative for female family members who do not often travel for work. Although non-farm work alternatives are appealing to the younger generation, they are nonetheless keen to find jobs with higher pay. However, it is dependent on the type of non-farm work people perform. The weaving girls will not be eager to work in China for agricultural labour. However, the female members of the household that work in the joss stick production are eager to work there for better remuneration. One household interviewee enthusiastically shared her daughter's first trip to work in a foreign country and the reasons she chose it.

"My second daughter went to China to work in September of last year. She worked in agricultural fields like tomato, chilli, egg plant, and melon production. She is unable to work for the entire year. In May, she returned to the village. I'm not sure exactly where she was working in China. I also have no idea how much money she can make in a day or a month. However, when she returns, she will be able to give the family approximately 16 lakhs. I believe she will return to work there in September this year as well. She cannot stay there all year because there is no job in China between May and September. If she stayed there at that time, she would be on her own, with no income. This is her first travel to China, and it is a first travel for work too. She normally makes joss sticks at home before that. She can work making joss sticks from home without leaving the house, but the remuneration is quite different. Although she is the primary producer of joss sticks, other members of the household assist her. If we work really hard, we can finish roughly 4000-5000 rough joss sticks every day. We can only produce 3000 sticks every day if we don't want to make them energetically. So, daily earnings might be around 2000 MMK from joss stick making at home. Here, it is not surprising the girls in the village are eager to go and work in China for the coming year. Even though there aren't many farm jobs available in the village, my daughter is still familiar with farm work. She can quickly learn to labour in China's agricultural fields. She is not frightened to touch the soil for work because she was born in the village."

7.5 Local perspectives on the undesirable impacts of non-farm activities and migration

There is a tension in the growth of non-farm livelihood activities in the study villages. Although non-farm activities are an important livelihood activity for rural households in the study villages, farm households held some negative views on it. Farmers highlighted how it contributed to labour shortage and an increase of the labour cost because people are more willing to work in non-farm activities.

> *"Before the busy time, I need to find the labour in advance. Last year, I can hire 5000 MMK per day but now I have to pay 7000-8000 MMK per day. If I paid 5000 MMK per day, no one would work for me. They will compare the wage of other works (non-farm work)". (46 years old male respondent at Village 5).*

Farmers also complained about the attitude of the younger generation to farm work.

> *"Young generation don't want to work in the farm. Even if they don't have to go for their work, we cannot hire them to work for us. They just help their family farming". (A participant of focus group discussion at Village 6).*

Participants in the focus group discussions of the study villages remarked that toddy farm labour has almost completely disappeared as there are many opportunities to work outside villages:

> *"In the past, there were many workers for harvesting toddy trees. It needs the whole labour family to stay in the toddy farms. They also work for processing traditional toddy sweet. This work is very hard because it needs to climb up the tree, harvest the toddy juices and make the process of toddy sweet. In the past, the toddy farm owners got the share of one time of harvesting on every four times. Nowadays, the owner cannot get this rate as there is very few toddy farm labour in the village. Most of them chose other work". (Focus group discussions at Village 1)*

Although many rural households embraced international migration, as a way of gaining remittances, some of the interviewees expressed their insecurity in sending a household member to work in a foreign country:

"I don't want my sons to work in the other countries for years. I would worry all the time for him if something went wrong. I can work whatever the odd jobs to get money for the household instead of letting my son go." (Female respondent at Village 2)

7.6 Summary of how climate change is intersecting with non-agricultural activities and migration

This chapter has illustrated the ways that non-farm livelihood activities are weaved within rural households in the study villages. Non-farm livelihood activities take many forms, and there are considerable differences between villages. Hence, while it is true that climate stresses have direct impact on crop production and produces incentives to accelerate rural people to join the non-farm economy, this is done in a context of longstanding traditions about non-farm work, and a shifting landscape of opportunities from migration. The expansion of non-farm livelihoods across the study villages cannot be ascribed simply as an adaptation to climate stresses.

Villages in the study area have a long history of engaging in the non-farm economy. The question posed at the outset of the chapter is the extent to which climate change has been a motivation for rural households to further increase their dependence on non-farm activities because of stresses in farming. Farmers certainly face agricultural losses due to climate stresses, and alternative livelihood options in the non-farm sector are part of an adaptive response to these problems. However, as described above, the types of non-farm activities undertaken by rural households are contextualised within a wider array of historical circumstances, and failure in the agriculture does not solely influence a household's decision-making to join the non-farm sector.

As an overview of non-farm work in the study villages, this is shaped influentially by local livelihood histories relating to tradition, geographical location, and resources. Also, non-farm activities in the villages are not new to farming households, although they have been intensified or modified in recent years. Villages have their own histories of non-farm livelihood. However, some non-farm work in recent years is related to new social networks, especially working outside villages. Hence, it cannot be hypothesized that crop failure due to climate stress in these regions is the only force for rural households to choose non-farm work. Based on the data

collected, farming households in villages with highly successful agriculture performance, such as Village 5 and Village 9, have still chosen to engage in non-farm work as a part of their livelihoods because of better income opportunities and new experiences for household members.

The formation of non-farm livelihoods is also related to the availability of the resources. Village 9 is located near the Ayeyarwady River, and the male household members from the village usually work for waterway transportation along the river. It needs particular skills for controlling the ships and managing the commodities to trade along the river. The transportation workers relay their skills to successive generations in the village, meaning that although Village 9 has very fertile alluvial land to produce crops, The rate at which farming household members work for waterway transportation has been increasing.

Tradition has been observed as a critical factor for rural farm households in engaging their livelihoods in the non-farm sector. When households shift into non-farm activities, their livelihood choices can be dependent on the role of tradition. Individual villages in the study area often are associated with their particular non-farm livelihood activities, including weaving, carpentry, and trading making among others. These traditional activities are embedded within rural households' sense of identity and see this non-farm work as contributing to a sense of pride in their village. They value the association of their village with being good at "something specific" and they will keep doing it even though there may be better income opportunities elsewhere. These specific non-farm livelihood traditions in villages encourage farm household members to join these works. Therefore, economic motivations in earning money from these non-farm activities is entwined within cultural logics associated with the status or pride of the feeling of being experts in a particular livelihood outside farming. The existence of these non-farm livelihoods is part of their culture.

The household demography of farming families also plays an important role in allocating labour to different livelihood activities. The average household number of persons in farming households in the Central Dry Zone is approximately five (LIFT, 2014). Non-farm work allows both males and females to work in the village or outside the village. For example, the joss stick is the famous product of Yesagyo due to the availability of the *Thanakha* tree. Making joss sticks is a job opportunity for the villages near the joss stick factory. Both male and female household members can work in their homes and earn the extra household income that can

cover their daily household expenditure for food. Some non-farm activities also relate to temporary migration because they need to work outside the village, such as trading and carpentry. The youth prefer to join the non-farm activities if other household members can manage the farming work at home; and join farm work in the peak season, such as harvesting time.

The contribution of non-farm income in rural households in the study villages varies dependent on the type of non-farm work. Landholders who possess the dry land with low fertility and without irrigation access have greater reliance on income from the non-farm work, such as those in Village 1. The male household members need to travel for trading commodities while female household members manage the farming activities. However, the villages with good agricultural productivity also rely on the non-farm income because farmers seek to allocate the family labour in both farm and non-farm.

Remittances from seasonal or temporary international migration are particularly promising in the study area since the income for working in other countries is substantially higher than the pay for working in the country. Temporary international migration to countries such as Korea is attracted to males while seasonal farm labour migration to China paves the way for females. Failure of crop production due to climate stresses would be part but not all of the reason to motivate these youth to work in other countries. Nevertheless, one thing for sure is this kind of migration happens only through social networking because the household sends their family member only with someone they trust.

7.7 Conclusions

Year after year, the Central Dry Zone experiences climatic stressors such as irregular rainfall and drought. Due to climate stresses, many farming households have seen crop production decreases or crop failure. Diversification of livelihoods into the non-farm economy offers a potentially significant adaptation alternative for rural households in the Central Dry Zone. Therefore, this chapter emphasises non-farm livelihoods as an indispensable aspect for agricultural households to boost their adaptability to climate stressors. Despite the fact that non-agricultural opportunities appear to be less stable in the study villages, they are still the primary reason why farming households could pay less attention to climatic stresses in their farming.

Although there are traditional restrictions on types of non-farm work and migration by means of gender, and farm labour shortage problems due to non-farm livelihoods, study respondents indicated strong desires to allocate their younger household members to opportunities in the non-farm sector. Therefore, the existence of non-agricultural work is more than push and pull factors for the farm households in the study villages. It is interlinked with village culture, tradition, resources, and geography. Therefore, rural households in the study villages are actively engaged in the non-farm livelihood activities regardless of agricultural performance. When they face crisis in crop production due to climate stresses, there are stronger incentives to rely on allocating household members to the non-farm economy. However, this works through a complex landscape of place-informed economic and cultural processes and cannot be understood as simply a response to climate stresses. Therefore, the organisation of the non-farm economy in the study villages is not simply a story of climate adaptation practices for farming. It is critical to other traditional livelihoods in term of their local resources, geography, and culture.

8. CHAPTER EIGHT: SUMMARY, IMPLICATIONS, LIMITATIONS, AND CONCLUSIONS

8.1 Introduction

The three previous chapters have provided evidence on the complex interactions between climate change adaptation and rural household livelihood decision-making in the Myanmar's Central Dry Zone. Using qualitative research methodology, insights were gained on the three research questions specified in the introduction to this study:

1) How do rural households diversify their livelihoods, and what changes are there to the role of agriculture?
2) To what extent can these changes of household livelihoods be explained as a strategy for addressing climate change vulnerability?
3) What does the conclusions about climate change adaptation in the Central Dry Zone reveal about the vulnerability of rural communities in the Global South more generally?

This final chapter revisits these questions in the context of the overall findings and contributions of the thesis, focusing on how the research questions have been answered in relation to how climate change is interacting with the complex rural livelihoods in the Central Dry Zone of Myanmar. It presents significant findings on farmers' perception of climate change and how climate change is positioned in the daily lives of rural households. In addition, the chapter highlights how most of the adaptation practices done by farmers are incremental, leaving transformative adaptation unaddressed as a mean of reducing vulnerability to drought and irregular rainfall in the Central Dry Zone.

The chapter then discusses some of the implications for local, national, and global adaptation plans and tactics to climate change, arguing that traditional, incremental adaptation measures may enhance vulnerability to climatic variability. To truly contribute to improving rural communities' adaptive capacity, it is necessary to understand how they perceive vulnerability and how they respond to climatic changes.

8.2 Summary of findings

This thesis commenced with three fundamental observations. First is the recognition that climate change is one of the most serious concerns confronting humanity (Steffen et al., 2015). Climate change has impacted all parts of the world, causing widespread disruptions that have inescapable economic consequences (Huong et al., 2018; Beniston and Haeberli, 2001). Climate change is a particularly serious problem for the Global South where poverty is prevalent and agriculture is the main source of people's income (Huong et al., 2018; Fahad et al., 2018). Therefore, farming households in the Global South are extremely vulnerable to the impact of climate stresses because agriculture is highly reliant on climatic factors. As observed by Li et al., (2010), farmers are often the first actors to confront the climate change emergency. How they respond affects local rural economies and the future of local, national and international food systems.

Second, the relationship between climate change and agriculture is especially relevant for Myanmar. Myanmar is an agriculturally based country. The majority of the country's population lives in rural areas and their main livelihoods are agriculture and allied activities. As Myanmar is ranked second among the countries at risk from climate related hazards (Kreft et al., 2017), farming households in Myanmar are very vulnerable to climate stresses. This is aggravated by the fact that Myanmar is weak in the process of climate change adaptation and vulnerability assessment (NAPA, 2012). The Central Dry Zone region of Myanmar is very applicable to such assessment because agriculture is the main livelihood source for rural households, and the region is highly challenged by climate change because most of farmers rely solely on rainfall which has become increasingly erratic in recent years.

Third, the relationship between agriculture and climate change is contextualised by other, major factors currently impacting on rural livelihoods. Rigg (2006), along with many other researchers, have pointed out the decline of rural farm households' reliance on farming and their engagements with non-farm activities, including reliance on remittances from migration. However, the existing literature related to climate change adaptation in agriculture all too often sheds the spotlight on climate change's effects on agriculture exclusively. This neglects the fact that climate change is intertwined with a wider array of human activities. Therefore, it is critical to integrate climate change into the diverse livelihoods of rural communities. These

three observations form the foundation for the empirical insights from field research conducted for this thesis. The key empirical insights are as follows.

8.2.1 Livelihood diversification

Livelihood diversification was found in the study. There are complex and place-based combinations of farm and non-farm activities in the study villages. Although the study area is relatively small, the livelihoods are diversified based on a highly localised differentiation of access to resources and village livelihood histories. The farm activities include crop production and livestock and land rental management while non-farm activities include government employment, self-employment, and local trading and artisanal activities.

Geographic location influences livelihood diversification in the study villages. Villages near irrigation canals can grow two-season crops, whereas villages on rainfed dry land can only grow one. The alluvial soil of the riverbank villages resulted in improved agricultural performance. Also, agriculture was modified by irrigation, or the absence thereof. Dryland agriculture or livestock grazing are the principal agricultural activity in villages without irrigation.

Rural households engage in a variety of non-farm sector activities such as government employment, business, trading, crafts, and labour. Although agriculture is a traditional livelihood for rural areas in the Central Dry Zone, other occupations are available depending on resources and job opportunities. A paradox between farm and non-farm economies is that parents want their children to be educated and have good careers while yet expecting them to continue farming as a family heritage. However, agricultural, and non-agricultural activity coexist in the study villages. Local biophysical conditions, cultural traditions, and individual entrepreneurship influences these villages' livelihood mixtures.

8.2.2 Farmers' perception on climate change

There is a clear awareness of climate change issues among respondents in the study villages. Climate change was known to respondents based on a variety of experiences. Climate change issues mentioned by respondents included higher temperatures, longer drought duration,

irregular rainfall patterns, less rainfall precipitation, and increased rainfall intensity in a short period of time, resulting in floods. Most respondents were able to connect climate stresses to crop production issues such as decreased crop quality, lower crop productivity, pest and disease outbreaks, soil fertility depletion, and crop failure.

