A GENDERED ANALYSIS OF CLIMATE CHANGE RESILIENCE IN A MATRILINEAL COMMUNITY OF PHALOMBE DISTRICT – MALAWI

PHD (DEVELOPMENT STUDIES) THESIS

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UNIVERSITY OF MALAWI

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PhD (DEVELOPMENT STUDIES) THESIS

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DECLARATION

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CERTIFICATE OF APPROVAL

The undersigned certifies that this thesis represents the student's own work and effort, and has been submitted with our approval in partial fulfillment of a degree of Doctor of Philosophy in Development Studies at the University of Malawi.

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DEDICATION

To my parents – Bine Michael Musa (Late) and Catherine Phiri, and my brothers and sisters.

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ABSTRACT

Dearth of gender disaggregated analysis in understanding impacts of climate change leads to blanket solutions for the vulnerable households. In Malawi, most of the policy responses lack gender disaggregated data and analysis to specify interventions for male and female headed households. Through the gender lens, this research sought to understand livelihood vulnerability and use of livelihood resources in the nexus of institutions to build resilience in Phalombe district in Malawi. The study adopted the cultural ecology theory to explain human interaction with the environment. The study adapted the Pressure and Release (PAR) model for understanding vulnerability, Historical Comparative Institutional Analysis (HCIA) for understanding land-related institutional trajectories as well as the capital-based framework for assessing disaster resilience. Primary data was collected using the phased sequential mixed methods approach while secondary data was collected from government offices. Qualitative data was collected using Participant Observation, Key Informant Interviews; One-on-one interviews and Focus Group Discussion, while quantitative data was collected using household survey. Results showed that the root causes of vulnerability are cultural traditions that regulate access to land; influence of gender on the choice of livelihood activities; edaphic factors; and moisture availability in the wetland. The dynamic pressure factors are food preference and available financial services. Unsafe living conditions were geographical location and dependence weather sensitive livelihoods. Main climate hazards were erratic rainfall, floods, pests and stormy

rainfall. The study showed that male-headed households had more human, financial and natural assets that enable them recover much quicker from floods. The study further showed that social assets are key to recovery from erratic rainfall and floods for both male and female-headed households. Natural assets contribute to recovery from erratic rainfall for male-headed households while human assets are vital for female-headed households. Human assets enable recovery from floods for both male and female-headed households while physical assets are vital for male-headed households. Formal and informal land institutions have changed paving way to formally and informally sale of land rights. This has enabled building resilience for resource rich households but not the poor. The climate change adaptation strategies included adoption of early maturing Maize and Rice varieties and climate smart agriculture practices. Adoption of the technologies and practices was influenced by a range of socio-economic and institutional factors. This thesis has demonstrated that albeit being exposed to similar climate change hazards, unique socio-cultural dimensions particular to the study area exacerbates vulnerability of female headed households compared to their male counterparts. Skewed distribution of livelihood assets towards male headed households make them more resilient. The current state of land related institutions enable the resource rich households to build resilience regardless of gender, since female headed households have lower access to financial assets, they are less likely going to benefit. Choice of climate change adaptation reflects varying priorities of between male and female heads. The female headed households center on food security while males focus on multiple goals including income generation. The study agrees with

the underlying theoretical and conceptual background of the study however the proposed transformation of the society to adapt to environmental change obscures intra-society differences such as gender. Since gender determine extent of vulnerability and resilience, the cultural ecology theory needs to highlight how gender differences influence response to similar impacts of climate change. The study thus recommended socio-cultural analysis of the vulnerability settings of male and female headed households to implement context specific interventions to build climate change resilience.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADDRMO	Assistant District Disaster Risk Management Officer
ASP	Area Stakeholder Panel
BVC	Beach Village Committee
CA	Conservation Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
DADO	District Agricultural Development Officer
DEO	District Environmental Officer
DFO	Dartmouth Flood Observatory
DODMA	Department of Disaster Management Affairs
DPD	Director of Planning and Development
DSOER	District State of Environment Report
FAO	Food and Agriculture Organization
FAW	Fall Army Worms
FGD	Focus Group Discussion
GOM	Government of Malawi
HCIA	Historical Comparative Institutional Analysis
HDDI	Household Dietary Diversity Index
IHS	Integrated Household Survey
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
MK	Malawi Kwacha
MVAC	Malawi Vulnerability Assessment Committee
NCST	National Commission for Science and Technology
NSO	National Statistical Officer
PAR	Pressure And Release

PO	Participant Observation
SES	Socio-Ecological System
SPSS	Statistical Package for Social Scientists
SSA	Sub-Saharan Africa
TA	Traditional Authority
USD	United States Dollar
VDC	Village Development Committee
VCPC	Village Civil Protection Committee
VIF	Variance Inflation Factor
VS&L	Village Savings and Loan

CHAPTER ONE

INTRODUCTION

1.1 Climate change

Climate change has received significant attention in both biophysical studies and social studies (Chen et al., 2018; Kolstad & Moore, 2020; Perera et al., 2020). Climate change has garnered attention because the magnitude of the impacts and the manner in which it has altered life-sustaining systems of the global community has often been historic (Kasperson & Kasperson, 2022). Owing to a number of factors, the impacts of climate change affect different countries differently as some experience more severe effects than others (Vicedo-Cabrera et al., 2020). A number of studies have supported this position. Liu et al. (2021) and Kahn (2019), for example, have reported that developing countries are more susceptible to the impacts of climate change than developed countries. Researchers have converged on this, observing that the impacts of climate change have been particularly devastating in Africa (Gebrechorkos et al., 2019; Girvetz et al., 2019). The Food and Agriculture Organization [FAO] (2010) and de Jalon et al (2018) have reported unpredictable and erratic weather patterns that are threatening rural livelihoods in sub–Saharan Africa [SSA].

Studies by Abegunde et al. (2019) and Fedele et al. (2019) have reported serious social repercussions such as conflicts over resources as being associated with increasing temperatures and erratic rainfall. These impacts are disrupting sustainability of most rural livelihoods (Aguiar et al., 2018). According to Shayegh and Dasgupta (2022), women in the developing countries have been identified as being more exposed to the adverse effects of climate change.

In Malawi, the main impacts of climate change have included floods, the shortening of the rainfall season through late-onset and early cessation of rains, prolonged dry spells and increased incidents of pest infestations (Government of Malawi [GoM], 2018). It has been observed that phenomena such as intense rainfall, changing rainfall patterns, floods and droughts or prolonged dry spells have kept increasing in intensity, magnitude and frequency in Malawi (Irish Aid, 2016). Reportedly, these occurrences have had adverse impacts on rural livelihoods that primarily depend on rain-fed agriculture. Njikho (2020), for example, has concluded that climate change keep threatening sustainable livelihoods and socio-economic well-being of vulnerable rural women in Malawi in ways never seen before. In that regard, destitution due to the impacts of climate change has been deepening while the ability to cope and adapt has been decreasing (Rosenzweig et al., 2018).

1.2 Vulnerability to the impacts of climate change

Vulnerability has been defined variously by different authors over time. For instance, Coppola (2021) puts it as a measure of the propensity of an object, area, individual, group, community, country, or other entity to incur the consequences of a hazard. Susman et al. (2019) describe it as the degree to which different classes of society are differently at risk.

As for Blaikie et al. (1994), vulnerability refers to characteristics of a person or group in terms of their capacity or ability to anticipate, cope with, resist and recover from the impacts of a hazard. Lastly, Wisner et al. (2016) define it as the characteristics that influence capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. It should be stated that all these definitions converge on the point that the concept of vulnerability encompasses exposure or susceptibility to shocks and capacity to abate and recover. This study adopts a definition that considers vulnerability as the extent to which households are prone to assets and livelihood losses due to climate change-related shocks.

Literature on vulnerability shows different regions of the world as experiencing different vulnerabilities owing to different socio-economic, environmental, and institutional factors that affect their respective populations. For instance, coastal communities are vulnerable to sea level rises (Bhattachan et al. 2018), while most of the tropical inland communities are vulnerable to erratic and extreme weather patterns (Li et al., 2019; Nagy et al., 2019; Mahmood et al., 2019). Other notable extreme weather incidents in the tropical regions include heatwaves, extreme precipitation that also causes floods and incidents of pest infestations (Morgan et al., 2020; Phophi et al., 2020; Ahmadalipour & Moradkhani, 2018; Weber et al., 2018; Kalantari et al., 2018).

Studies on climate change and vulnerability on Africa reveal some common attributes associated with climate change vulnerability across the continent. For instance, Bedeke (2023) reported poverty as the key underlying contributor to vulnerability in SSA. Schilling et al. (2020), writing on North Africa, notes that it is social unrest that is a contributor to increased vulnerability due to impacts of climate change there.

Olivier (2019) identifies yet another contributor, namely poor natural resources governance as the contributing factor to vulnerabilities in South Africa, while Khumalo (2021) identifies the high dependence on rain-fed farming among rural smallholder farmers as being highly associated with climate change vulnerability in Malawi.

Malawi, like most of the developing countries within the SSA region, is highly vulnerable to the impacts of climate change (Warnatzsch & Reay, 2019). Although the whole country is considered vulnerable to climate-related shocks, variations within the country have been noted. The Government of Malawi (GoM), therefore, demarcated the country into 5 key zones of vulnerability based on severity (Svesve, 2016). The zones in question were demarcated into very low; low; medium; high; and very high.

In Malawi, most of the vulnerable populations are in the rural areas of the Southern Region because of environmental and socio-economic factors that exacerbate their susceptibility to climate change-related shocks (GoM, 2018). Albeit homogenous designation of zonal vulnerability by the government, scholars, for example, Coulibaly et al (2015) pointed out gender differentiated vulnerabilities where women and female-headed households are more susceptible to climate change-related shocks than their male counterparts.

1.3 Resilience

The concept of resilience was primarily applied in mechanics in 1858 to refer to the capability of a material to resist a force (rigidity) as well as to absorb the force with deformation (Béné & Doyen, 2018; Alexander, 2013).

In this context, resilience was taken for the ability to resist destruction either by internal strength to hold together under stress or flexibility to contain stress and ability to revert to pre-stress state (Hirpo et al., 2018). In the 1950s, the concept was used in human psychology to explain situations where people continue to show competent functions and development despite some negative circumstances that, on average, predict worse outcomes (Alexander, 2013; Cutuli & Herbers, 2018).

The concept of resilience was further adopted in system ecology focusing on ecosystem dynamics around equilibrium as well as the capacity of an ecosystem, and relationships within it to persist and absorb stress to state variables, driving variables, and parameters (Holling, 1973; Folke, 2006). The conceptualization of resilience was broadened when it was extended to socio-ecological systems [SES] in the 1990s (Alexander, 2013). Integration of humans in the ecological studies extended the complications, considering that humans use ecosystems with varying goals, objectives and institutions to respond to shocks (Adger et al., 2005).

1.4 Climate change resilience

With regard to climate change, when the concept of resilience is studied under socio-ecological settings it assumes multiple epistemological entry points (Schipper et al., 2007). This is unlike the case when it is considered under natural environment. In the broadest sense, resilience is defined as the capacity or ability of the system (individual, or group) to anticipate, accommodate, cope, adapt, and/or transform when exposed to specific hazards (Satterthweite et al., 2020; Frankenberger et al., 2014; Walker et al., 2004).

Literature puts resilience into three capacities, namely the capacity to cope/absorb; the capacity to adapt; and the capacity to transform (Bene et al., 2012).

Asmamaw et al. (2019) refer to absorptive capacity as that ability to manage the consequences while adaptive capacity as the ability to adjust, moderate damage and take opportunities. As for transformative capacity, it is the ability to create a new system to make conditions attainable.

Most countries in Sub-Sahara Africa are considered to have low resilience due to their limited access to resources and knowledge regarding the capacity to cope, transform and adapt to the shocks before and after they occur (Asmamaw et al., 2019). Previously in 2017, Chirambo had reported that most of the rural households in Africa take longer to recuperate from climate change-related shocks due to low resource endowment. Two years prior, Banda (2007) had reported low or delayed recovery from climate change related impacts of poor households in rural communities in Malawi. As for the Government of Malawi itself, the declining levels of resilience of the most vulnerable population were due to erosion of critical resources for recovery because of increased frequency and intensity of climate change-related shocks in the country (GoM, 2018).

Various contextual factors have also been associated with low resilience in developing countries. For instance, Nyerere et al. (2021) argued that response and recovery mechanisms to develop resilience in developing countries are institutionally weak. Other studies have also shown that social inequalities and informal structures create barriers for accessing and using resources (Quandt, 2019).

In some instances, some researchers, for example, Forsyth (2018) have identified an array of socio-economic factors that affect resilience.

While there is existing evidence on resilience and its associated determinants, little has been researched on gender dynamics associated with climate change resilience for rural vulnerable households in Malawi.

1.5 Problem statement

In Malawi, climate change vulnerability assessments are done annually to establish food insecurity status in the country and recommend response mechanisms (GoM, 2018). Understanding such vulnerability has been a subject of a number of studied. Scholars such as Kakota et al. (2011) and Coulibaly et al. (2015) studied gender and vulnerability using once off data collection methods, and noted that female-headed households are relatively more vulnerable than are their male counterparts. Although these studies have been informative, their conceptual and methodological approaches, such as high dependence on once off data collection through household interviews, Focus Group Discussions (FGD) and Key Informant Interviews (KII), elude in-depth background information that could contribute to robust understanding of overall vulnerability. Furthermore, concentrating on food shortages only presents a narrow view of vulnerability context as opposed to the broader vulnerability context (Flynn et al., 2018). These issues are compounded by the fact that current vulnerability assessment methods lack data disaggregation, an oversight that ends up obscuring gender specific vulnerabilities.

Studies show that access to and ownership of livelihood assets contribute significantly towards climate change resilience at both the household level and the community level

(Mwasha, 2021). Such studies have been conducted across the globe, for example, in the Philippines (Uy et al., 2011), in Iran (Pour et al., 2018), and in Kenya (Quandt, 2019). However, the distribution of such livelihood assets across various categories of people might be due to socio-cultural and economic dynamics that affect the households and communities (Bapuji & Chrispal, 2020).

For the reason, studies have been conducted with the purpose to understand resilience and distribution of livelihood assets between male-headed households and female-headed households and how such assets contribute to recovery from the impacts of climate change. Following such studies, nations have devised strategies to facilitate distribution of assets to male-headed households and female-headed households to build resilience. A case in point is Malawi where the Government is implementing the National Resilience Strategy though there has not been clear evidence on how exactly such interventions can facilitate distribution of assets to male-headed households and female-headed households to build their resilience.