Farmers, responded to climate change in a variety of ways. Many dry land farmers viewed climatic stress as a threat to their ability to produce crops. Some others, however, believed that climate change would increase the level of uncertainty, but that it was not a reason to stop farming. These farmers stated that they would like to continue cropping in the hope of reaping benefits when better times came. The surprising suggestion by some respondents with alluvial land that the lengthening of drought duration was beneficial, highlighted the complex ways in which climate change was understood to have impacts on farming. All of this indicates an awareness of climate change and consideration of how it affects farming. However, farmers interpret these processes using their worldviews, indigenous knowledge, local norms, and past climate stress experiences. As a result, they range from being extremely concerned about their farming, to being fatalistic, and, in some cases (farmers on alluvial land), even with a degree of optimism.

8.2.3 Farm adaptation strategies in response to climate stresses

Farmers made farm adjustments according to their land types in the case study villages. Changing the planting date is a critical reaction to climate change for all of the farmers in the study villages. The decision of when to sow is highly dependent on the onset of the monsoon. Regardless of the type of land they own, all farmers across all villages have adjusted their sowing dates and farm operations. An important adaptation to climate change for many dryland farmers committed to conventional crops like pulses and oilseed crops is to use greater tillage to capture more rainfall. The importance of tillage increases mechanisation. Machine ploughing is used by farmers to prepare the soil because it saves time and makes them more responsive to the monsoon. Wealthier farm households are more prepared to make this adjustment than poorer ones. The rising usage of agricultural technology is a response to a lack of farm labour due to rural people leaving the non-farm industry and a need to save time due to fluctuating rainfall patterns. Tube well irrigation alleviates drought and water shortage for alluvial CP corn growers. Fertilizer application strategies assist farmers in adapting to uncertain weather. Fertilizer use has increased in alluvial farming because it is thought to boost crop vitality in

unpredictable weather conditions. Increasing the use of family labour as an adaptation strategy for dry land farmers was explored because it decreases the costs and hazards of depending on paid labour in the face of local labour scarcity and the need to respond more quickly in climate-uncertainty-related situations.

8.2.4 Farm adjustments to non-climate stresses

As argued throughout this thesis, the effects of climate change are just one factor influencing farmer decision-making. Farm adjustments to non-climatic factors were revealed in the case study villages. Short-term market conditions were found to have a considerable influence on farmer decision-making. Farmers in all interviews and focus groups indicated they placed high priority on the market price of crops in the decision-making of process of "what to grow." This was the case both for dry land and fertile alluvial land.

Sesame illustrates these motivations. Sesame is a Central Dry Zone crop, but its popularity grew after a Korean-owned processing business was built in Magway in 2017. Sesame is a climate-sensitive crop called a "gambling crop". Climate-sensitive crops became more important to farmers although they became more aware of and worried about climate change. Another example is CP corn. Alluvial soil is the most productive and valuable in the Central Dry Zone. Villages near rivers with alluvial soil have more productive agricultural sectors. However, farmers changed the area of their traditional crops such as pulses and oil seed crops into CP corn growing area. This is because the market price of CP corn is much higher than traditional crops. The third example is melon. Melons have thrived in northern Myanmar, notably the Central Dry Zone, due to commerce with China. Local farmers aren't usually well-positioned to grow melons because the industry is capital-intensive and relies on brokers and dealers. Central Dry Zone farmers are increasingly renting land to melon producers. Usually, land hired for melons is flat, irrigated land which is less subject to climatic stress. Landowners would rather rent their land to melon farmers than grow their traditional crops with uncertain market prices.

Fourth is the shift to non-traditional farming activities. Traditional crop production is being replaced by goat farming in the Village 8. The goat market was developed after China and Myanmar opened their borders for trade. Despite climate change, farm households emphasised the profitability of goat husbandry compared to the traditional crops. Also, wild almond tree

cultivation is another market-oriented farming practise which is moving away from traditional agriculture. Wild almond trees have been imported to the Central Dry Zone in recent years, and farmers who can invest more in agriculture have been replacing their traditional crops and pushing this sector due to its potential market in China.

8.2.5 Non-farm activities as the key livelihood strategy

Rural households in the study villages have several non-farm livelihood options, which vary substantially between villages. Non-farm work is usually individual or village-wide activities. Individual non-farm employment depends on a person's qualification, and credentials. Education has a major effect on people's ability to work in specific non-farm jobs. However, most non-farm occupations are village-wide ones. These kinds of work may require great competence, but no formal education or qualification. This employment may include physical activities or high levels of craftsmanship, but it does not require any formal educational degrees. Non-farming activities include local resource-based, location-based, and tradition-based activities.

Traditional based non-farm livelihoods mean rural households in the village have done these activities for generations and these works help determine residents' identity. The examples of these non-farm livelihoods are weaving, household commodity trading and carpenters' work. Similar to agriculture, biophysical resources determine rural non-agricultural livelihoods. The manufacture of bricks illustrates this. Farmers employ illuvial cropland soil to bake bricks. Because of these resources, the village has become a brick-making centre. Examples of location-based non-farm livelihoods include waterborne transportation and joss stick making because both non-farm works rely on their location of the villages. Village 9 is near the Ayeyarwady-Chindwin River confluence, a popular shipping route and its proximity to key intersections has allowed residents to engage. Also, the existence of joss stick manufactures in Yesagyo allows the rural households in the township engage in this work.

Remittances are a major source of income in the study villages and both domestic and international migration have been observed. Most domestic migration is for non-agricultural employment, including trading, carpentry, and water transport and male migration prevails in this case. Few women from the case study villages went to cities to work in markets or factories. Some women work as farm labourers in nearby townships. Also, international migration to

Korea, Malaysia or Thailand is mostly transient, and male dominated. However, seasonal migration to China was a new trend in the Central Dry Zone and female labourers outweigh male workers because they are more adept at nursery plantation labour.

8.2.6 Gender and generational perspectives on livelihoods

In the study villages, gender norms affect livelihood perspectives. Land preparation is a masculine activity in farming. Females cannot operate draught livestock or machinery. This study found transitory and seasonal male migration for non-farm jobs. Female family members, especially in young households, manage farming operations without infringing on local restrictions. Farm mechanisation plays a key role in modifying farming activities for climate change and replacing male household farm labour. In every study village, agricultural households are able to access farm machinery for farmland clearing, ploughing, and harrowing. This service lets women run farms without breaching cultural norms.

However, non-farm livelihoods in study villages are more gender centric. Weaving is an example. Due to its "working at home and being safe" customs for women, male household members are not eager to weave, and they would feel ashamed if they did. Similar logic applies to non-farm livelihoods that requires travel to different towns or regions. In non-farm jobs like carpentry, women are barred due to "risk" for the female. Local communities consider climbing structures and using carpenter tools is "risky" for women, but they encourage young males to join village carpenter groups to acquire a new vocation and earn extra household money. Waterborne transportation is another male-centric non-farm job. Cultural traditions deem the occupation "inappropriate" for women, even if it pays more than farming. As the profession requires night stays on the ship and river navigation, the locals consider it a job for males.

Non-farm jobs and migration require rural youth. Most farm workers are elderly. They have little options outside farm work. Elderly farmers grumble about the younger generation's lack of interest in farming, which causes agricultural labour shortages. International migration is not a possibility for rural elderly men and women.

8.3 Interpreting the findings

The findings from the research undertaken in the Central Dry Zone have wider implications for our knowledge of climate change adaptation among rural populations in the Global South. These wider implications are discussed by relating findings with existing literatures on the relationships between farmers' perceptions of climate change on the one hand, and their decision-making on adaptation, on the other. This brings to attention the role of climate change in farmers' daily lives, the importance of geographical context, and local traditions in relation to the rural livelihoods in both farm and non-farm sectors. The critical element of these arguments is the need to appreciate and understand how multiple stresses are coupled with climate stresses to exacerbate the vulnerability of rural households. This discussion points towards the importance of understanding the underlying causes of vulnerability if comprehensive responses to the challenges of climate change adaptation are to be formulated.

8.3.1 Incremental adaptation is the norm, despite climate change literacy

The research shows that farmers tend to adjust to climate stresses in minimal ways based on their traditional knowledge. For dryland farmers who have difficulty accessing irrigation, the key response to climate stress is implementing crop sowing date changes and changing other farming practices to capture the rainwater and save the moisture. Additional tactics include altering ploughing methods from traditional draught plough to mechanized ones and making changes to irrigation. All of these adjustments are examples of *incremental adaptation* methods that are not capable of resolving the underlying causes of vulnerability. They assist farmers to minimize the detrimental effects that climate change will have on crop production, but do not enable them to escape the overall threat. This finding is consistent with insights from the IPCC (2022: 1639), which has observed: "smallholder farmers tend to address short-term shocks or stresses by deploying coping responses rather than transformative adaptations." In the Central Dry Zone of Myanmar, most agricultural adjustments are short-term adaptations, and they are unable to address farmers' long-term vulnerability.

Farmers' reluctance to embrace anything more than incremental adaptations is not because of a lack of climate change literacy. Farmers in the study villages are aware of these climate stresses and the impacts they have on their crop production. However, this awareness is not easily translated to changes in farming behaviour. Farmer awareness of the negative impact of

climate stresses, in the context of irregular rainfall and drought on their crop production, is expressed through pragmatism and fatalism – a few changes here and there. Farmers are mostly unwilling to radically shift to 'climate safe' practices but retain commercial orientations in which they seek to optimise income in the knowledge that their practices are at risk from climate uncertainty. As argued by Wiid and Zievogel (2012) perception of climate change does not follow in a straightforward line to adaptation. In my findings, farmers' capacities to substantively adapt to climate change are compromised because their first priority is household income in order to stabilize family livelihoods. This finding is consistent with Maddison (2007) who found that smallholders' available institutional and financial resources was critical to the adaptation strategies they took in response to a rise in temperature and a decrease in rainfall.

There is a tension here with the way that climate literacy is discussed in the latest IPCC report. That report addresses it as an important element for transformative adaptation. In this context, climate change literacy means not only farmers' awareness to climate stresses but also that they understand the anthropogenic cause of climate change (Ledley et al., 2018). The IPCC report makes the point that without an understanding of the anthropogenic cause of climate change, its impacts and future risks, adaptations are more likely to be the short-term responses. This argument is also made by Guido et al. (2020). However, what such arguments may fail to recognise is limitations on the capacity for farmers to act. In my study, as described above, climate change is widely understood in their area – farmers are certainly climate literate – but their responses remain incremental. In the next sections, I discuss the reasons for these responses.

8.3.2 The lived reality of climate change

In the Central Dry Zone, climate change is making heat stress and drought more intense, but these conditions are not entirely new to farmers. This encourages a tendency by farmers to respond to these factors in stepwise fashion, rather than perceive these as a reason to entirely change their livelihood arrangements. The fact that most crop production in the Central Dry Zone is rainfed means that farmers are highly experienced in dealing with erratic rainfall and drought. A strong narrative in fieldwork was that farmers said they saw these issues as 'out of their control'. This is consistent with the findings of Woods et al. (2017), who argued that hazards with longer time spans are perceived as less important than those with shorter time periods.

The predominance of perceived short-term farm survival risks over long-term climate concerns may impede adaptation or the adoption of other best practises (Findlater et al., 2018). Overall, farmers indicated many types of future uncertainty, with climate change risk presented as part of the day-to-day problems of farming rather than as an issue requiring special or targeted attention (Takahashi et al., 2016). This inevitably encourages adaptation to be more incremental than transformational (Fischer, 2019). Hence, concern for short-term farm survival impedes long-term adaptation behaviour (Findlater et al., 2018).

8.3.3 Farmers as benefit maximisers

The incentive to prioritise short-term farm survival calls to attention the question of how to understand farmer decision-making. Clearly, income generation is important. This is especially critical for farmers in economic precarity. In the Central Dry Zone there is considerable evidence of how farmers respond to market opportunities as they emerge. Strategies and pathways differ across the region because farmers' decisions on their farming practices are closely connected to the biophysical environments and the shifting commercial environments in which they operate. Even though alluvial farming and irrigated rice farming have fewer risks to crop losses due to irregular rainfall and drought, farmers' crop choices are still based on the potential market prices, with relatively little internalisation of climate risks in decision-making. This is lighted in the case of sesame, already discussed, known as a gambling crop. Instead of focusing on the climate-tolerant crops such as pigeon peas, there has been an expansion in the cultivation of sesame in recent years due to its increasing market price. Similarly, one village replaced traditional crop production with goat production once border trade opportunities were opened with China. The same concept goes to growing wild almond trees, where farmers have made on-farm changes in order to gain benefits from market prices, and melons, where farmers made decisions to rent out irrigated land instead of own-crop production. In all cases, short-term opportunities to generate income were the drivers of change to farm operations, rather than considerations relating to climate adaptation. These findings on the way farmers' decisions prioritise market prices over climate stresses are echoed in some findings in Africa where market conditions and socioeconomic factors have been shown to be more important to rural people and farming households than climatic and weather conditions (Berrang-Ford et al., 2011; Tucker et al., 2010; Mertz et al., 2009; Ostwald and Chen, 2006).

Prioritisation of commercial considerations occurs within diverse contexts in which farmers have different levels of physical assets, access to productive resources, human capital, risk attitudes (Feder et al., 1985); types of technology within specific agroecological systems (Pingali et al., 2001), and the particular farming season (Moser and Barrett, 2003). Moreover, it depends on random elements such as who their colleagues and neighbours are (Munshi, 2004; Fan and Cai, 2002; Pomp and Burger, 1995; Case, 1992). Farming traditions are also important, as farmers often regard farming as their way of living (Ohlmer et al., 1998) and hence there can be a conservative side to strategies for making decisions in the face of uncertainty (Ohlmer et al., 1998; Murray-Prior, 1998).

However, in this research, prioritisation of income is a thread that can be seen to run through these various contextual factors. Farmer behaviour is highly dependent on the sources of income that allow them to earn more within their capability. Farmers with irrigated land, for example, would choose to rent out their land to melon growers rather than cultivating conventional crops such as pulses and rice since agricultural markets are uncertain, but they may receive money from the land rental for three consecutive years. Although climatic stressors like as erratic rainfall and drought are prevalent, their farm management decisions are mostly dependent on how much income they can earn. In spite of their efforts to lessen the unfavourable effects of climatic stress, their primary agricultural adjustments are mostly motivated by financial incentives.