Although the distribution of livelihood assets is key to recovery from climate change-related shocks, institutions that govern access to and use of the assets equally play a significant role (Ablo & Asamoah, 2018). Evidence therefore shows that access, ownership and use of livelihood assets are determined by rules and regulations for a particular community (Negera et al., 2019). In Malawi, land as the main productive asset in rural areas is primarily regulated by rules and regulations that are derived from and sustained by traditional and cultural systems under customary tenure (Kishindo, 2014; Berge et al., 2014).

Despite the existence of information on institutions that regulate land under customary tenure, little is known about the evolutionary trajectories of these institutions and the extent to which they have influenced rights to land for male-headed households and female-headed households and they seek use of land to build climate change resilience in a matrilineal rural community. Currently there are calls to revise the land-related laws without adequate details on how the laws should be formulated to enable equitable building of climate change resilience between male-headed households and female-headed households.

The interaction between climate change adaptation and resilience is complex, however, the former is widely considered a sub-component of the latter (Dapilah et al., 2020). In this view, vulnerable populations choose different climate change adaptation strategies that suit their context (Dilling, 2015). Studies show that adaptation of livelihood activities minimizes the impacts of climate change and enables people to exploit opportunities that emerge from the changes (Kom et al., 2020; Kerr, 2018).

Adoption and use of climate change adaptation practices has been explored in many developing countries, Malawi inclusive (Ojo & Baiyegunhi, 2020; Abegunde et al., 2019; Makate et al., 2019). However, there is little information on how climate change adaptation practices/technologies are adopted among male-headed households and female-headed households in Malawi. Literature on other factors associated with how those practices/technologies can be adopted in Malawi is also scanty. Thus, though the Government of Malawi and other development partners and sectors are increasingly promoting various climate change adaptation strategies, all this is happening in a context

where clear evidence is lacking on the nature of technologies suitable and specific for, on the one hand, male-headed households, and on the other, female-headed households based on their priorities.

1.6 Justification

Using evidence from previous empirical studies and assessments on vulnerability, this study unravels information on the underlying factors that contribute to the various dimensions of climate change vulnerability. Besides, the study promises to aid understanding of situations of the food shortages that are detected by the Malawi Vulnerability Assessment Committee (MVAC) in the overall vulnerability maze. This information is crucial for planning and programming interventions towards reducing vulnerability to various shocks. In this way, the research findings will inform the efficient and effective design of interventions by targeting contextual bottlenecks that exacerbate vulnerability. In the end, this information will feed into discussions that will deepen understanding of the fundamental conditions that contribute to vulnerability and thus enrich debate on this topical issue.

This research shows how livelihood assets are distributed among male-headed and female-headed households. Further, it shows how these assets contribute towards the recovery of the two forms of household from the impacts of climate change. Consequently, in the midst of a heated debate on climate change resilience, the findings from this research will give new insights of the gender dynamics behind resilience to the impacts of climate change in rural households of developing countries. At the policy level, the research findings will contribute towards much-needed gender disaggregated data and analysis for climate

change resilience. In this case, the findings will also inform the incorporation of gender in programming and implementation of interventions towards climate change resilience.

Debate on the roles of institutions and how they affect long-term investments in land has persisted over time (Wily, 2011). As an extension to this debate, findings from this study will provide a robust base-stand to studies in future on the evolution of land-related institutions under customary tenure and how the development has affected male-headed and female-headed households in building climate change resilience. At the policy level, findings from this study will help decision makers identify and address institutional gaps on customary land to enable building climate change resilience.

This study unveils climate change adaptation practices/technologies in the matrilineal community of Phalombe District. Specifically, it targets the adaptations and factors associated with adoption by male-headed households and female-headed households in this matrilineal community.

1.7 Objectives

1.7.1 Main Objective

The main objective of the study was to analyze climate change vulnerability and resilience through gender lens in the matrilineal rural households of Phalombe District.

1.7.2 Specific Objectives

1. To investigate underlying factors that contribute towards climate change vulnerability;

2. To analyze contribution of livelihood assets in building climate change resilience for male-headed households and female-headed households;
3. To investigate the historical evolution of formal and informal land-related institutions towards building climate change resilience; and
4. To analyze factors associated with the choice of climate change adaptation strategies for male-headed households and female-headed households.

1.8 Outline of the chapters

Chapter 1: Introduction and Background

The first chapter has located climate change as a subject of heated debate from the global level, narrowing it down to its impacts on developing countries such as Malawi. As a way of background, the chapter has therefore articulated the concept of climate change vulnerability and factors that contributes to such vulnerability. Afterwards, the discussion on vulnerability narrowed down to the country of study, namely Malawi, taking into account the various degrees of vulnerability therein. Also introduced is the concept of climate change resilience, and pertinent scholarly debate around it. Towards the end of the chapter is proffered the rationale of the study which has highlighted the problems that led to the research and how its findings will add breadth and width to the academic debate, thereby informing general policy. The chapter has also presented the main and specific objectives of the study. At the very end is the outline of the study.

Chapter 2: Literature review

This chapter presents findings from the previous studies on the impacts of climate change.

It reviews and analyses literature on the impacts on all nations before zeroing in on Malawi proper to inform on experiences in the developing nations. The chapter also discusses previous findings on climate change vulnerability, and factors that exacerbate vulnerability. Literature has also been analyzed on the role and contribution of livelihood assets to resilience. This discussion has dwelt on how the five categories of livelihood assets are used to minimize the impacts of climate change. Another section has considered issues specific to land-related institutions in Malawi. In this, how both formal and informal institutions in the country have evolved from pre-colonial period to present has been discussed at length. The penultimate section delves into previous studies focusing on various climate change adaptation practices and technologies and even factors associated with choice of the practices/technologies. The chapter concludes by unveiling the conceptual and theoretical frameworks the study has adopted as its scaffolding. The conceptual framework explains the analytical model of how the concepts of vulnerability, institutional change, use of livelihood assets and choice of adaptation practices/technologies are done. On the other hand, the theoretical framework explain the cultural ecology theory and how it applies to the research study at hand.

Chapter 3: Methodology

This chapter presents the methodological approach used in this study. The chapter starts by introducing that study area – Phalombe District and its geographical and socio-economic attributes. The chapter then details the methodological approach of the study. The study justifies its choice of the qualitative and the quantitative methods used to collect data.

The chapter also explains data analysis for both qualitative and quantitative data that were collected during the study. The chapter concludes by presenting the ethical considerations and challenges encountered during data collection.

Chapter 4: Results - Climate change vulnerability context of the study area

This chapter presents finding from the analysis of qualitative data on underlying factors that contribute towards climate change vulnerability. The chapter starts by presenting major root causes of vulnerability, namely cultural customs on access to land and gender-related traditions. It then provides related root causes of vulnerability, namely soil type in the study area and moisture availability in the wetland during dry season. Also explored are the dynamic pressure factors which have included food preference by the majority of the people in the study area and nature of financial services that provide loans to survive leans season. Also doled out are the unsafe condition that exacerbates vulnerability and have included geographical location of the study area and vulnerable livelihood activities that most people depend on. Key climate change hazards identified in the study area have included floods, stormy rainfall, pest infestation and erratic rainfall.