It is important to emphasise the role of income generation as a key determinant of farmer decision-making in the case study area. Because climate change is a global concern which potentially endangers the entirety of human life on the planet, there can be a tendency for research to ‘seek out’ and spotlight this factor in studies of adaptations in agriculture. This is what Tessema et al. (2019) calls the social desirability bias, which is the phenomena in which survey respondents give researchers answers what they believe the researchers would like to hear. Because many farmers know that researchers are looking for a comprehensive list of adaptations, they are likely to report any actions they are doing that may be related to climate change, even if climate change is not a primary motivation. Even when researchers ask farmers to evaluate the relative relevance of several causes, there is reason to expect that farmers may exaggerate the impact of climate change in their activities. A major theme of this study has been to seek to not fall into the trap of the social desirability bias. It has sought to assess how climate change, as a source of stress for rural households, fits within the wider landscape of

adaptive responsiveness and behaviour. This has uncovered how market price and better income sources are prioritised over climate changes in livelihood arrangements.

In this sense, farmers might be thought of as utility maximizers (Schultz, 1975; Duflo, 2006), making decisions to maximise nett benefits by minimising possible losses from bad occurrences and maximising gains from new chances. The negative impacts of climate change on the crop production of the Central Dry Zone and farmers' struggle to respond to it cannot be denied. However, climate stress is not the only stress farmers in the study villages have been faced for years, and there are other stresses such as instability of crop market prices unrelated to climate. Farmers make adaptations in the cultivation practices to protect crop losses due to climate changes based on their own traditional knowledge and available resources. However, as seen in the cases of study villages, the priority for farm households is to obtain better income, and this may lead to behaviour that pays lesser regards to the need to deal with climate change risks.

Therefore, while it is true that farmers in the Central Dry Zone indeed respond to climate changes in their farming, this is a secondary consideration. The incremental adaptations that characterise farmers' responses to climate change play second fiddle to immediate economic developments, such as responses to crop market prices and new opportunities in non-farm sectors. This is an important lens for vulnerability research, because it stresses the need of considering climate change adaptation in the context of the complex interaction of other global changes or stresses (Westerhoff and Smit, 2008; Smit and Wandel, 2006; O'Brien et al., 2004). This is a crucial finding since actions are rarely designed to address climate change by itself (Noble et al., 2014; Smit and Wandel, 2006).

Because farmers are responding to a wide range of challenges, it is incredibly difficult to draw a link between agricultural transformation and climate change. Nowadays, farmers have to contend with a terrain that is forever changing. As the threats of climate change have been increasing, farmers have to employ adaptive methods to mitigate the effects of risks and shocks, including droughts, floods, erratic rainfall, and declining soil fertility. Also, the increased availability of new technology, new markets or changing trading policies is bringing forth a wealth of exciting new opportunities, many of which require adjustments to be made on farms in order to fully capitalise on them. Therefore, in order to make policy suggestions that may be adopted to enhance adaptation, it is essential to demonstrate a causal relationship between

changes in agricultural practises and climatic or non-climatic factors. There is more and more evidence that treatments that do not situate adaptation in the context of the complex interaction between climate and other factors are less likely to work and may be maladaptive (Westerhoff and Smit, 2008).

8.3.4 Non-farm is more than push and pull factors

There is also a need to incorporate rural non-farm livelihoods and migration into research on farmers' responses to climate change. When research is focused on the threats of climate change to farm output, there can be a tendency to understand households' engagements in the non-farm economy in terms of distressed livelihood diversification (Lohmann and Liefner, 2009). While it is true that climate stresses have direct impacts on crop production and produce incentives to accelerate rural people to join the non-farm economy, what needs remembering is that this is done in a context of longstanding traditions about non-farm work, and a shifting landscape of opportunities from migration. The expansion of non-farm livelihoods across the study villages cannot be ascribed simply as an adaptation to climate stresses. The types of non-farm activities undertaken by rural households are contextualised within a wider array of historical circumstances, and failure in agriculture does not solely influence a household's decision-making to join the non-farm sector.

Because of its flexibility, there are longstanding traditions in the study region relating to non-farm livelihood diversification. Households have strategies for allocating different members to work in these activities at different times of the year. As agriculture is historically rainfed in the study villages, this allows farm households to join the non-farm activities in the off-season. Therefore, the non-farm activities in the study villages are not new to these areas and linking with their tradition, location, and resources. This said, the extent of non-farm livelihood activities in rural households in the study villages has been growing year after year. It seems that this is a result of varied connecting factors, inclusive of climate change. Notably, for example, climate stresses have been implicated in encouraging farmers to adopt mechanisation, which in turn reduces local agricultural labour demand, and hence produces a labour market context encouraging workers to shift into the non-farm sector. However, it remains the case that the types of non-farm jobs adopted by people who might previously have worked in agriculture are shaped influentially by local livelihood histories relating to tradition, geographical location, and resources. The research has emphasised that non-farm activities in

the study site villages are not new to farming households, although they have been intensified or modified in recent years. Villages have their own histories of non-farm livelihood, augmented in recent years by new social networks, especially working outside villages.

Migration is one of these new social networks. Although migration is not entirely new to the region, previously it was more limited in scope (domestic migration closely linked to their non-farm activities such as trading or working on river ships). Therefore, it has been largely based on local livelihood histories rather than climate stresses. Some scholars consider migration as a form of transformative adaptation (Hadarits et al., 2017) because it enables households to shift away from highly vulnerable, agriculture-dependent livelihoods. Conversely, at the regional scale, male out-migration from rural areas may increase vulnerability, leading to fewer opportunities for transformative adaptation, because it reduces local labour forces, especially in gender-related roles of land preparation (Sumner et al., 2017). When male household members have migrated, female household members need to manage farm and other household activities, placing additional stresses within households and squeezing adaptation options. Under these contexts, women's labour participation in the agriculture sector has increased, as well as ongoing household duties, with impacts on time-budgets and quality of care for other household members. On this basis, Jacobson et al. (2018) argue that migration may be maladaptive action in long term. Their study showed that rural households who use migration as a coping strategy to climate stress is affecting food production systems in Cambodia. In their research contexts, migration is mostly temporary, and time of peak migration are coincided with the time of peak rice planting. Therefore, migration affects crop production and fails to reduce food insecurity in Cambodia. In these cases, migration represents a loss of critical labour from rural farm communities and makes the effect of climate change worse than remedying it.

In the current study, although there is evidence that male migration has impacted on rural labour supply, it would be difficult to extrapolate from that to assume it is maladaptive. Although study respondents noted these undesirable perspectives on migration, they equally noted the important role remittance money plays in the household family income. Typically, remittances come in lump-sum form when the migrant returns, which allows large expenditures such as building or repairing houses, or in making religious donations that are important for households' traditional obligations and social capital. Hence, although farmers complained about farm labour shortages due to migration among the young generation, income from these non-agricultural activities appeared to more than compensate for these problems. To this end,

although this research has documented most climate change adaptation in the study villages as being incremental, the increased out-migration of younger people could be considered a form of transformative adaptation that, with the receipt of remittances to home villages, is not maladaptive.

8.3.5 The precarity of rural livelihoods

It is abundantly obvious that rural livelihoods in the study villages are both diverse and dynamic. Farm households have become more flexible in their pursuit of diverse economic alternatives, including farming, non-farming work, and migration. Even though non-agricultural jobs like as weaving might give a somewhat stable income to rural households when compared to income from farming, this type of work is nevertheless extremely precarious and uncertain.

To a large extent, these results are consistent with what is known about rural livelihoods in the Global South. Rigg conducted his long-term research over the previous two decades, and he draws the conclusion that a growing percentage of people in the rural areas of the Global South are opting out of working in agriculture. Across Southeast Asian countries, the percentage of rural residents working in agriculture is decreasing, and the current situation of occupational multiplicity, in which households' sources of income include farm and non-farm work, commoditized and quasi-subsistence work, and in situ and ex situ work, was discovered to be a likely outcome if non-farm jobs remained traditionally precarious and social safety netting was thinly woven (Rigg, 2020). Rural households in the Central Dry Zone are more susceptible to climate risks because their incomes are highly unstable.

The IPCC (2022) and a large number of scientists have pointed out the need for transformative adaptation in the Global South. It is without a doubt necessary in Myanmar. The goal of transformative adaptation is to eradicate the fundamental problems that underlie climate change vulnerability. In the context of the Central Dry Zone, farmers have been practising incremental adaptations, and the issue arises as to what forms of adaptation will produce transformational adaptation, which can minimise their susceptibility over the long term.

The findings bring to light the fact that agricultural households do not have stable incomes, which makes such households extremely susceptible to climate stresses, but also, means they

need to prioritise short-term income earning opportunities over longer-term changes that may require investments. The fact that farmers do not have many other sustainable sources of income is the primary reason why they continue to respond primarily to market price considerations. For instance, every respondent stated that they wish for their children and grandchildren to have the opportunity to obtain an education, secure employment, and a reliable income through professional occupations. This is because they are all aware that the income derived from agriculture is highly unstable and that the incomes are primarily dependent on the climatic conditions and crop market prices.

In addition, farmers have attempted to change their agricultural practices in order to take advantage of better income opportunities; nevertheless, this might result in the introduction of new forms of vulnerability in some cases. For example, when rural households switch from their traditional crop production to the rearing of goats, they see an increase in their income. These changes are closely connected to developments in policies regarding the trade of livestock over the border into China. Similar to this context, other adjustments such as renting out their agricultural lands to melon farmers and establishing new perennial crops such as wild almond trees are mentioned as examples of these kinds of changes. However, all of these changes are entirely dependent on the border trade to Chinese market. Any closure of the Chinese border creates a new form of vulnerability for these farmers. This scenario played out in 2020 and 2021, when trade was stopped in response to the COVID-19 pandemic. Farmers' incomes were locked into expectations about sales to China that failed to materialise.

As a result, precarity means that the rural households studied in the Central Dry Zone had little scope to do anything but incremental adaptation, and hence their vulnerability to a more uncertain climate remains. Only through out-migration is any form of transformative adaptation occurring, but as discussed above, this brings with it a new set of contradictions, by reducing local labour supply. Hence, this research has found limited evidence of capacities and actions in the Central Dry Zone to address the threats of climate change. According to Panda (2016), transformative adaptation requires going beyond adjustments made at the farm level and incorporating changes made at higher scales and across larger spaces. Choices for transformational adaptation include less focus on agronomy at the field level and more focus on options related to the scale and structure, such as rebalancing regional economies and establishing new networks for sustainable geographical diversification (Douxchamps et al.,

2016). Once in place, farmers are more able to tackle on-farm problems relating to climate with longer-term, transformative agendas in mind.

However, transformational adaptation may require disproportionately large inputs of resources (such as money, people, and time), and its benefits may take a long time to become evident. Transformational changes include cultural changes, institutional reforms, and the questioning of long-held assumptions (O'Brien, 2012). These changes also include the introduction of large-scale, innovative elements to a system that have the potential to have long-term repercussions and result in the establishment of an altogether new social-ecological system (Kates et al., 2012; Nelson et al., 2007). Therefore, it may receive less support from society or the government (Kuntz and Gomes, 2012; Adger et al., 2005).

Additionally, transformational adaptation may have less possibility since it requires the participation of a large number of various persons, institutions, sectors, and levels of government, each of which may have a different set of interests (Meadowcroft, 2011; Van den Bergh, 2011). It may also be required to reconcile opposing future expectations. Complex ethical and distributional issues across institutions that need to be solved before implementation may also make it hard to do. These impediments increase the risks and uncertainties associated with developing transformational adaptation (Blythe et al., 2018).

Moreover, due to a lack of knowledge about transformational adaptation, there may be limited financial arrangements for such tactics. As a result, farming households in the Global South typically choose more gradual methods of adaptation rather than questioning systems (Abson et al., 2017; Thornton and Comberti, 2017; Gibson et al., 2016).

8.4 Building from place-based research for transformative adaptation

The need to develop transformational adaptations in the Global South raises a final set of questions about the contributions made by place-based researchers. It is necessary to conduct place-based research because planning for adaptation to climate change requires first gaining a knowledge of how communities at local levels are reacting to these changes.

However, the findings about vulnerability in place-based studies are frequently quite local and context-rich, with classic political ecology issues clearly visible, and translating these to larger

scales can be problematic. As a consequence, the rich data of place-based studies has received less attention than it deserves for higher level policy making (Miller and McGregor, 2020).

Therefore, it is critical to upgrade the findings from place-based research and incorporate these into the building of strategies for transformational adaptation. This would make them usable in wider contexts. Implementing transformational adaptations, in particular, entails institutional reforms, cultural changes, and the potential establishment of new social-ecological systems (Nelson et al., 2007, Kates et al., 2012). In turn, it accordingly necessitates high investments of resources (such as time, labour power, and finance) (Adger et al., 2005; Kuntz and Gomes, 2012). Therefore, it requires the involvement of a wide range of individuals, organisations, and national and international institutions. However, without the context provided by place-based research, the approaches advocated by these organisations may be ill-fitting or even maladaptive.

However, despite this need, the outcomes of place-based studies are rarely considered for generalisation in the larger context of climate change policy by either national or international decision-makers or climate change adaptation funding organisations (Miller and McGregor, 2020). Therefore, a clear issue is the need to highlight and upscale the context rich data of place-based research to be applicable to national, regional and global scales, where scope is available to attempt to enact transformative adaption.

This scaling up requires the coordination of results from place-based studies that rely heavily on context. Miller and McGregor (2020, p. 665) discuss these concerns and provide three potential solutions: “comparative analysis of place-based research; generation of diverse counter-narratives; and consideration of flows and network”. For example, for this study to expand beyond the Central Dry Zone, the findings of farm households using incremental adaptation strategies should be compared to other research, such as adaptation practises in other regions or other nations. Also, the precarity of rural livelihoods was identified as the primary source of vulnerability for rural families, preventing them from making long-term adaptation, and farm households used various livelihood strategies to meet their fundamental requirements. These findings should be combined with other location-based research in the Global South because comparative work can explain why climate initiatives in some regions appear to be more equitable and responsive than others, or why certain locations appear to be more resilient than others (Miller and McGregor, 2020).

The second approach to upscale the rich data of place-based studies of climate change is to make narratives about climate change adaptations that are different from what other studies have found. For example, one finding from this research is that farmers' perspectives on climate change do not seem to have much of an impact on how they adapt on the farm. This finding may be used in conjunction with results from place-based research in other regions that challenge dominant narratives to shed light on the myriad factors that have influenced agricultural practises in the Global South.

Thirdly, the research here emphasises the importance of flows and networks. It shows that although there are certain negative aspects contributing to a scarcity of farm labour, youth migration might be a type of transformational adaptation. Implementing this conclusion in the Global South's adaptation programmes will require consideration of how out-migration from the Central Dry Zones fits within more extensive regional networks of people movement. This research, for example, includes various migratory patterns such as seasonal border crossings to China and temporary migration to other countries such as Korea, Thailand, and Malaysia. A fuller understanding of these flows as potentially transformative forms of adaptation must look beyond national borders and consider migration in international contexts.

Therefore, translating the rich data from place-based studies to global scales is challenging, but important. Because local context exists in a part of the global context, a lesson from this study is the need for governments and other stakeholders to recognise and appreciate the complexity of rich data from place-based studies in designing and implementing climate change adaptation plans for larger display.

8.5 Conclusion

The conditions under which this study were undertaken highlight the problems that face transformative regional change in the Central Dry Zone in response to climate change. The original research design required two fieldwork sessions: the primary fieldwork for data collection and the follow-up fieldwork for data validation. The main fieldwork was undertaken in 2019, however the follow-up fieldwork was not possible due to pandemic's travel restrictions. In addition, the February 2021 coup has contributed to the ongoing political turmoil in Myanmar. This made further contact with study sites, even by phone or text,

impossible. Several of the study villages have resisted the military takeover with vigour and the Central Dry Zone has been the target of violent attacks.

Accordingly, the thesis data was collected under the National League for Democracy (NLD) government, at a time when Myanmar was looking forward to stable, democratic government. However, political unrest in the Central Dry Zone has had a significant influence on agricultural households in the military government period following the February 2021 coup. As in other parts of Myanmar, the political crisis led to a considerable breakdown in local administration in the Central Dry Zone. Concerns for longer-term planning and investments to address climate change were washed away in the immediacy of the crisis. Informal communication indicates that agricultural markets, trade policy, transportation, and freedom of farming households have undergone considerable change between the period of data collection for this study and the present (September 2022).

Myanmar's political crisis following the February 2021 coup may appear a separate issue to climate change adaptation, but there is a connection. Transformative adaptation requires institutional stability. The need for investments, changes in regional economic plans, etc, can be implemented only when there is economic and political certainty. In Myanmar, at the time of writing, immediate concerns for life among rural populations necessitates that climate change adaptation agendas are secondary. This means that addressing the vulnerability of the Central Dry Zone due to climate change, documented above, remains as elusive as ever.

REFERENCES

Abid, M., Schilling, J., Scheffran. J, Schneider, J., & Zulfiqar, F. (2016). Climate change vulnerability, adaptation and risk perceptions at farm level in Punjab, Pakistan. *Science of Total Environment, 547*, pp. 447-460.

Abson, D.J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., vonWehrden, H., Abernethy, P., Ives, C.D., Jager, N.W., & Lang, D.J. (2017). Leverage pointsfor sustainability transformation. *Ambio 46*, 30–39.

Abu, M., Codjoe, S. N. A., & Sward, J. (2013). Climate change and internal migration intentions in the forest-savannah transition zone of Ghana. *Population and Environment*, *35(4)*, 341–364.

Acevedo, M., Pixley, K., Zinyengere, N., Meng, S. S., Tufan, H., Cichy, K., Bizikova, L., Isaacs, K., Ghezzi-Kopel, K., & Porciello, J. (2020). A scoping review of adoption of climate-resilient crops by small-scale producers in low- and middle-income countries. *Nat. Plants*, 6, 1231–1241.

Adaptation Fund. (2012). *Addressing climate change risks on water resources and food security in the dry zone of Myanmar.* Adaptation Fund Project.

Adger, W. N. (2003). Social Capital, Collective Action and Adaptation to Climate Change. *Economic Geography, 79*, 387-404.

Adger, W. N., & Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes Rendus Geoscience, 337(4)*, 399-410.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Adapting to climate change: Perspectives across scales. *Global Environmental Change, 15*, 75–76.

Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change, 3*, 112–117.

Adger, W. N., & Jordan, A. (2009). Sustainability: exploring the processes and outcomes of governance. *In: Field, C.B. (Ed.), Governing Sustainability. Cambridge, Cambridge University Press,* pp. 3–31.

Adger, W. N., Brown, K., Nelson, D.R., Berkes, F., Eakin, H., Folke, C., Galvin, K., Gunderson, L., Goulden, M., O'Brien, K., Ruitenbeek, J., & Tompkins, E.L. (2011).

Resilience implications of policy responses to climate change. *Wiley Interdisciplinary Reviews Climate Chang, 2*, 757–766.

Afifi, T., Liwenga, E., & Kwezi, L. (2014). Rainfall-induced crop failure, food insecurity and out-migration in Same-Kilimanjaro, Tanzania. *Climate and Development*, *6(1)*, 53–60.

Alam, K. (2015). Farmers' adaptation to water scarcity in drought-prone environments: a case study of Rajshahi District, Bangladesh. *Agricultural Water Management, 148*, 196–206.

Alemayehu, A., & Bewket, W. (2017). Determinants of smallholder farmers' choice of coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. *Environmental Development, 24*, 77-85.

Ali, I., & Penia, E. M. (2003). *Infrastructure and poverty reduction—what is the connection?* ERD Policy Brief No. 13, Economics and Research Department, Asian Development Bank, Manila, Philippines.

Andrews, T. M., & Smirnov, O. (2020). Who feels the impacts of climate change? *Global Environmental Change, 65*, 102164.

Antwi-Agyei, P., Dougill, A. J., Fraser, E. D., & Stringer, L. C. (2013). Characterising the nature of household vulnerability to climate variability: Empirical evidence from two regions of Ghana. *Environment, development and sustainability, 15(4),* 903-926.

Antwi-Agyei, P., Stringer, L. C., & Dougill, A. J. (2014). Livelihood adaptations to climate variability: Insights from farming households in Ghana. *Regional Environmental Change,14(4)*, 1615–1626.

Antwi, E. K., Boakye-Danquah, J., Owusu, A. B., Loh, S. K., Mensah, R., Boafo, Y. A., & Apronti, P. T. (2015). Community vulnerability assessment index for flood prone savannah agro-ecological zone: A case study of Wa West District, Ghana. Weather and Climate Extremes, 10, 56-69.

Artur, L., & Hilhorst, D. (2012). Everyday realities of climate change adaptation in Mozambique. *Global Environmental Change, 22(2),* 529–536.

Ash, A., Thornton, P., Stokes, C., & Togtohyn, C. (2012). Is proactive adaptation to climate change necessary in Grazed Rangelands? *Rangeland Ecology and Management, 65*, 563–568.

Ash, A., Thornton, P., Stokes, C., & Togtohyn, C. (2012). Is proactive adaptation to climate change necessary in Grazed Rangelands? *Rangeland Ecology and Management. 65*, 563–568.

Ashwood, L., Harden, N., Bell, M. M., & Bland, W. (2014). Linked and situated: grounded knowledge. *Rural Sociology*, *79*(4), 427-452.

Asian Disaster Preparedness Center (ADPC). (2015). *Risk Assessment Roadmap, Myanmar.* In technical collaboration with ADPC, funded by UNICEF, Disaster Risk Assessment and Monitoring, Technical paper.

Asian Development Bank (ADB). (2016). *Republic of the Union of Myanmar: Irrigated Agriculture Inclusive Development Project.* Asian Development Bank.

Assan, E., Suvedi, M., Schmitt, L., & Joseph, K. (2020). Climate change perceptions and challenges to adaptation among smallholder farmers in semi-arid Ghana: A gender analysis. *Journal of Arid Environments ,182*.

Awoniyi, O. A., & Salman, K. K. (2011). *Non-farm income diversification and welfare status of rural households in South West Zone of Nigeria.* In A conference organized by IFPRI in conjunction with the AV, UNECA and FARA in 1st–3rd Nov in addis Ababa, Ethopia.

Bacud, E.S., Puskur, R., Duyen, T.N., Sander, B.O., & Luis, J. (2019). Rural outmigration-feminization-agricultural production nexus: Case of Vietnam. *Migration and Development.*

Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change, 20*, 211-213.

Barrett, C. B., & Reardon, T. (2000). *Asset, activity, and income diversification among African agriculturalists: Some practical issues.* Project report to USAID BASIS CRSP.

Barrett, C. B., Clark, M. B., Clay, D. C., & Reardon, T. (2005). Heterogeneous constraints, incentives and income diversification strategies in rural Africa. *Quarterly journal of international agriculture*, 44(1), 37-60.

Barrett, C. B., Marenya, P. P., Mcpeak, J., Minten, B., Murith, F., Oluoch-Kosur, W., Place, F., Randrianarisoa, J. C., & Wangila, J. (2006). Welfare dynamics in rural Kenya and Madagascar. *Journal of Development Studies, 42*, 248–277.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food policy, 26(4),* 315-331.

Bassett, T. J., & Fogelman, C. (2013). Déjà vu or something new? The adaptation concept in the climate change literature. *Geoforum*, *48*, 42-53.

Bebbington, A. (1999). Capitals and capabilities: a framework for analysing peasant viability, rural livelihoods and poverty. *World Development, 27*, 2021–2044.

Below, T., Artner, A., Siebert, R., & Sieber, S. (2010). Micro-level practices to adapt to climate change for African small-scale farmers. A review of selected literature, *953*, 1-20.

Below, T.B., Mutabazi, K.D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., & Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? *Global Environmental Change, 22 (1),* 223–235.

Belton, B., Filipski, M., Hu, C. Oo, A.T., & Htun, A. (2017). *Rural Transformation in Central Myanmar: Results from the Rural Economy and Agriculture Dry Zone Survey*. Research paper 64. July 2017. East Lansing: Michigan State University.

Beniston, M., & Haeberli, W. (2001). Sensitivity of Mountain Regions to Climatic Change, Climate of the 21st Century. *Changes and Risks*, 237–244.

Berdegué, J.A., Rosada, T. & A.J. Bebbington. 2014. "The Rural Transformation." In Currie-Alder, B., Kanbur, R., Malone, D.M. and Medhora, R. *(Eds). International Development: Ideas, Experience and Prospects*. New York: Oxford University Press. 463–78.

Berg, B. L. (2007). A dramaturgical look at interviewing. Qualitative Research Methods for the Social Sciences, *6*, 101–152.Bernard, H. R. (2000). *Social research methods: qualitative and quantitative approaches.* Thousand Oaks, Sage..

Berrang-Ford, L., Ford, J. D., & Paterson, J. (2011). Are we adapting to climate change? *Global Environmental Change, 21(1)*, 25-33.

Biermann, F., Abbott, K., Andresen, S., Bäckstrand, K., Bernstein, S., Betsill, M.M.,Bulkeley, H., Cashore, B., Clapp, J., Folke, C., Gupta, A., Gupta, J., Haas, P.M.,Jordan, A., Kanie, N., Kluvánková-Oravská, T., Lebel, L., Liverman, D., Meadowcroft,J., Mitchell, R.B., Newell, P., Oberthür, S., Olsson, L., Pattberg, P., Sánchez-Rodríguez, R., Schroeder, H., Underdal, A., Vieira, S.C., Vogel, C., Young, O.R., Brock, A., & Zondervan, R. (2012). Transforming governance and institutions for global sus-tainability: key insights from the

Earth System Governance Project. *Current Opinion in Environmental Sustainability. 4*, 51–60.

Bohle, H.G., Downing, T.E., & Watts, M.J. (1994). Climate change and social vulnerability: toward a sociology and geography of food insecurity. *Global Environmental Change, 4*, 37–48.

Boori, M. S., Choudhary, K., Evers, M., & Paringer, R. (2017). A review of food security and flood risk dynamics in Central Dry Zone area of Myanmar. *Procedia engineering*, *201*, 231-238.

Bouahom, B., Douangsavanh, L., & Rigg, J. (2004). Building sustainable livelihoods in Laos: Untangling farm from non-farm, progress from distress. *Geoforum*, *35(5)*, 607–619.

Boyd, E., Osbahr, H., Ericksen, P. J., Tompkins, E. L., Lemos, M. C., & Miller, F. (2008). Resilience and 'climatizing' development: examples and policy implications. *Development*, *51*(3), 390-396.

Breman, J., & Wiradi, G. (2002). *Good times and bad times in rural Java: Case study of socio- economic dynamics in two villages towards the end of the twentieth century.* Leiden: KITLV Press.

Briones, R. M. (2017). *Transformation and Diversification of the Rural Economy in Asia*; International Fund for Agricultural Development: Rome, Italy, 2017; ISBN 9789290727941.

Brockhaus, S., Kersten, W., & Knemeyer, A. M. (2013). Where do we go from here? Progressing sustainability implementation efforts across supply chains. *Journal of Business Logistics*, *34(2)*, 167–182.

Brown, K., Few, R., & Tompkins, E. L. (2007). Climate change and coastal management decisions: insights from Christchurch Bay. *Coastal Management, 35(2-3)*, 255-270.

Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science and Policy, 12* (4), 413-426.

Bryant, C. R., Smit, B., Brklacich, M., Johnston, T. R., Smithers, J., Chiotti, Q., & Singh, B. (2000). Adaptation in Canadian agriculture to climate variability and change. *Climate Change ,45*, 181–201.

Bryceson, D. (2002). The scramble in Africa: Reorienting rural livelihoods. *World Development, 30(5)*, 725–739.

Bryman, A. (2012). *Social research methods*, Oxford University Press, New York

Burnham, M., & Ma, Z. (2016). Linking smallholder farmer climate change adaptation decisions to development. *Climate and Development, 8(4)*, 289-311.

Burton, I., Huq, S., Lim, B., Pilifosova, O., & Schipper, E. A. (2002). From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy, 2*, 145–159.