Chapter 5: Results - Role of livelihood assets in climate change resilience

This chapter presents finding on how livelihood assets are distributed between male-headed households and female-headed households. The chapter also presents analysis that shows that there is no significant difference in the period of recovery from erratic rainfall between male-headed households and female-headed households but that male-headed households

recover more quickly from floods than do female-headed households. The chapter also presents analysis on contribution of livelihood assets between male-headed households and female-headed households. In general, results show that human and social assets are critical to recovery from erratic rainfall and floods for female-headed households while natural social and financial assets are critical for male-headed households. Further, social, human and physical assets are critical for recovery from floods for male-headed households.

Chapter 6: Results - Role of land related institutions on climate change resilience

This chapter starts by presenting a historical background of the formal and informal land-related institutions in Malawi. The chapter then presents an analysis of the current land-related institutions in the study area. In summary, the study area has three informal institutional regimes. The first and oldest in grounded on the matrilineal traditions where land is inherited through females, and male spouses have user rights but not ownership. The second regimes is usufructuary and dynamic ownership of land in the permanent wetland. Land is owned by individual households but not controlled by the clans. Ownership change at the discretion of the chief under unique circumstances. The third regime is permanent ownership of land under informal land registration. The third regime presents a more secure tenure and thus an opportunity to make more stable and long-term investments to build climate change resilience.

Chapter 7: Results – Climate change adaptation pathways

This chapter presents analysis of choice of climate change adaptation practices and technologies.

In summary, the results show a general shifting from late to early maturing maize and rice varieties for both male-headed households and female-headed households. The chapter presents a range of factors that influence adoption of early maturing varieties. The chapter also shows a range of moisture conservation practices used for rain-fed and small-scale irrigation in the wetland. In general, adoption of the climate change adaptation practices is influenced by a range of factors but gender of the household head highly influences choice of the technologies and practices owing to the household food security goals by the head. Female-headed households are inclined towards higher food production to ensure food security while male heads are inclined towards multiple goals such as income generation in addition to food security.

Chapter 8: Conclusion, Recommendations and Originality

The chapter draws the study to a close by discussing the major findings and arguments of the thesis in terms of vulnerability, role of land-related institutions on resilience, livelihood assets distribution and adaptation. The chapter articulates how cultural factors are pivotal in determining extent of vulnerability for male-headed households and female-headed households. The chapter also discusses how informal and related institutions have evolved over time and aligned towards commoditization of land to achieve individual ownership of land. This evolutionary trajectory has enabled some households to have more secure tenure that can lead to climate change resilience. The chapter has also discussed skewed assets distribution between male-headed households and female-headed households and its impacts on building climate change resilience. In the course, the chapter has demonstrated that gender of the household head is pivotal in deciding adaptation practices because of the

roles and aspirations of the heads. The key originality claim is the empirical contribution this thesis makes to the scholarship on gender and climate change resilience in the context of matrilineal culture in Malawi. The study recommends analysis of resilience through gender lens to identify nuances that can guide designing of interventions to enhance resilience of both male-headed households and female-headed households according to their specific needs and aspirations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The amount of research that has been conducted on climate change so far has been truly voluminous. Studies across the world have investigated impacts of climate change and how people and communities are developing resilience. This chapter presents a review of previous research findings on vulnerability to the impacts of climate change impacts; contribution of livelihood assets for recovery from the impacts of climate change; and the role of formal and informal institutions on access, control and use of land to build resilience. In the course, the review will analyze aspects surrounding the adoption and use of climate change adaptation practices/technologies among vulnerable farming dependent households. The very end of the chapter is the preserve of the conceptual and theoretical frameworks for the research study.

2.2 Impacts of climate change

Climate change has had a range of impacts on human population across an array of geographical and socio-economic strata in the world.

Such research has, however, shown that the impacts of climate change are severe in most developing countries owing to their pre-existing conditions such as poverty, underdevelopment, unequal distribution of resources and low technological development (Kasperson & Kasperson, 2022). High impacts of climate change are associated with populations that are distant from economic activities and social amenities. For instance, high destitution has been reported in rural areas of developing countries that constitute about 60 to 85% of their populations (Evans et al., 2020; Juran et al., 2018). In most such rural populations in the developing countries, limited livelihood sources has been marked as a key vulnerability factor. For instance, scholars like Sujakhu et al. (2019), Schilling et al. (2020), Osumanu (2020), Ndalilo et al. (2020) and Balde et al. (2020) have reported that the main livelihood activity in the rural areas of developing countries is the stallholder rain-fed farming. Other studies, however, have shown that communities along wetlands and coastal areas engage in low cost irrigation and fishing (Haile et al., 2021; Gowing et al., 2020; Uduji & Okolo-Obasi, 2020; Feleke et al., 2019). All these livelihood activities are increasingly being thwarted by the increasing frequency and intensity of climate-related shocks, especially erratic rainfall, drought, floods and pests infestations (Chitongo, 2019; Mulungu & Ng'ombe, 2019). The aforementioned studies have ably articulated susceptibility of rural populations in developing countries though little has been highlighted on how similar climate change-related shocks impact male-headed households and female-headed households within the same locality.

Negative impacts of climate change in Malawi have been reported by scholars such as Šakić Trogrlić et al. (2019), Chawawa (2018) and lately McCarthy et al. (2021).

Impacts of climate change are evident by struggling households and the dwindling of the economy at national level. For instance, the country experienced food insecurity and decline in economic output during 2001/02, 2011/12 and 2015/16 seasons primarily due to either prolonged dry spells or floods (Nyondo et al., 2021; Lautze et al., 2019). At the household level, Coulibaly et al (2015) reported that female-headed households are disproportionately affected by the impacts of climate change. Despite highlighting the gender difference in terms of impacts at the household level, little has been explored on underlying conditions that lead to the varying outcome after experiencing similar shocks.

2.3 Underlying conditions that contribute to climate change vulnerability

Climate change vulnerability has been conceptualized differently in literature. For instance, IPCC (2014) conceptualizes climate change vulnerability as including susceptibility or exposure, internal and external pre-existing conditions that minimize or exacerbate the impact, and the ability to adjust, and continue to exist after the shock. Other authors such as Twigg (2001) categorize climate change vulnerability as an interplay of physical, social and motivational factors, while Awal (2015) considers climate change vulnerability as a matrix of underlying factors that ultimately influence system's state after exposure to climate hazard. Considering the first specific objective of this thesis, literature review of this section aligns with the conceptualization by Twigg (2001). This subsection therefore will explore literature on how physical or geographical, edaphic, social and institutional factors create underlying conditions that contribute towards climate change vulnerability.

One of the fundamental factors that influence vulnerability is the physical or geographical location of an area.

Motivated by this understanding, Preston et al (2011) noted that mapping climate change vulnerability enables the representation of the local context through the spatial rendering of geographically heterogeneous determinants of vulnerability and their interactions. Bukvic et al. (2020) also acknowledges the necessity of understanding vulnerability in the context of the geography of the study area. It was for this very reason that Bevacqua et al. (2018) identified high vulnerability of coastal communities to hazards such as coastal storms and erosion while Pantusa et al (2018) projected that future storms along coastal areas and floods were expected to become more intense. Although studies acknowledge role of geography towards vulnerability to climate shocks, literature is devoid of how the same affects male-headed households and female-headed households in the same location similarly or differently.