Burton, I., Kates, R.W., & White, G.F. (1993). *The Environment as hazard*, Second ed. Guilford, New York.

Byg, A., & Salick, J. (2009). Local perspectives on a global phenomenon—climate change in Eastern Tibetan villages. *Global Environmental Change, 19*, 156–166.

Carr, E. R., & Thompson, M. C. (2014). Gender and climate change adaptation in agrarian Settings: Current Thinking, New Directions, and research Frontiers. *Geography Compass, 8(3)*, 182–197.

Case, A. (1992). Neighborhood influence and technological change. *Regional Science and Urban Economics, 22(3)*, 491-508.

Center for Excellence in Disaster Management and Humanitarian Assistance (CEDMHA). (2014). *Myanmar disaster management reference handbook'*. The Republic of the Union of Myanmar, Nay Pyi Taw, 2014.

Challinor, A., Watson, J., Lobell, D. B., Howden, S. M., Smith, D.R., & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change, 4*, 287–291.

Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. Institute of Development Studies (UK).

Chhetri, N., Chaudhary, P., Tiwari, P.R., & Yadaw, R.B. (2012). Institutional and technological innovation: understanding agricultural adaptation to climate change in Nepal. *Applied Geography, 33*, 142–150.

Chianu, J. N., Ajani, O. I. Y., & Chianu, J. N. (2008). Livelihoods and rural wealth distribution among farm households in western Kenya: Implications for rural development, poverty

alleviation interventions and peace. *African Journal of Agricultural Research, 3(7)*, 455–464.

Choithani, C. (2015). *Livelihoods on the Move: Understanding the Linkages Between Migration and Household Food Security in India Chetan Choithani*. Doctoral Thesis. School of Geosciences. The University of Sydney.

Cinner, J., Mcclanahan, T. R., & Wamukota, A. (2010). Differences in livelihoods, socioeconomic characteristics, and knowledge about the sea between fishers and non-fishers living near and far from marine parks on the Kenyan coast. *Marine Policy, 34*.

Colloff, M. J., Doherty, M.D., Lavorel, S., Dunlop, M., Wise, R.M., & Prober, S.M. (2016). Adaptation services and pathways for the management of temperate montane forests under transformational climate change. *Climate Change, 138*, 267–282.

Colloff, M.J., Martín-López, B., Lavorel, S., Locatelli, B., Gorddard, R., Longaretti, P.Y. Walters, G., van Kerkhoff, L., Wyborn, C., Coreau, A., Wise, R.M., Dunlop, M.,Degeorges, P., Grantham, H., Overton, I.C., Williams, R.D., Doherty, M.D., Capon, T.,Sanderson, T., & Murphy, H.T. (2017). An integrative research framework for enabling transformative adaptation. *Environmental Science and Policy, 68*, 87–96.

Cornish, P. S., Birchall, C., Herridge, D. F., Denton, M. D., & Guppy, C. (2018). Rainfall-related opportunities, risks and constraints to rainfed cropping in the central dry zone of Myanmar as defined by soil water balance modelling. *Agricultural systems*, *164*, 47-57.

Crane, T.A., Roncoli, C., & Hoogenboom, G. (2011). Adaptation to climate change and climate variability: The importance of understanding agriculture as performance. *NJAS - Wageningen Journal of Life Sciences, 57,* 179-185

Craven, L. K., & Gartaula, H. N. (2015). Conceptualising the Migration–Food Security Nexus: Lessons from Nepal and Vanuatu. *Australian Geographer*, *46*(4), 455–471.

Creighton, C., Hobday, A. J., Lockwood, M., & Pecl, G. T. (2015). Adapting Management of Marine Environments to a Changing Climate: A Checklist to Guide Reform and Assess Progress. *Ecosystems*, 1–33.

Currie-Alder, B., Kanbur, R., Malone, D. M., & Medhora, R. (Eds.). (2014). *International development: ideas, experience, and prospects*. OUP Oxford.

Dapilah, F., Nielsen, J. Ø., & Friis, C. (2020). The role of social networks in building adaptive capacity and resilience to climate change: A case study from northern Ghana. *Climate and Development*, *12*(1), 42-56.

Dasgupta, A., & Baschieri, A. (2010). Vulnerability to climate change in rural Ghana: Mainstreaming climate change in poverty-reduction strategies. *Journal of International Development, 22(6)*, 803-820.

Deaton, A. (1991). Saving and liquidity constraints. *Econometrica*, *59 (5),* 1221–1248.

Department of Meteorology and Hydrology (DMH). (2011). *Presentation of Climate Change made at the Monsoon Forum Stakeholders meeting*. February 2011.

Department of Metrological Organization, Forest department and relief and resettlement Department, Irrigation department and fire Services Department. (2009). *Hazard profile of Myanmar.* Yangon, Union of Myanmar.

Deressa, T. T, Ringler, C., & Hassan, R. M. (2010). *Factors Affecting the Choices of Coping Strategies for Climate Extremes: the case study in the Nile Basin of Ethiopia.* Discussion Paper 01032, (IFPRI) International Food Policy Research Institute.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia. *Global Environmental Change ,19 (2)*, 248–255.

Diao, X., Magalhaes, E., & Mcmillan, M. (2019). Rural Nonfarm Enterprises in Tanzania's economic transformation the role of the youth. In V. Mueller, & J. Thurlow *(Eds.), Youth and jobs in rural Africa: Beyond Stylized Facts.* International Food Policy Research Institute, Oxford University Press, pp. 205–250.

Ding, D., Maibach, E.W., Zhao, X., Roser-Renouf, C., & Leiserowitz, A. (2011). Support for climate policy and societal action are linked to perceptions about scientific agreement. *Nature Climate Chang 1,* 462–466.

Douxchamps, S., Van Wijk, M. T., Silvestri, S., Moussa, A. S., Quiros, C., Ndour, N. Y. B., Buah, S., Somé, L., Herrero, M., Kristjanson, P., Ouedraogo, M., Thornton, P. K., Asten, P. V., Zougmoré , R., & Rufino, M. C. (2016). Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. *Regional Environmental Change, 16(5)*, 1305-1317.

Dow, K., Berkhout, F., Preston, B.L., Klein, R.J.T., Midgley, G., & Shaw, M.R. (2013). Limits to adaptation. *Nature Climate Change, 3*, 305–307.

Downing, T. E., Ziervogel, G., & Shale, M. (2009). *Using science to improve adaptation in Africa*.

Downing,T. E., Patwardhan, A., Klein, R. J. T., Mukhala, E., Stephen, L., Winograd, M., & Ziervogel, G. (2005). Assessing vulnerability for climate adaptation. In B. Lim, E. Spanger-Siegfried, I. Burton, E. Malone, & S. Huq (Eds), *Adaptation policy frameworks for climate change: Developing strategies, policies and measures*. Cambridge University Press, pp. 61–90.

Duflo, E. (2006). Poor but Rational? In: Banerjee, A.V., B nabou, R., & Mookherjee, D. (Eds.), *Understanding Poverty*. Oxford University Press, New York.

Easterling III, W.E., Hurd, B.H., & Smith, J.B. (2004). *Coping with Global Climate Change: The Role of Adaptation in the United States.* Pew Centre on Global climate Change, Arlington, VA.

Easterling, W., Aggarwal, P., Batima, P., Brander, K., Bruinsma, J., Erda, L., & Baethgen, W. (2007). Food, fibre, and forest products. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., Hanson, C.E. (Eds.)*, Climate Change 2007: Impacts, adaptation and vulnerability. contribution of working group ii to the fourth assessment report of the intergovernmental panel on climate change.* Cambridge, Cambridge University Press, pp. 273–313.

Echebiri, R. N., & Onwusiribe, C. N. (2017). Effect of livelihood diversification on food security status of rural farm households in Abia State Nigeria. *Scientific Papers Series Management*, *Economic Engineering in Agriculture and Rural Development, 17(1)*, 159–166.

Economist. (2005). *Japan's farmers: Facing the scythe?* The Economist, 28th May.

Eitzinger, A; Binder, C. R., & Meyer, M. A. (2018). Risk perception and decision-making: do farmers consider risks from climate change? *Climatic Change*, *151*, 507-524.

Elbehri, A., Elliott J., & Wheeler, T. (2015). Climate change, food security and trade: An overview of global assessments and policy insights. In Elbehri, A. (ed)., *Climate change and food systems: global assessments and implications for food security and trade*. Food Agriculture Organization of the United Nations (FAO), Rome.

Ellis, F. (2000). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics, 51(2)*, 289–302.

Elshirbiny, H., & Abrahamse, W. (2020). Public risk perception of climate change in Egypt: A mixed methods study of predictors and implications. *Journal of Environmental Studies and Sciences, 10(3)*, 242-254.

Engle, N. L. (2011). Adaptive capacity and its assessment. *Global Environmental Change 21*, 647–656.

Evans, H. E. (1991). Rural-Urban Relations, Household Income Diversification and Agricultural Productivity. *Development and Change, 22(3)*, 519–545.

Evans, L. S., Hicks, C. C., Adger, W. N., Barnett, J., Perry, A. L., Fidelman, P., & Tobin, R. (2016). Structural and psycho-social limits to climate change adaptation in the Great Barrier Reef Region. *PloS ONE*, *11(3)*, e0150575.

Fahad, S., & Wang, J. (2018). Farmers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan. *Land Use Policy, 79*, 301–309.

FAO, IFAD & WFP. (2015). *The State of Food Insecurity in the World 2015.* Meeting the 2015 international hunger targets: taking stock of uneven progress. Rome, FAO.

Fazey, I., Moug, P., Allen, S., Beckmann, K., Blackwood, D., Bonaventura, M., Burnett, K.,Danson, M., Falconer, R., Gagnon, A.S., Harkness, R., Hodgson, A., Holm, L., Irvine,K.N., Low, R., Lyon, C., Moss, A., Moran, C., Naylor, L., O'Brien, K., Russell, S.,Skerratt, S., Rao-Williams, J., & Wolstenholme, R. (2018). Transformation in a changing climate: a research agenda. *Climate and Development, 10*, 197–217.

Fedele, G., Donatti, C. I., Harvey, C. A., Hannah, L., & Hole, D. G. (2020). Limited use of transformative adaptation in response to social-ecological shifts driven by climate change. *Ecology and society., 25(1)*, 25.

Fedele, G., Donatti, C. I., Harvey, C. A., Hannah, L., & Hole, D. G. (2019). Transformative adaptation to climate change for sustainable social-ecological systems. *Environmental Science and Policy 101*, 116–125.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: a survey. *Economic Development and Cultural Change, 33(2)*, 255-298

Findlater, K. M., Satterfield, T., Kandlikar, M., & Donner, S. D., (2018). Six languages for a risky climate: how farmers react to weather and climate change. *Climatic Change, 148 (4*), 451–465.

Findlay, R., Park, C-Y., & Verbiest, J. P. A. (2016). Myanmar: building economic foundations. *Asian-Pacific Economic Literature*, *30,* 42–64.

Finger, R., Hediger, W., & Schmid, S. (2011). Irrigation as adaptation strategy to climate change—a biophysical and economic appraisal for Swiss maize production. *Climate Change 105 (3),* 509–528.

Fischer, A. P. (2019). Adapting and coping with climate change in temperate forests. *Global Environmental Change*, *54*, 160-171.

Fischer, G., Shah, M., Tubiello, N. , & van Velhuizen, F.H. (2005). Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. *Philosophical Transactions: Biological Sciences 360 (1463),* 2067–2083.

Fisher, M., & Carr, E. R. (2015). The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: The case of drought-tolerant maize seed in eastern Uganda. *Global Environmental Change, 35*,82–92.

Food and Agricultural Organization (FAO). (2016). *The State of Food and Agriculture: Climate Change, Agriculture and Food Security.* Rome, FAO.

Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD), United Nation Children's Fund (UNICEF), World Food Programme (WFP), and World Health Organization (WHO). (2017). *The State of Food Security and Nutrition in the World 2017.* Building resilience for peace and food security. Rome, FAO.

Food and Agriculture Organization (FAO). (2009). *Climate.* Agricultural Atlas of the Union of Myanmar. FAO Environment, Environmental Assessment and Management Unit (NRCE). FAO, Rome

Food and Agriculture Organization (FAO). (2013). *Drought and the farming sector: Loss of farm animals and post-drought period*. ILRI, Food and Agriculture Organization, Rome.

Food and Agriculture Organization (FAO). (2014). *Myanmar Dry Zone development programme: Scoping Report*. FAO Investment Centre. https://www.lift-fund.org/myanmar-dry-zone-development-programme-scoping-report.

Fook, T. C. T. (2017). Transformational processes for community-focused adaptation and social change: a synthesis. *Climate and Development, 9*, 5–21.

Foster, A. D., & Rosenzweig, M. (2004). Agricultural productivity growth, rural economic diversity, and economic reforms: India, 1970–2000. *Economic Development and Cultural Change*, *52(3)*, 509–542.

Frank, E., Eakin, H., & López-Carr, D. (2011). Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. *Global Environmental Change, 21 (1*), 66–76.

Gandure, S., Walker, S., & Botha, J. J. (2013). Farmers perceptions of adaptation to climate change and water stress in a South African rural community. *Environmental Development*, *5*, 39-53.

Gao, J., & Mills, B.F. (2018). Weather shocks, coping strategies, and consumption dynamics in rural ethiopia. *World Dev*. 101, 268–283.

Gbetibouo, G.A., & Ringler, C. (2009). *Mapping South African farming sector vulnerability to climate change and variability: a sub-national assessment*. International Food Policy Research Institute (IFPRI) and Centre for Environmental Economics and Policy in Africa (CEEPA), pp. 12–18.

Gentle, P., & Maraseni, T. N. (2012). Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. *Environmental science and policy*, *21*, 24-34.

Gibson, T. D., Pelling, M., Ghosh, A., Matyas, D., Siddiqi, A., Solecki, W., Johnson, L.,Kenney, C., Johnston, D., & Du Plessis, R. (2016). Pathways for transformation: disaster risk management to enhance resilience to extreme events. *Journal of Extreme Events 3*, 1671002.