Aridity is another contributor to climate change vulnerability in dry lands. Kuvare et al (2008), Jha and Srivastava (2018), Sissoko et al. (2011) and Wiederkehr et al (2018) have indicated that incidents of erratic rainfall are more severe in dry lands due to their pre-existing environmental limitations. Similarly, Spear et al (2018) have noted that semi-arid areas are vulnerable to seasonal and highly variable rainfall. Not long ago, a study in Ghana by Asamoah and Ansah-Mensah (2020) also reported severe devastation due to flooding in arid and semi-arid environments unlike in the forest and savannah ecosystems through which the same river passes. In the same year Asamoah and Ansah-Mensah conducted their study, Njogu (2020) also reported that flooding on Kavuma river in Kutui county caused relatively more severe destruction in the semi-arid environment compared to fully developed ecosystems.

In this way, literature reveals that aridity exacerbates vulnerability to climate shocks because of its delicate nature. However, literature on how arid conditions contribute towards climate vulnerability in Malawi has been scanty.

Edaphic factors have also been acknowledge as contributing factors towards climate change vulnerability. For example, Alam et al (2018) in Bangladesh identified poor soil conditions as a precursor for high incidents of food insecurity caused by impacts of climate change. Aslam et al (2018) also noted that type of soil does determine sensitivity to the impacts of climate change that affect moisture availability for crop growth in the soil. Furthermore, Schilling et al. (2012) reported that poor quality soils are more likely going to exacerbate impacts of climate change as crop production on such soils will yield less outputs compared to good quality soils. Studies have showed that edaphic factors are critical to climate change vulnerability across many countries and most likely the same applies in Malawi. Albeit these findings, it is not known whether both male-headed households and female-headed households perceive soil conditions as an underlying factor that contributes towards climate change vulnerability.

Studies have shown that apart from physical attributes, social factors also determine climate change vulnerability. For instance, Innes et al. (2021) noted that vulnerability to the impacts of climate change also arises from inherent social interactions, institutions and systems of cultural values of a community. These factors can contribute to vulnerability independently or concurrently. Factors like social inequalities influence or shape the susceptibility of various groups to climate hazards (Cutter et al., 2003; Kuchimanchi et al., 2019).

Previous studies have shown that both household and community socio-cultural rules of exchange between individuals and their community at large contribute towards degree of vulnerability (Dilshad et al., 2019).

The socially determined roles that influence duties, responsibilities and access to resources between males and females in a society are also said to influence extent of vulnerability. The socio-cultural and gender norms, gender division of labor and differing levels of access to productive resources, not only make women more vulnerable but also affect women's ability to respond and adapt to the impacts of climate change (Alston, 2013). There are varying gender specific informal institutions that determine access and ownership of productive resources. For instance, Berge et al (2014) reported that two systems of inheritance in Malawi are rooted in the matrilineal and patrilineal traditions. Females inherit land with limited control over it under matrilineal traditions while males inherit land with limited control under patrilineal traditions.

Gender roles have also been acknowledged to impact opportunities to pursue livelihood activities. In most developing countries, females are socially limited to opportunities outside homes because of gender roles (Jerneck, 2018). For example, women have responsibilities such as caring for children and the household chores which affect their ability to timely escape shocks like floods (Ampaire et al., 2020). Rao (2019) reported that female-headed households struggle more with the same impacts of climate change that affect male-headed households because of women's inability to mobilize resources through alternative livelihood activities.

Traditional systems of inheritance in rural African communities are still strong and prominent. Access to key productive resources like land in most rural communities in Africa is still under customary tenure (Chimhowu, 2019). Perhaps this is the reason Balehey et al (2018) assert that inheritance of household assets in most rural communities still follow prevalent cultural traditions. Informal traditional rules of resource ownership and allocation marginalizes the underprivileged and socially underrepresented groups who may be in need of more resources to reduce their vulnerability. Lovell (2021) observes that control of land in rural Malawi creates imbalances that increase vulnerability of marginalized groups such as minority tribes and women, even in matrilineal communities where land is presumably controlled by them. Similarly, a study by Kambewa (2005) in Phalombe showed that the chief demanded honoraria for allocating land that created a barrier for impoverished households to acquire some.

Traditions around food and food beliefs have also been recognized as sources of social vulnerability in rural communities of developing countries. Food preferences and prioritization have evolved through cultures and traditions over history (Schösler & de Boer, 2018). Communities have preconceived opinions and perceptions towards food. For instance, Rusike et al (2010) reported that maize meal is preferred over other staples such that the availability of maize is synonymous with food security and vice versa in Malawi. Municipality (2021) also reported a similar phenomenon in Ghana where maize meal is preferred to other staples. Literature shows that although maize production is increasingly becoming difficult due to the impacts of climate change in Malawi, insistence on it as a staple food has led to artificial food insecurity albeit presence of alternatives (Rusike et al., 2010).

Informal financial institutions have also been studied and recognized for their role in reducing or accelerating poverty and vulnerability of developing countries. Informal savings and credit are community-based financial arrangements found throughout the developing world (Eeckhout & Munshi, 2010). Studies have shown that informal financial institutions have contributed towards reducing poverty and vulnerability (Yusuf et al., 2021). However, other studies have also shown that informal money-lending mechanisms have led to exploitation of borrowers and even deeper vulnerability. Most often, dependence on informal credits has made the borrowers even more vulnerable under conditions of high interest rates and repeated crop failures due to climate change and the resultant debt accumulation (Kuchimanchi et al., 2019).

In summary a study by Grothmann et al. (2017) investigated climate change vulnerability in rural areas of Mkomazi Water Basin in Tanzania and the Keiskamma River Catchment in South Africa using the Socio-Ecological Systems Framework to study explanatory factors for the variation in vulnerability. The study found that an aggregate of ecological factors including water availability and soil depletion and social determinants including conflicts, strength of institutions and leadership as well as knowledge, influenced climate change vulnerability. It was noted that Climate change-related factors play a role with regard to rainfall frequency and quantities. The study recommended the need for explicit and clear institutional structures, legitimized leadership and good knowledge about land use options and their consequences to manage climate change vulnerability.

2.4 Role of livelihood assets in climate change resilience

Livelihood assets play a significant role in enabling households manage climate change related. Scholars like Awazi and Quandt (2021) and Zeleke et al., (2021) write that assets help households to withstand shocks either through strengthening their ability to withstand shocks or increasing the breadth of the assets base for recovery. Regardless of either the preventive (strengthening resistance to breaking down under a shock) or recovery (flexibility to re-allocate resources after a shock) roles of assets, households use the assets to sustain their wellbeing during and after shocks (Aniah et al., 2019; Jacobson et al., 2019). The literature review in this sub-section will follow the categorization based on the Sustainable Livelihood Framework (SLF). This approach has previously been used by other scholars such as Uy et al. (2011), Pour et al. (2018), and Quandt (2019).

Financial assets have been considered key and a form of flexible assets in recovering from climate change-related shocks. The composition of financial assets varies across different studies. For instance, Asmamaw et al. (2019) included sources of income and access to credit in the financial asset component while Panman et al. (2021) included household savings and membership in savings groups as a contributor to the financial asset base for resilience. Pour et al. (2018) included income from regular sources as a contributor to financial assets. Albeit variation in individual variables that comprise financial assets, Pacoma and Delda (2019) praised their convertibility to other assets or food in times of crisis. Previous studies have shown that male-headed households have higher assets and often use them to recover from shocks (Paxton, 2009; Caranza & Niles, 2019; Naz & Saqib, 2021).

Having higher financial assets does not guarantee more resilience to climate change-related shocks as expenditure patterns even in such crisis may differ between male and female households heads.

The human assets are the most readily available resources that comprise the number of available and productive people in a given household. Human assets play a vital role in sustaining livelihoods (Elasha et al., 2005). On this, Soltani et al. (2014) note that quality of human assets in terms of education is vital for enhancing climate change resilience. Previously, Ellis (2000) had established that the number of productive members of the household contributes towards resilience. Apart from the number and quality of human assets other studies have identified health as an equally important factor. For example, Arora and Rada (2020) note that the sickness of household members negatively affects human assets through the declining number of working members or withdrawal of working members to attend to the sick. In general, the survival and continuity of the household during and after climate change-related shocks depend on the status of human assets qualitatively or quantitatively. Rola-Rubzen et al (2020) report that generally, female-headed households have lower human assets compared to their male counterparts.

Physical assets comprise household possessions that usually store value. Physical assets play a vital role in abating the impact of shocks (Hedner et al., 2011). The composition of physical assets varies across studies. In general, key assets under this category include physical structures such as houses, household valuables and livestock (Pour et al., 2018). Households accumulate assets as a means to build an asset base that can be converted to other forms such as financial resources to recover from a livelihood shock (Sultana et al.,

2020). Other studies have also shown that physical assets like permanent dwelling units are owned to withstand impact of shocks such as floods (Chacowry et al., 2018; Fatemi et al., 2020). A study by Neway and Zegeye (2022) in Ethiopia, and Bulawayo et al (2019) in Zambia showed that female-headed households generally have lower physical assets. Albeit the aforementioned studies in Ethiopia and Zambia, endowment of physical assets in rural areas of developing countries varies between male-headed households and female-headed households owing to differing cultural and inheritance traditions.

Dependence on social relations in rural communities has equally been documented as a social safety net in times of crisis. Scholars like Aldrichi et al. (2018), Chowdhury et al. (2019) and Craig et al. (2023) have reported that social capital forms a vital resource base for managing climate change-related shocks and food security. Households may depend on bonding social assets comprising close relations, for assistance, in times of shocks (Carmen et al., 2022; Claridge, 2018). Bridging social assets which consist of friends and acquaintances are also vital for managing livelihood shock although they are weak ties and often loosely connected, thus less dependable (Wilkin et al., 2019). Higher level networks (linking social assets) between households and political, administrative and leadership structures have also been reported to play crucial roles in developing and sustaining livelihood resilience to the impacts of climate change (MacGillivray, 2018). Caetano et al (2013) reported that in general, women tend to have more close relationships than men, although men usually have larger social networks. Nature and strength of relationships within social capital matrix in rural areas vary due to cultural differences.

Several studies have reported dependence on natural assets for survival and for recovery from climate-induced shocks in developing countries. Scholars like Asfaw et al. (2019), Baffoe and Matsuda (2018), Feurer et al. (2018) and Aye et al. (2019) have reported high dependence on natural resources by rural communities as a crisis recovery strategy. Gathering forest products such as firewood and fruits for sale or food to survive periods of food and income scarcity has also been reported by Ali (2018), Leßmeister et al., (2018) and Nerfa et al., (2020). Studies further show that some communities utilize wetland resources such as residual moisture to practice small-scale irrigation during the dry season to abate food shortages arising from rain-fed production (Mukaratirwa et al., 2018). Communities around water bodies such as lakes and rivers also engage in artisanal fishing as a source of food and income to cushion food shortages created by impacts of climate change (Freduah et al., 2019; Green at al., 2021). Dependence on natural resources may vary across regions and communities due to different factors. For instance, Clement et al (2019) reported that gender and other socio-cultural systems determine access to natural resources such as water and land.

Using the Household Livelihood Resilience Approach (HLRA), Awazi et al. (2023) explored how livelihood systems contribute to climate change resilience. Using a sample of 350 households, the study assessed the levels of resilience of farmers to climate change, and the extent to which farmers' livelihood assets (natural, physical, human, social, financial) affect resilience. Findings showed that, farmers' levels of resilience varied with respect to different livelihood assets, with farmers currently relying on natural, financial, and social assets.

The multiple linear regression model showed that, the most important assets affecting farmers' livelihood resilience were ownership of farm equipment and use of local irrigation systems (physical capital), as well as indigenous knowledge (human capital). The study therefore recommended that policy focus should be directed towards human and physical assets as well as strengthening financial, natural, and social assets in order to improve the resilience of farmers in the Western Highlands of Cameroon.

Availability and accessibility of various livelihood assets therefore become key to household level decisions to survive in times of climate change-related shocks. Considering that intensity of climate change-related shocks is increasing, re-allocation or utilization of livelihood assets is becoming a more regular subject under climate change resilience studies. However, little is known on how these assets are distributed between male-headed households and female-headed households as well as how these assets are being used to recover from climate change-induced shocks in Malawi.

2.5 Institutions and institutional changes on land

Control and use of land is key to most rural households of developing countries because of their high dependence on smallholder farming. Farming is central to most rural communities; as such, access to land is vital to sustenance of rural households in developing countries (Snyder et al., 2020). Most of the rights to land in rural communities are allocated informally/customarily albeit existence of formal institutions on the same. Customary tenure dominates land rights in most rural communities of Sub-Saharan Africa

(Chimhowu, 2019). Therefore, institutions on customary land are pertinent to livelihood sustainability as well as resilience to the impacts of climate change.

This section reviews literature on the formal and informal land-related institutions. The purpose is to understand what scholars have explored on how the laws (formal and informal) have evolved over time. The review will further investigate whether the current laws may impact (positively and or negatively) the use of land to build climate change resilience for male-headed households and female-headed households.

2.5.1 Historical evolution of formal institutions on customary land

Formal land institutions constitute laws and policies by the governments to regularize land access and use within its jurisdiction. There are three major rights of access to land, which are governed by land tenure — the right to use, the right to control, and the right to transfer (Chimhowu, 2019). The governing institution (or tenure) for land access entails the manner in which the rights, restrictions, and responsibilities that people have on the land are exercised (Chigbu et al., 2019). There is a vital link between access to land and productive resources to food security, sustainable resource management, peace and security, and consequently the reduction of poverty (International Land Coalition, 2014). This section explores literature on the history of customary land tenure and their evolutionary trajectories to present time as well as their implications on land ownership and use to build climate change resilience.

African countries in general and sub-Saharan Africa in particular inherited most of the land tenure and governance structures from colonial governments.

Studies by Kironde (2000), NJOH (2004) and Kalabamu (2019) reveal the prominence of colonial traits in land laws of African countries. Studies however show that regardless of the laws being crafted to suit colonial interests, traditional land management and inheritance systems have remained unaltered in most countries. In Malawi, the colonial government considered customary land a subset of public land (Mbalanje, 1982; Pachai, 1973). Despite government assuming overall ownership of the land, community level customs on land were left intact. Customary land laws were therefore formally recognized by colonial governments that considered land a resource that belongs to the government but used by community members at a given time subject to the fulfilment of local access and use conditions (Kishindo, 2014).