Gifford, R. (2011). The dragons of inaction: psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol, 66*, 290–302 (2011)

Girard, C., Pulido-Velazquez, M., Rinaudo J. D., Page, C., & Caballero, Y. (2015). Integrating top-down and bottom-up approaches to design global change adaptation at the river basin scale. *Global Environmental Change, 34,* 132–146.

Gorddard, R., Colloff, M.J., Wise, R.M., Ware, D., & Dunlop, M. (2016). Values, rules and knowledge: adaptation as change in the decision context. *Environmental Science and Policy, 57*,60–69.

Government of Myanmar. (2019). *Myanmar Climate Change Strategy (2018-2030)*. The Republic of the Union of Myanmar.

Guido, Z., Zimmer, A., Lopus, S., Hannah, C., Gower, D., Waldman, K., Krell, N., Sheffield, J., Caylor, K., & Evans, T. (2020). Farmer forecasts: impacts of seasonal rainfall expectations on agricultural decision-making in sub-Saharan Africa. *Climate Risk Management, 30*, 100247.

Gunderson, L., Cosens, B. A., Chaffin, B. C., Arnold, C. A. T., Fremier, A. K., Garmestani, A.S.,Craig, R.K., Gosnell, H., Birge, H.E., Allen, C.R., Benson, M.H., Morrison, R.R., Stone,M.C., Hamm, J.A., Nemec, K., Schlager, E., & Llewellyn, D. (2017). Regime shifts and panarchies in regional scale social-ecological water systems. *Ecol. Soc.* 22.

Hadarits, M., Pittman, J., Corkal, D., Hill, H., Bruce, K., & Howard, A. (2017). The interplay between incremental, transitional, and transformational adaptation: A case study of Canadian agriculture. *Regional Environmental Change,17*, 1515–1525.

Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., & Jackson, L. E. (2012). Global and local concerns: what attitudes and beliefs motivate farmers to mitigate and adapt to climate change? *PloS one, 7(12)*, e52882.

Haggblade, S., Hazell, P., & Reardon, T. (2010). The rural Non-farm econ-omy: Prospects for growth and poverty reduction. *World Development,38(10)*, 1429–1441.

Hallegatte, S, Bangalore, M., Bonza nigo, L., Fay, M., Kane, T., Narloch, U., Rozenberg, J., Treguer, D., & Vogt-Sch ilb, A. (2016). *'Shock Waves: Managing the Impact s of Climate Change on Poverty', Climate Change and Development Series.* Washington DC, World Bank.

Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., & Campbell, B. (2019). Climate risk management and rural poverty reduction. *Agricultural Systems,172(July 2017)*, 28–46.

Hay, I. (2005). *Qualitative research methods in human geography*. (2nd ed.) Oxford University Press.

Henley, G. (2014). *Case study on Land in Burma*. London, Overseas Development Institute (ODI).

Herrero, M., Wirsenius, S., Henderson, B., Rigolot, C., Thornton, P.K., Havlik, P., de Boer, I., & Gerber, P. J. (2015). Livestock and the environment: what have we learned in the past decade? *Annual Review of Environment and Resources, 40*, 177–202.

Herridge, D. F., Win, M. M., Nwe, K. M. M., Kyu, K. L., Win, S. S., Shwe, T., Min, Y. Y., Denton, M. D., & Cornish, P. S. (2019). The cropping systems of the Central Dry Zone of Myanmar: Productivity constraints and possible solutions. *Agricultural Systems*, *169*, 31-40.

Hertel, T. W., & Rosch, S. D. (2010). Climate change, agriculture, and poverty. *Applied economic perspectives and policy*, *32(3*), 355-385.

Hisali, E., Birung, P., & Faisal, B. (2011). Adaptation to climate change in Uganda: evidence from micro level data. *Global Environmental Change, 21*, 1245–1261.

Horrocks, L., & Harvey, A. (2009). *The implications of 4+C warming for adaptation strategies in the UK: Time to change? In Four degrees and beyond*. Oxford, England: Environmental Change Institute, Oxford University. Retrieved from http://www.eci.ox.ac.uk/events/4degrees/ppt/8-4horrocks.pdf

Huong, N. T. L., Bo, Y.S., & Fahad, S. (2018). Economic impact of climate change on agriculture using Ricardian approach: A case of northwest Vietnam. *Journal of the Saudi Society of Agricultural Sciences*, *18*(4), 449-457.

Iiyama, M., Kariuki, P., Kristjanson, P., Kaitibie, S. & Maitima, J. (2010). Livelihood Diversification Strategies, Income and Soil Management Strategies: A Case Study from Kerio Valley, Kenya. *Academe*, *96(1),* 10–14.

Intergovernmental Panel on Climate Change (IPCC). (2007). *Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Synthesis Report, Core writing team, Pachauri, R.K and Reisinger, A. (Eds.). IPCC, Geneva, Switzerland, pp. 104.

Intergovernmental Panel on Climate Change (IPCC). (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R.,C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M.

Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.

Intergovernmental Panel on Climate Change (IPCC). (2022) *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.O. Prtner, D.C.Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegr a, M. Craig, S. Langsdorf, S. L schke, V.M ller, A. Okem, B. Rama (Eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, USA, pp. 3056. doi:10.1017/9781009325844.

International Fund for Agricultural Development (IFAD). (2016). *Structural and rural transformation in Asia and the Pacific*; IFAD: Rome, Italy.

International Water Management Institute (IWMI). (2015). *Improving water management in Myanmar's dry zone for food security, livelihoods and health*. Colombo, Sri Lanka: International Water Management Institute (IWMI). pp. 52.

Irrigation, A. (2012). *Increasing the Efficiency and Effectiveness of Pumped Irrigation Schemes in the Central Dry Zone of Myanmar.* United Nations Office for Project Services Working Paper No. 3 - Agriculture. Yangon: Livelihoods and Food Security Trust Fund /UNOPS. Water Resources Utilization Department.

Irrigation Department and Water Resources Utilization Department. (2003). *Agricultural Water Resources Study in Myanmar: Water Scarcity Variation in Myanmar.*

Jacobson, C., Crevello, S., Chea, C., & Jarihani, B. (2018). When is migration a maladaptive response to climate change? *Regional Environmental Change*, 1–12.

Jamelske, E., Barrett, J. & Boulter, J. (2013). Comparing climate change awareness, perceptions, and beliefs of college students in the United States and China. *Journal of Environmental Studies and Science, 3*, 269–278 (2013)

Japan International Cooperation Agency (JICA) (2013). *Data collection survey on agricultural sector in the Republic of the Union of Myanmar*. Final report, SANYU consultants INC, pp. 167.

Japan International Cooperation Agency (JICA). (2010). The Development Study on Sustainable Agricultural and Rural Development for Poverty Reduction Programme in the Central Dry Zone of the Union of Myanmar.

Jensen, R. (2000). Agricultural volatility and investments in children. *Amer. Econ. Rev*. 90 (2), 399–404.

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development, 8(2),* 133–144.

Karlsson, M., & Bryceson, I. (2016). Continuity and change: understanding livelihood shifts and adaptation in coastal Belize 1830–2012. *Local Environment*, *21*(2), 137-156.

Kates, R.W., Travis, W.R., & Wilbanks, T. J. (2012). *Transformational adaptation when incremental adaptations to climate change are insufficient.* Proceedings of the National Academy of Science, *109 (19)*, 7156–7161.

Kelly, P. M., & Adger, W. N. (2000). Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climate Change, 47*, 325–352

Khaing, M. A., Zin, W. W., & Kyi, T. C. (2016). Climate change effect in Central Dry Zone, Myanmar. *International Journal for Innovative Research in Multidisciplinary Field*, *2*, 267-73.

Khaing, O. (2010). *Climate change human security (including food and nutrition, and energy security) and human rights*. Retrieved on June 1, 2019 from http://hdru.aprc.undp.org/ext/HDRU/pdf/climate/Sub%20theme%204.pdf

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *The qualitative report*, *10*(4), 758-770.

Kreft, S., Eckstein, D., & Melchior, I. (2017). *Global climate risk index 2017 who suffers most from extreme weather events? Weather-related Loss Events in 2015 and 1996 to 2015* Germanwatche.V., Bonn, Germany.

Kubo, K., Pritchard, B., & Phyo, A. S. (2021). How Chinese demand for fresh fruit and vegetables is creating new landscapes of rural development and vulnerability in Southeast Asia: Insights from the Myanmar melon frontier. *Geoforum*, *122*, 32-40.

Kuntz, J.R.C., & Gomes, J.F.S. (2012). Transformational change in organisations: a self-regulation approach. *Journal of Organizational Change Management, 25*, 143–162.

Kyi, K. M. (2012). *Farmer vulnerability amidst climate variability: a case study of dry Zone of Myanmar, ICIRD 2012*. MA, RCSD program, Faculty of Social Science, Chaing Mai University.

Kyi, T (2016). *Influence of climate change impact on agricultural risks in Myanmar's dry zone,* FFTC Agricultural Policy Platform.

Lacroix, T. (2011). *Migration, rural development, poverty and food security: a comparative perspective*. International Migration Institute, University of Oxford.

Ledley, T. S., Gold, A. U., Niepold, F., & McCaffrey, M. (2018). Moving toward collective impact in climate change literacy: the climate literacy and energy awareness network (CLEAN). *J. Geosci. Educ*., 62, 307–318.

Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.Y., & Leiserowitz, A. A. (2015). Predictors of public climate change awareness and risk perception around the world. Nat. *Climate Change, 5*, 1014–1020.

Lemos, M. C., Lo, Y.-J., Nelson, D. R., Eakin, H., & Bedran-Martins, A. M. (2016). Linking development to climate adaptation: Leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. *Global Environmental Change, 39*, 170–179.

Li, C., Tinga, Z., & Rasaily, R. G. (2010). *Farmer's Adaptation to Climate Risk in the Context of China-A research on Jianghan Plain of Yangtze River Basin*, International Conference on Agricultural Risk and Food Security 2010. Agriculture and Agricultural Science Procedia 1,. 116–125.

Livelihoods and Food Security Fund (LIFT). (2012). *Baseline survey results*. LIFT, Yangon, Myanmar.

Livelihoods and Food Security Fund (LIFT). (2014). *Household Survey 2013*. LIFT Fund Management Office, Yangon, Myanmar.

Liverpool-Tasie, L. S., Pummel, H., Tambo, J. A., Olabisi, L. S. and Osuntade, O. (2020). Perceptions and exposure to climate events along agricultural value chains: Evidence from Nigeria. *Journal of environmental management, 264*, 110430.

Lobell, D.B., & C.B. Field. (2011). California perennial crops in a changing climate. *Climatic Change, 109,* 317-S333.

Lohmann, C., & Liefner, I. (2009). Location, non-agricultural employment, and vulnerability to poverty in rural Thailand. *Erdkunde, 63(2),* 141–160.

Maddison, D. (2007). The perception of and adaptation to climate change in Africa. World Bank policy research working paper. 4308. World bank, Washington, D.C.

Mapfumo, P., Adjei-Nsiah, S., Mtambanengwe, F., Chikowo, R., & Giller, K. E. (2013). Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. *Environmental Development*, *5*, 6-22.

Martin, S. M., & Lorenzen, K. (2016). Livelihood Diversification in Rural Laos. *World Development, 83*, 231–243.

McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., & White, K.S.(Eds.). (2001). *Climate Change 2001: Impacts, adaptation and vulnerability*. Cambridge University Press, Cambridge.

McCartney, M., Pavelic, P., Lacombe, G., Latt, K., Zan, A. K., Thein, K., Douangsavanh, S., Balasubramanya, S., Ameer, R., Myint, A., Cho, C., Johnston, R., & Sotoukee, T. (2013). *Water resource assessment of the Dry Zone of Myanmar*. Final report for component 1, Project report of the Livelihoods and Food Security Trust Fund (LIFT) Dry Zone Program, International Water Management Institute (IWMI); Vientiane, Laos, National Engineering and Planning Services (EPS), Yangon, Myanmar, 52 pp.

Mccartney, M., pavelic, P., Lacombe, G., Latt, K., Zan, A. K., Thein, K., Douangsavanh, S., Soumya, H., Ameer, R., Myint, A. CHO, C., Johnston, R., & Sotoukee, T. (2015*). Water Resource Assessment of the Dry Zone of Myanmar.* Final Report for Component 1. Colombo, Sri Lanka: IWMI.

Meadowcroft, J. (2011). Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions, 1*, 70–75.

Mehar, M., Mittal, S., & Prasad, N. (2016). Farmers coping strategiesfor climate shock: Is it differentiated by gender? *Journal of Rural Studies, 44*,123–131.

Meinke, H., Howden, S.M., Struik, P. C., Nelson, R., Rodriguez, D., & Chapman, S. C. (2009). Adaptation science for agricultural and natural resource management – urgency and theoretical basis. *Current Opinion in Environment Sustainability*, *1*, 69-76.

Meldrum, G., Mijatović, D., Rojas, W., Flores, J., Pinto, M., Mamani, G., Condori, E., Hilaquita, D., Gruberg, H., & Padulosi, S. (2018). Climate change and crop diversity: farmers' perceptions and adaptation on the Bolivian Altiplano. *Environment, Development and Sustainability*, *20*(2), 703-730.

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Farmers' perceptions of climate change and agricultural adaptation strategies in rural sahel. *Environmental Management, 43*, 804–816.

Milan, A., & Ruano, S. (2014). Rainfall variability, food insecurity and migration in Cabricán, Guatemala. *Climate and Development, 6(1),* 61–68.

Miller, F. P., & McGregor, A. (2020). Rescaling political ecology? World regional approaches to climate change in the Asia Pacific. *Progress in Human Geography*, *44*(4), 663-682.

Minale, L. (2018). Agricultural productivity shocks, labour reallocation and rural– urban migration in China. *Journal of Economic Geography, 18(4),* 795-821.