Most African countries which were under the colonial rule revised their land-related laws and policies after independence. Despite this, evidence shows that some of the countries retained basic elements of the colonial laws (Pachai, 1973; Pwiti & Ndoro, 1999). In Malawi, the post-independence land-related laws sought to fundamentally change the customary land laws by introducing land registration. The government enacted the two land-related laws namely the Registered Land Act 1965 and the Customary Land Development Act 1967 (GoM, 2002). The two laws recognized the shortcoming of the customary tenure thus were intended to encourage land registration under customary tenure system. Implementation of these laws however was unsuccessful and thus the initial tenure arrangements under tribal customary tenure traditions persisted (Ng'ong'ola, 1982).

Until the advent of multiparty in 1994, there had not been government efforts to revise and change the customary tenure laws in Malawi.

In 1999 efforts to revise the land laws started with the drafting of National Land Policy. This came from the backdrop of notable incidents of sale of land under customary tenure. Recognizing the rise in informal land trading, the government revived the drive to promote the registration of customary land through the National Land policy of 2002 and the Customary Land Act of 2016 (GoM, 2002; GoM, 2016). Apart from curbing unregulated sale of customary land, global financial institutions such as the World Bank were also promoting customary land registration as a way of improving its productivity (Chimhowu, 2019). Albeit the premise that land rights registration improve its productivity, a study by Byamugisha (2013) found that in societies where the traditional rules and norms are stable, productivity can equally be enhanced under customary tenure. So far, there have not been a study to demonstrate whether the current land laws are being implemented and whether their implementation is impacting livelihoods in terms of building climate change resilience.

2.5.2 Historical evolution of informal institutions on customary land

Different tribes migrated in the country before and after colonization. The pre-colonial era in Malawi was characterized by tribe specific traditional or customary systems of land ownership and inheritance (Pachai, 1973). Each native land administration arrangement was particular to cultural traditions of the settling tribal groups. A matrilineal system of inheritance dominated the central and southern region while patrilineality was common in the northern region (Langworthy, 1970). Ngwira, (2005) reported that in the Northern Region, tribal leaders distributed the land to male clan members and land was eventually inherited by their sons while Peters (2010) observed that under matrilineal system, traditional leaders (chiefs) distributed land to clan leaders, often males (uncles –

Mwinimbumba) who distributed the land to their sisters, and land was consequently inherited by the daughters. These customary land tenure systems persisted for many decades in most rural communities of the country.

The integration of traditional communities into global economic systems has led to transformation of customary land institutions in many developing countries (Boone, 2017). The institutional transformations have been a response to demand for more secure or private land even under customary tenure. For instance, studies by Kambewa in 2006 and Kishindo in 2014 noted that traditional land inheritance and acquisition patterns were changing in order to allow the trading of land rights. Similar incidents have been reported in Zambia by Chitonge et al. (2017), in Mozambique by Burr (2004) and in Zimbabwe by Chimhowu and Woodhouse (2010). Evidence therefore shows that despite the persistence of the informal (customary) institutions over the years, the traditions are being revised informally to permit the transactions of land rights. Revision of informal land laws by traditional leaders have created informal private ownership which is more secure tenure, however, it is not known if the same is contributing to reduced vulnerability and higher resilience to the impacts of climate change.

2.6 Climate change adaptation practices

Technologies and practices to enhance food production, processing and utilization have been proposed, promoted and adopted in various regions based on their respective vulnerabilities (Aggarwal et al., 2018). Key adaptation practices have included the alteration of livelihood activities, the adoption of high yields and resilient crop varieties to water stress, the modification of agronomic practices, and the utilization of food to abate

the severe impacts of climate change (Connolly-Boutin & Smit, 2016; Vikram et al., 2015). Modification of agronomic practices includes climate smart agricultural practices/technologies, soil fertility enhancement, improved crop spacing, and change in timing of planting to align the crop cultivation period to the changed rainfall patterns (Tripathi & Mishra, 2017). These technologies and practices have been promoted depending on climate change-related shocks that affect specific region.

Water/moisture stress during rain-fed crop production season is one key result of climate change-related hazards. Moisture stress is enabled by late onset and early cessation of rains which shortens crop production season (Wainwright et al., 2019). A notable strategy to the shortening of crop production season for rain-fed dependent farmers has been cultivating early maturing varieties (Enright et al., 2015). Apart from the early maturing trait being desirable for climate change adaptation, other traits such as storability, poundability and productivity levels per unit area have also been sought by farmers (Hoogendoorn et al., 2018). Evidence therefore suggests that farmers seek a range of characteristics in crop varieties to holistically address food insecurity created by the impacts of climate change.

Incidents of prolonged dry spells have also been reported as impacts of climate change. Crop breeders have responded to this challenge by producing varieties that are tolerant to moisture stress. Despite lower preference of drought resistant maize among farmers in Zimbabwe, the study established that farmers that adopted drought tolerant varieties experienced higher output compared to farmer that did not (Lunduka 2019 et al., 2017). A range of other attributes such as higher output and storability drives preference and ultimate choice of varieties (Waldman et al., 2017; Ekpa et al., 2018; Kehinde et al., 2021).

A study by Holden and Mangisoni (2013) reported that during the 2011/12 drought in Malawi there was a reduction in maize yields of 400 kg/ha.

However, most commonly used hybrid maize varieties performed significantly better with yields about 600 kg/ha higher than local maize. Besides a range of factors that might have contributed to the better yields for hybrid varieties, moisture stress tolerance in those varieties minimized the severity of prolonged dry spells. Olson et al (2014) also reported that hybrid rice has exhibited resilience under low moisture levels in Malawi. Adoption and use of moisture stress tolerant hybrid varieties therefore lessened severity of the impacts of climate change.

In summary, the impacts of climate change have added to food production challenges that have led to food insecurity for most smallholder farming-dependent communities and countries (Thornton et al., 2018). Climate change adaptation strategies such as early maturing varieties, stress tolerance and high yielding varieties are therefore being promoted to sustain and increase production regardless of the emerging challenges to production. Considering that the pressures are different and dynamic, the breeding of suitable varieties has therefore been evolving to compound all the preferable traits.

2.6.1 Factors associated with adoption of climate sensitive seed varieties

Although climate change adaptation technologies and practices have been promoted, scaled adoption thereof has varied due to a range of factors. Acevedo et al (2020) reported that the availability and effectiveness of extension services and outreach, the education levels of household heads, farmers' access to inputs, and the socio-economic status of farming

families were positively associated with adoption of climate-resilient crops. The study further found that male-headed households and married household heads adopted new varieties as climate change-adaptation strategies.

Manda et al (2018) in Zambia found that the education level of the household head, available household labor, and livestock ownership positively influenced adoption of improved maize varieties while gender (female-headed households), dependency ratio and access to credit negatively affected adoption. In Ghana, Sadiq et al (2019) noted that farming experience and rainfall perception positively influenced the adoption of improved varieties.

A study by Devkota et al (2018) in Nepal found a negative relationship between large farmland, access to subsidies, high dependence on farming, fertility in rice fields, and adoption of improved rice varieties. However, membership to farmer organizations and knowledge of climate change increased the likelihood of adopting improved rice varieties. A study by Donkoh et al (2019) in Ghana found that the extension service, education, household size, farming experience, farm size, gender, and age of the farmer play significant roles in adoption of improved rice varieties. Donkoh et al (2019) specifically noted that among the institutional factors, membership in farmer-based organizations, training, and access to credit significantly particularly influenced the adoption of improved rice varieties. On the same, Paltasingh and Goyari (2018) found that the education of the household head influences the adoption of improved rice varieties.