Ministry of Agriculture and Irrigation (MOAI). (2014). *Myanmar agriculture in brief*. Department of agricultural planning. Naypyitaw, Union of Myanmar

Hom N. H., Htwe N. M., Hein Y., Than, S. M., Kywe, M., & Htut T. (2015). *Myanmar: Climate smart agriculture strategy*, co-produced by MOAI, CGIAR, CCAFS, and IRRI, MOAI publication, Nay Pyi Taw, Myanmar. https://cgspace.cgiar.org/rest/bitstreams/63308/retrieve

Ministry of Agriculture Livestock and Irrigation (MOALI), Food and Agriculture Organization (FAO) and Livelihoods and Food Security Fund (LIFT). (2016). *Formulation and operationalization of national action plan for poverty alleviation and rural development through agriculture (NAPA) Myanmar.*

Ministry of Agriculture, Livestock and Irrigation (MOALI). (2016). *Sector assessment (summary): Agriculture, natural resources and rural development*. Irrigated agriculture inclusive development project (RRP Myanmar 47152), Nay Pyi Taw, Myanmar.

Ministry of Labour, Immigration and Population (MLIP) (2015). The 2014 Myanmar Population and Housing Census: Thematic Report on Population Dynamics. Census Report Volume 4-E. Nay Pyi Taw, Myanmar.

Molle, F., & Srijantr, T. (1999). *Agrarian change and the land system in the Chao Phraya Delta*. DORASDELTA research report no. 6, ORSTOM, Kasetsart University, Bangkok.

Molle, F., Srijantr, T., Latham, L., & Thepstitsilp, P. (2001). *The impact of the access to irrigation water on the evolution of farming systems: A case study of three villages in the Chao Phraya Delta*. DORASDELTA research report no. 11, ORSTOM, Kasetsart University, Bangkok.

Ministry of Natural Resources and Environment Conservation (MoNREC) (2016). *Myanmar Climate Change Strategy and Action Plan (MCCSAP) 2016–2030*.

Moore, F. C., Obradovich, N., Lehner, F., & Baylis, P. (2019). Rapidly declining remarkability of temperature anomalies may obscure public perception of climate change. *Proceedings of the National Academy of Science, USA 116*, 4905–4910.

Mortimore, M. (2010). Adapting to drought in the Sahel: lessons for climate change. Wiley interdisciplinary reviews: *Climate Change, 1(1)*, 134-143.

Moser, C. M., & Barrett, C. B. (2003). The disappointing adoption dynamics of a yield-increasing, low external-input technology: the case of SRI in Madagascar. *Agricultural Systems, 76(3)*, 1085-1100.

Mulyoutami, E.; Lusiana, B., & Van Noordwijk, M. (2020). Gendered migration and agroforestry in Indonesia: livelihoods, labor, know-how, networks. *Land*, 9, 529.

Munshi, K. (2004). Social learning in a heterogeneous population: technology diffusion in the Indian Green Revolution. *Journal of Development Economics, 73(1),* 185-213.

Murray-Prior, R. (1998). Modelling farmer behaviour: a personal construct theory interpretation of hierarchical decision models. *Agricultural Systems, 57(4),* 541-556

Murshid, K., Iqbal, K., & Ahmed, M. (2000). *A study on remittance inflows and utilization.* Dhaka, IOM (mimeo).

Mutandwa, E., Hanyani-Mlambo, B., & Manzvera, J. (2019). Exploring the link between climate change perceptions adaptation strategies among smallholder farmers in Chimanimani district of Zimbabwe. *International Journal of Social Economics, 46*, 850–860.

Nadvi, K., & Barrientos, S. (2004). *Industrial clusters and poverty alleviation: mapping links and developing a methodology for poverty and social impact assessment of cluster development initiatives.* Working paper, Vienna: United National Industrial Development organization.

National Adaptation Programme of Action (NAPA). (2012). *The Myanmar National Adaptation Programme of Action (NAPA) to Climate Change*. Nay Pyi Taw, Myanmar. Available from: http://unfccc.int/resource/docs/napa/mmr01.pdf

NCEA (National commission for Environmental affair). (2010). *National report on the UNCCD implementation,* Yangon, Myanmar.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environment and Resources, 32*, 395–419.

Nelson, G. C., Rosegrant, M. W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M., & Lee, D. (2009). *Climate Change: Impact on Agriculture and Costs of Adaptation.* International Food Policy Research Institute, Washington, D.C.

Neuman, W. L., & Kreuger, L. (2003). *Social work research methods: Qualitative and quantitative approaches*. Allyn and Bacon.

Nguyen, Q., Hoang, M.H., Öborn, I., & van Noordwijk, M. (2013). Multipurpose agroforestry as a climate change resiliency option for farmers: an example of local adaptation in Vietnam. *Climate Change, 117*, 241–257.

Nhemachena, C., & Hassan, R. (2007). *Micro-level analysis of farmers' adaptation to climate change in Southern Africa.* IFPRI Discussion Paper No. 00714. International Food Policy Research Institute, Washington, DC.

Nielsen, H.Ø. (2009). *Bounded Rationality in Decision-Making: How cognitive shortcuts and professional values may interfere with Market-Based regulation*. Manchester University Press, Manchester.

Nielsen, J. Q., & Reenberg, A. (2010). Cultural barriers to climate change adaptation: a case study from Northern Burkina Faso. *Global Environmental Change 20 (1),* 142–152.

Nkoana, E. M. (2020). Exploring the effects of an environmental education course on the awareness and perceptions of climate change risks among seventh and eighth grade learners in South Africa. *International Research in Geographical and Environmental Education, 29*, 7–22.

Noble, I. R., Anokhin, Y. A., Carmin, J., Goudou, D., Lansigan, F. P., Osman-Elasha, B., & Villamizar, A. (2014). Adaptation needs and options. In C. B. Field, V. R. Barros, D. J.

Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea and L.L.White (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

O'Brien, K. L., & Leichenko, R. M. (2000). Double exposure: assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change, 10(3)*, 221-232.

O'Brien, K. (2012). Global environmental change II: from adaptation to deliberate transformation. *Progress in Human Geography, 36*, 667–676.

O'Brien, K., Leichenko, R., Kelkar, U., Venema, H., Aandahl, G., Tompkins, H., & West, J. (2004). Mapping vulnerability to multiple stressors: climate change and globalization in India. *Global Environmental Change, 14 (4),* 303–313.

Oduniyi, O. S., & Tekana, S. S. (2019). *Adoption of agroforestry practices and climate change mitigation strategies in North West province of South Africa.* International Journal of Climate Change Strategies and Management.

Ohlmer, B., Olson, K., & Brehmer, B. (1998). Understanding farmers' decision making processes and improving managerial assistance. *Agricultural Economics, 18(3)*, 273-290.

Oladipo, J. A. (2015). Seeing through the opaque glass, darkly: farmers' perception of climate change. *Climate and Development, 8*, 122–132.

Olsson, P., Galaz, V., & Boonstra, W.J. (2014). Sustainability transformations: a resilience perspective. *Ecology and Society, 19 (4)*, 1.

Oluwatayo, I. B. (2005). The Effect of Poverty on Children's Upbringing in Ibadan, Oyo State, Nigeria: A Case Study of Abadina Community. *Multidisciplinary Journal of Research. 2 (1),* 21-30.

Oo, Aung. (2018). *Community perceptions of the impacts of climate change on agriculture in Myanmar's central dry zone*.

Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., & Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change, 11(4)*, 306-312.

Ostwald, M. & Chen, D. (2006). Land-use change: Impacts of climate variations and policies among small-scale farmers in the Loess Plateau, China. *Land Use Policy, 23(4)*, 361-371.

Pahl-Wostl, C., & Knieper, C. (2014). The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes. *Global Environmental Change, 29*, 139-154.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Adm Policy Ment Health*, *42***,** 533–544.

Panda, A. (2016). Exploring climate change perceptions, rainfall trends and perceived barriers to adaptation in a drought affected region in India. *Natural Hazards, 84(2)*, 777-796.

Park, S.E., Marshall, N.A., Jakku, E., Dowd, A.M., Howden, S.M., Mendham, E., & Fleming, A. (2012). Informing adaptation responses to climate change through theories of transformation. *Global Environmental Change, 22 (1)*, 115–126.

Parry, M.L., Canziani, O.F., & Palutikof, J.P. (2007). Climate change: impacts, adaptation and vulnerability. In: van der Linden, P.J., Hanson (Eds.), *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. United Kingdom, Cambridge University Press, United Kingdom, pp. 976.

Paul, P., Sonali, S., Sellamuttu, ROBYN, J., Matthew, M., Touleelor, S., Soumya, B., Diana, S., Guillaume, L., Somphasith, D., Olivier, J., Latt, K., Zan, A. K., Thein, K., Myint, A., Cho, C., & Htut, Y. T. (2015). *Integrated Assessment of Groundwater Use for Improving Livelihoods in the Dry Zone of Myanmar*. Colombo, Sri Lanka.

Pelling, M. (2011). *Adaptation to Climate Change: From Resilience to Transformation.* Routledge, Oxon.

Pelling, M., O'Brien, K., & Matyas, D. (2015). Adaptation and transformation. *Climate Change, 133*, 113–127.

Perz, S. G. L. (2005). The importance of household asset diversity for livelihood diversity and welfare among small farm colonists in the Amazon. *Journal of Development Studies*, 41(7), 1193–1220.

Pingali, P. L., Rozelle, S. D., & Gerpacio, R. V. (2001). The farmers' voice in priority setting: a cross-country experiment in eliciting technological preferences. *Economic Development and Cultural Change, 49(3)*, 591-610.

Pomp, M., & Burger, K. (1995). Innovation and imitation - adoption of cocoa by Indonesian smallholders. *World Development, 23(3),* 423-431.

Porter, J.R., L. Xie, A.J. Challinor, K. Cochrane, S.M. Howden, M.M. Iqbal, Lobell, D.B. & M.I. Travasso. (2014). Food security and food production systems. In: Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (Eds.). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA, Cambridge University Press, pp. 485-533.

Pritchard, B., Dibley, M., Rammohan, A., Htin, Z.S., Khay, M.M., Htet, K., Vicol, M., Horton, J. and Welch, E. (2018). *Food and Nutrition Insecurity in Rural Myanmar under Conditions of Rapid Livelihood Change: Survey Findings from the 2015-18*. Australian Research Council Project. ISBN 978-1-74210-439-3.

Pursch, W., Woolcock & Zurstrussen. (2017). *Documenting Myanmar's Social Transformation: Insights from Six Rounds of Research on Livelihoods and Social Change in Rural Communities*, World Bank Policy Research Paper 8055.

Raymond, C. M., & Spoehr, J. (2013). The acceptability of climate change in agricultural communities: comparing responses across variability and change. *Journal of environmental management, 115*, 69-77.

Raynaut, C. (2001). Societies and nature in the Sahel: ecological diversity and social dynamics. *Global Environmental Change, 11(1)*, 9-18

Reardon, T., Taylor, J. E., Stamoulis, K., Lanjouw, P., & Balisacan, A. (2000). Effects of non-farm employment on rural income inequality in developing countries: An investment perspective. *Journal of agricultural economics*, *51*(2), 266-288.

Regional Integrated Multi-Hazard Early Warning System (RIMES). (2011). *Managing Climate Change risks for Food Security in Myanmar*. Technical Reports, RIMES, Bangkok Thailand. Access from: http://www.rimes.int/

Reidsma, P., Ewert, F., Lansink, A. O., & Leemans, R. (2010). Adaptation to climate change & climate variability in European agriculture: The importance of farm level responses. *European Journal of Agronomy, 32*,. 91–102

Rickards, L., & Howden, S. M. (2012). Transformational adaptation: agriculture and climate change. *Crop Pasture Sci.,* 63, 240–250.

Rigg, J. (2005). *Living with transition in Laos: Market integration in Southeast Asia*. London and New York: Routledge.

Rigg, J. (2006). Land, farming, livelihoods and poverty: Rethinking the links in the rural south. *World Development, 34*, 180–202.

Rigg, J. (2020). *Rural development in southeast asia: Dispossession, accumulation and persistence.* Cambridge University Press.

Rigg, J., Salamanca, A., Phongsiri, M., & Sripun, M. (2018). More farmers, less farming? Understanding the truncated agrarian transition in Thailand. *World Development*, 107, 327–337.

Risbey, J., Kandlikar, M., Dowlatabadi, H., & Graetz, D. (1999). Scale, context and decision-making in agricultural adaptation to climate variability and change, *Mitigation and Adaptation Strategies for Global Change, 4*, 137–165.

Robertson, M., & Murray-Prior, R. (2016). Five reasons why it is difficult to talk to Australian farmers about the impacts of, and their adaptation to, climate change. *Reg. Environ. Chang. 16 (1)*, 189–198.

Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A., Müller, C., Arneth, A., Boote, K., Folberth, C., Glotter, M., Khabarov, N., Neumann, K., Piontek, F., Pugh, T., Schmid, E., Stehfest, E., Yang, H., & Jones, J. (2014). *Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison.* Proceedings of the National Academy of Sciences of the United States of America, *111(9)*, 3268-3273.

Rosenzweig, C., Iglesius, A., Yang, X. B., Epstein, P. R., & Chivian, E. (2001). *Climate change and extreme weather events-Implications for food production, plant diseases, and pests*. NASA Publications. 24.

Rosenzweig, C., Tubiello, F. N., Goldberg, R., Mills, E. , & Bloomfield, J. (2002). Increased crop damage in the US from excess precipitation under climate change. *Global Environmental Change, 12(3)*, 197-202.

Rosset, P. (2006). Moving forward: agrarian reform as a part of food sovereignty. *Promised land: Competing visions of agrarian reform*, 301-321.

Roy, A., & Basu, S. (2020). Determinants of livelihood diversification under environmental change in coastal community of Bangladesh. *Asia Pacific Journal of Rural Development, 30*, 7–26.

Rugg, G., & Petre, M. (2007). *A Gentle Guide to Research Methods.* California: Sage.

Sandelowski, M. (2000). Whatever happened to qualitative description? *Research in nursing and health*, *23*(4), 334-340.

Sandelowski, M. (2010). What's in a name? Qualitative description revisited. *Research in nursing and health*, *33*(1), 77-84.

Sautier, M., Piquet, M., Duru, M., & Martin-Clouaire, R. (2017). Exploring adaptations to climate change with stakeholders: A participatory method to design grassland-based farming systems. *Journal of environmental management*, *193*, 541-550.

Schipper, E.L. (2010). Religion as an integral part of determining and reducing climate change and disaster risk: an agenda for research. In *Voss, M. (ed.) Climate Change: The Social Science Perspective*. VS-Verlag: Wiesbaden, Germany, pp. 377-393.

Schmidhuber, J., & Tubiello, F. N. (2007). *Global food security under climate change.* Proceedings of the National Academy of Sciences, *104(50)*, 19703-19708.

Schofield, D., & Gubbels, F. (2019). Informing notions of climate change adaptation: A case study of everyday gendered realities of climate change adaptation in an informal settlement in Dar es Salaam. *Environment and Urbanization*, 1–22.

Schultz, T.W. (1975). The Value of the Ability to Deal with Disequilibria. *Journal of Economic Literature, 13 (3)*, 827–846.

Scoones, I. (1998). *Sustainable Rural Livelihoods: A Framework for Analysis*, IDS Working Paper 72, Brighton: IDS.

Scoones, I. (2009). Livelihoods perspectives and rural development. *Journal of Peasant Studies, 36(1)*, 171–196.

Shaffril, H. A. M., Krauss, S. E., & Samsuddin, S. F. (2018). A systematic review on Asian's farmers' adaptation practices towards climate change. *Science of the Total Environment, 644*, 683–695.

Shikuku, K.M., Winowiecki, L., Twyman, J., Eitzinger, A., Perez, J.G., Mwongera, C., & L¨aderach, P. (2017). Smallholder farmers' attitudes and determinants of adaptation to climate risks in East Africa. *Climate Risk Management, 16*, 234–245.

Simpson, N. P., Andrews, T. M., Krönke, M., Lennard, C., Odoulami, R. C., Ouweneel, B., Steynor, A., & Trisos, C. H. (2021). Climate change literacy in Africa. *Nature Climate Change*, *11*(11), 937-944

Slagle, J. T. (2014). *Climate Change in Myanmar: Impacts and Adaptation*. Dissertation, Naval Post graduate School, Monterey, California.

Smit, B., & Wandel, J. (2006) Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16*, 282-292.

Smit, B., & Pilifosova, O. (2001). Adaptation to climate change in the context of sustainable development and equity. *In J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability.* Cambridge: Cambridge University Press, pp. 877-912.

Smit, B., & Skinner, M.W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaption for Strategies for Global Change, 7 (1)*, 85–114.

Smit, B., & W&el, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16 (3)*, 282–292.

Smit, B., & Skinner, M. W. (2002). Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change, 7 (1)*, 85–114.

Smith, L. E. D., Khoa, S. N., & Lorenzen, K. (2005). Livelihood functions of inland fisheries: policy implications in developing countries. *Water Policy, 7(4),* 359–383.

Smith, M. S., Horrocks, L., Harvey, A., & Hamilton, C. (2011). Rethinking adaptation for a 4C world. *Philosophical Transactions of the Royal Society A, 369*,196–216.

Smith, W. J., Liu, Z., Safi, A. S., & Chief, K. (2014). Climate change perception, observation and policy support in rural Nevada: A comparative analysis of Native Americans, non-

native ranchers and farmers and mainstream America. *Environmental Science and Policy, 42*,101–122.

Soe, A., & Kyi, T. (2016). *Overview of Irrigation Development and Government Policy in Myanmar.*

Soubry, B., Sherren, K., & Thornton, T. F. (2020). Are we taking farmers seriously? A review of the literature on farmer perceptions and climate change, 2007–2018. *Journal of Rural Studies*, *74*, 210-222.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., De Vries, W., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855.

Stewart, D. W., Shamdasani, P. N., & Rook, D. W. (2007). *Focus Groups: Theory and Practice (2nd Edn).* Applied Social Science Research Methods Series, vol. Volume 20, SAGE Publication, USA.

Steynor, A., Pasquini, L., Thatcher, A., & Hewitson, B. (2021). Understanding the links between climate change risk perceptions and the action response to inform climate services interventions. *Risk Analysis*, *41*(10), 1873-1889.

Stirling, A. (2014). Transforming power: social science and the politics of energy choices. *Energy Research and Social Science, 1*, 83–95.

Sultana, F. (2014). Gendering climate change: Geographical Insights. *The Professional Geographer, 66(3)*, 372–381.

Sumner, D., Christie, M. E., & Boulakia, S. (2017). Conservation agriculture and gendered livelihoods in Northwestern Cambodia: decision-making, space and access. *Agriculture and Human Values*, *34(2)*, 347–362.

Survey, P. (2011). *Effect of Migration on food security: a problem or a solution?* Study of small village of Kalikot district, Nepal.

Swe, L. M. M. (2012). *Farmers' perception and adaptation to climate change through agriculture in the dry zone area of Myanmar*. Master Thesis. Asian Institute of Technology.

Takahashi, B., Burnham, M., Terracina-Hartman, C., Sopchak, A.R., & Selfa, T. (2016). Climate change perceptions of NY state farmers: the role of risk perceptions and adaptive capacity. *Environmental Management, 58*, 946–957.

Termeer, C. J. A. M., Dewulf, A., & Biesbroek, G. R. (2016). Transformational change: governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management, 60*, 558–576.

Tessema, Y., Joerin, J. & Patt, A. (2019). Climate change as a motivating factor for farm-adjustments: rethinking the link. *Climate Risk Management, 23*, 136–145.

The Government of the Republic of the Union of Myanmar. (2018). *Myanmar agriculture development strategy and investment plan (2018-19 – 2022-23)*.

Thein, M. T. (2009). *A Sustainability Assessment of Dryland Agriculture Practices in Myanmar and Their Impact on Local Livelihoods.* Faculty of Environment and Resource Studies, Mahidol University.

Thomas, D. S. G., Twyman, C., Osbahr, H., Osbahr, H., & Hewitson, B. (2007). Adaptation to climate change and variability: farmer responses to intra-seasonal precipitation trends in South Africa. *Climatic Change 83*, 301–322.

Thornton, P., & Lipper, L. (2014). *How does climate change alter agricultural strategies to support food security?* The International Food Policy Research Institute (IFPRI). Discussion paper 01340.

Thornton, T. F., & Comberti, C. (2017). Synergies and trade-offs between adaptation, mitigation and development. *Climate Change, 140*, 5–18.

Tucker, C. M., Eakin, H., & Castellanos, E. J. (2010). Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change, 20(1)*, 23–32.

Tugjamba, N., Walkerden, G., & Miller, F. (2021). Adaptation strategies of nomadic herders in northeast Mongolia: climate, globalisation and traditional knowledge. *Local Environment*, *26*(4), 411-430.

Tun, K. K. K., Shrestha, R. P., & Datta, A. Q. (2015). Assessment of land degradation and its impact on crop production in the Dry Zone of Myanmar. *Int. J. Sustain. Dev. WorldEcol.,* 22, 533–544.

Ugwoke, F., Nnadi, F., Anaeto, C., Aja, O., & Nwakwasi, R. (2013). Crop farmers' perception of and adaptation to climate change in Orlu agricultural zone of Imo state. Niger. *Journal of Agricultural Extension, 16*, 212–223.

United Nations Environment Programme (UNEP). (1997). *World Atlas of Desertification*, Second Edition.

United Nations Framework Convention on Climate Change (UNFCC). (2007). *Climate change: impacts, vulnerabilities and adaptation in developing countries*.

United State Agency for International Development (USAID). (2007). *Adapting to Climate Variability And Change*. A Guidance Manual For Development Planning. U. S. agency for international development, Washiton, DC.

Van den Bergh, J. C. (2011). Environment versus growth - A criticism of "degrowth" and a plea for "a-growth.". *Ecological Economics, 70*, 881–890.

Vaughan, E., & Levine, E. (2015). *The Dry Zone of Myanmar: A Strategic Resilience Assessment of Farming Communities.* Mercy Corps, Oregon, USA.

Vermeulen, S. J., Challinor, A. J., Thornton, P. K., Campbell, B. M., Eriyagama, N., Vervoort, J. M, Kinyangi, J., Jarvis, A., Läderach, P., Ramirez-Villega, J., Nicklin, K. J., Hawkins, E., & Smith, D. R. (2013). *Addressing uncertainty in adaptation planning for agriculture.* Proceedings of the National Academy of Sciences of U.S.A, *110*, 8357–8362.

Vermeulen, S. J., Dinesh, D., Howden, S. M., Cramer, L., & Thornton, P. K. (2018). Transformation in Practice: a review of empirical cases of transformational 47 adaptation in agriculture under climate change. *Frontiers in Sustainable Food Systems, 2*, 48.

Vermeulen**, S.,** Zougmoré, R., Wollenberg, E., Thornton, P., Nelson, G., Kristjanson, P., Kinyangi, J., Jarvis, A., Hansen, J., Challinor, A., Campbell, B., & Aggarwal, P. (2012). Climate change, agriculture & food security: a global partnership to link research and action for low-income agricultural producers and consumers. *Current Opinion in Environmental Sustainability Open issue, 4* , 128-133.

Westerhoff, L., & Smit, B. (2008). The rains are disappointing us: dynamic vulnerability and adaptation to multiple stressors in the Afram Plains, Ghana. *Mitigation and Adaptation Strat for Global Change, 14 (4)*, 317.

Wiid, N., & Ziervogel, G. (2012). Adapting to climate change in South Africa: commercial farmers' perception of and response to changing climate. *South African Geographical Journal, 94 (2)*, 152-173

Wise, R. M., Fazey, I., Stafford Smith, M., Park, S. E., Eakin, H. C., Archer Van Garderen, E. R. M., & Campbell, B. (2014). Reconceptualising adaptation to climate change as part of pathways of change and response. *Global Environmental Change, 28*, 325–336.

Woods, B. A., Nielsen, H. Ø., Pedersen, A. B., & Kristofersson, D. (2017). Farmers' perceptions of climate change and their likely responses in Danish agriculture. *Land Use Policy*, *65*, 109–120.

World Bank. (2013). *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience.* A report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, DC: World Bank.

World Bank Group. (2016). *Myanmar: analysis of farm production economics.* Economic and Sector Work Report No. 100066-MM. World Bank Group, Yangon, Myanmar.

World Bank Group. (2016). *Myanmar: analysis of farm production economics.* Economic and Sector Work Report No. 100066-MM. World Bank Group, Yangon, Myanmar.

World Bank. (2006). *Sustainable land management: Challenges, Opportunities and Trade-offs*. Washington, DC.

World Bank. (2014). *Turn Down the Heat: Confronting the New Climate Normal*. Washington, DC: World Bank.

World Bank. (2016). *A country on the move: Domestic migration in two regions of Myanmar*. QSEM Thematic Study. World Bank.

World Bank. (2017). *Capitalizing on Investment Opportunities*. World Bank.

World Bank. (2019). *Migration and Remittances: Recent Developments and Outlook*. World Bank: Washington, DC, USA.

World Food Programme (WFP). (2009). *FAO/WFP Crop and Food Security Assessment Mission to Myanmar*, Special Report, Rome, FAO.

World Food Programme (WFP). (2011). *Food security assessment in the dry zone Myanmar*.

World Food Programme (WFP). (2013). Food security focus in dry zone, regional integrated multi-hazard early warning system (RIMES), 9th Monsoon Forum, Nay Pyi Taw. Myanmar.

World Metrological Organization and United Nations Environmental Programme. (1992). *IPCC First Assessment Report, Climate change: The IPCC 1990 and 1992 Assessments*. Canada, IPCC

Wrigley-Asante, C., Owusu, K., Egyir, I. S., & Owiyo, T. M. (2017). Gender dimensions of climate change adaptation practices: The experiences of smallholder crop farmers in the transition zone of Ghana. *African Geographical Review, 6812,* 1–14.

Yegbemey, R.N., Yabi, J.A., Tovignan, D.S., Gantoli, G., & Kokoye, S.E.H. (2013). Farmers' decisions to adapt to climate change under various property rights: a case study of maize farming in Northern Benin (West Africa). *Land Use Policy, 34*, 168–175.

Yi, T., Hla, W. M., & Htun, A. K. (2012). *Drought conditions and Management Strategies in Myanmar*'. Report prepared for United Nations-Water, Department of Meteorology and Hydrology, Yangon, Myanmar.

Yiridomoh, G. Y., Sullo, C., & Bonye, S. Z. (2021a). Climate variability and rural livelihood sustainability: evidence from communities along the Black Volta River in Ghana. *GeoJournal*, *86*(4), 1527-1543.

Yiridomoh, G. Y., Chireh, V. K., Bonye, S. Z., & Derbile, E. K. (2021b). Enhancing the adaptive capacity of pro-poor populations for climate change adaptation: analysis of cash transfer programs in rural Ghana. *Local Environment*, *26*(1), 146-164.

Yohe, G., & Tol, R. S. (2002). Indicators for social and economic coping capacity—moving toward a working definition of adaptive capacity. *Global environmental change*, *12*(1), 25-40.

Zhang, X., Fan, S., & Cai, X. (2002). The path of technology diffusion: which neighbors to learn from? *Contemporary Economic Policy, 20(4)*, 470-479

Ziervogel, G., Bharwani, S. & Downing, T.E. (2006). Adapting to climate variability: pumpkins, people and pumps. *Natural Resource Forum, 30*, 294–305.

APPENDICES

Appendix A – Questions for focus group discussions

1) What are the current livelihood activities in the village?
2) What are the current resources for livelihood activities in the village?
3) How do resources or conditions influence your decision for the selection of livelihood activities?
4) Is there any change for livelihood activities in the community in compare with the past condition?
    - Follow-up: If there is any change for livelihood activity in the community, what are the reasons for changing the activities and the main drivers for those changes?
5) Are there any available alternative livelihood options in your community?
    - Follow-up: What are the main reasons for not choosing alternative livelihood activities?
6) What do you want to do for the improvement of livelihood activities in the future?
7) What do you need to select the livelihood activities what you want?
8) What kind of support have you got from Government or INGOs?
9) What is your opinion for services provided by government or INGOs?

Appendix B: Questions for semi-structure in-depth household interview

1) What are the main livelihoods of your households? Who is doing in what livelihood?
2) What are the motivations for choosing these livelihoods?
3) Is there anyone in your household who is working in farming? Why?
4) Did someone in your household migrate to other places for work? When? Why?
5) Do your household own land (for agriculture)? What is your plan for land in the future?
6) Do you grow crops for household consumption? If not, how do you manage for household consumption?