A study in 4 provinces of South Africa analysed factors that influence the adoption of climate change adaptation strategies among smallholder farmers.

The empirical results of the multivariate probit model showed that location, access to extension, non-farm income, farming experience, crop and livestock production, susceptibility, agricultural training and access to credit variables influenced the smallholder decision to adopt climate change adaptation strategies. The endogenous switching regression model showed that location, age, marital status, gender among others, influenced adoption of climate change adaptation strategies. The study recommended that stakeholders and government must cooperate and collaborate to improve the conditions under which farmers can gain access to climate change information and suitable agricultural credit (Ojo et al., 2021).

2.6.2 Alteration of crop production practices

Kom et al. (2020) observed that most of the farmers depend on their experience to determine the actual onset of rains. This experience however has led to crop losses because such knowledge is continually being challenged by the erratic and unpredictable rainfall patterns. Change in planting dates has therefore been considered to be one of the adaptation practices for smallholder farmers. For instance, Daccache et al (2015) reported that smallholder farmers altered planting dates for rice in order to adapt to the impacts of climate change. Similar observations were made by Acharjee et al (2019) in Bangladesh. The study by Eshetu et al. (2021) recommended that farmers must follow meteorological forecasts instead of arbitrary estimations on the planting dates.

Pit planting is another adaptation that has been promoted to enable crop production to withstand the impacts of climate change, such as dry spells and erratic rainfall (Partey et al., 2018).

Pit planting ensures moisture conservation especially during prolonged dry spells. A study in Zimbabwe showed that pit planting has the potential to avert moisture stress compared to traditional planting methods (Kugedera et al., 2020). A study by Nyirenda and Balaka (2021) in Malawi reported that maize under pit planting performed better and recorded higher yields compared to traditional planting methods. The same was reported in Tanzania and further acknowledged significantly higher yields compared to traditional planting after experiencing water stress (Gamba et al., 2020).

Plant spacing determines extent of evapotranspiration and moisture retention in the soil and overall yields in a given area. Changing plant spacing and ridge spacing has also been recognized as a moisture loss reduction strategy and increasing yield per unit area (Ngwira et al., 2014; Toungos, 2021). Recommended ridge and crop spacing minimizes rates of moisture loss during periods of dry spells and erratic rainfall. Recommended plant and ridge spacing is an efficient land utilization strategy considering declining land sizes, due to among other factors land degradation and population increase (Gebreselassie, 2006). A study by Muhammed et al (2019) in Nigeria showed significantly higher average yields per hectare for farmers who adopted recommended ridge and crop spacing.

2.7 Conceptual framework

The study has four specific objectives that are focusing on four different but linked concepts to the overall picture of climate change resilience. The first objective focuses on climate change vulnerability, thus the adoption of pressure and release [PAR] (Blaikie et al., 1994) model to explain the root causes, dynamic pressures and unsafe conditions that

necessitate vulnerability. The second objective focuses on roles of formal and informal institutions in determining access to land, thus the Historical Comparative Institutional Analysis (HCIA) (Greif, 1998) was used to explain their impact on access to land as well as vulnerability and resilience. The third objective seeks to unveil distribution and the roles of livelihood assets in recovering from climate shocks, thus capital based framework for assessing disaster resilience by (Mayunga, 2007) was used and the household's adaptation strategy framework by Aryal et al. (2020) was used to guide analysis of climate change adaptation choices by male-headed and female-headed households. Figure 2.1 below presents the conceptualized model for the study.

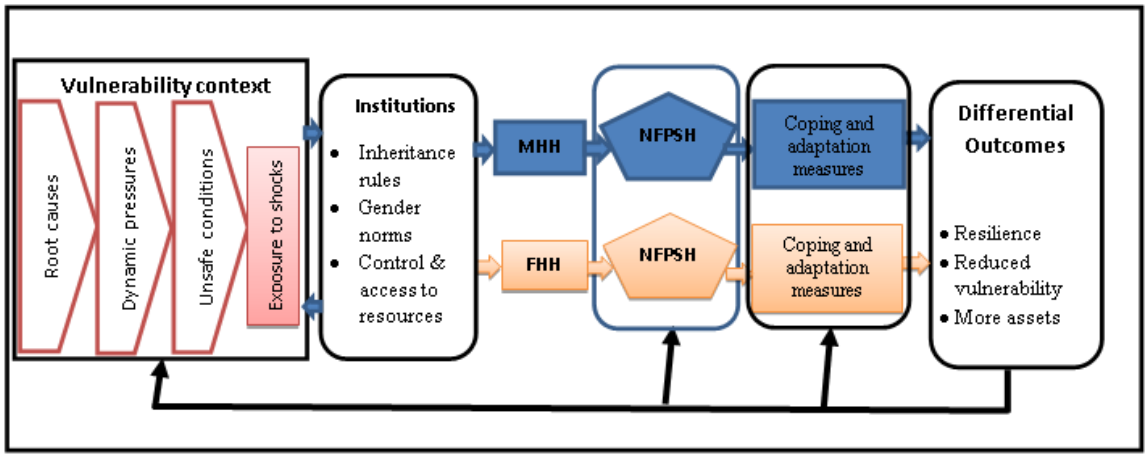

Figure 2. 1 Conceptual framework for the study. Merged the PAR (Blaikie et al., 1994); capital based approach framework (Mayunga, 2007) and Aryal et al., (2020) framework.

The pressure and release (PAR) model depicts vulnerability to shocks as a product of physical exposure to shocks or hazards on one side and socio-economic, demographic and environmental pressures on the other side (Blaikie et al., 1994). The model has three components, generating vulnerability in one side, namely root causes, dynamic pressure, and unsafe conditions; meanwhile, the other side includes the hazards or shock.

The root causes include a nexus of economic/institutional and social processes (Bevacqua et al., 2018; Innes et al., 2021; Yusuf et al., 2021). Dynamic Pressure are drivers that translate root causes into a local context (Nyondo et al., 2020). The unsafe conditions are the specific situations in which people live in an endpoint of the root cause, dynamic pressure in time and space. A combination of these pre-existing conditions determine severity of the impacts to the affected system (household/individual) upon being affected by shocks (Blaikie et al., 1994). Examples of unsafe conditions can include living in flood prone areas, poor infrastructure, and vulnerable livelihood activities.

Formal and informal institutional trajectories and associated dynamics influence access to and use of livelihood assets for coping and adaptation measures. This study adapted the Historical and Comparative Institutional Analysis (HCIA) to understand history and state of both formal and informal institutions (Greif, 1998). Analysis of the institutional evolutionary trajectories and their impacts on access to and use of livelihood resources is essential in understanding climate change vulnerability and resilience.

Livelihood assets consist of human, natural, financial, physical, and social capital (Pour et al., 2018). Informal gender-related rules, norms and traditions influence access to some livelihood assets especially in the rural communities of developing countries (Aboda et al., 2022). Rules and traditions on inheritance, control and access to land and communal resources favor males in rural communities of developing countries (Errico, 2021). Such rules consequently lead to varying assets endowment for managing climate shocks between male-headed households and female-headed households. Choice of coping and adaptation measures depends on the type and amount of resources available (Berman et al., 2015;

Zekele et al., 2021). Aryal et al (2020) noted that females have low livelihood assets compared to males hence, limited capacity to cope and adapt to the climate shocks. The difference in assets and coping or adaptation strategies consequently results in different resilience and vulnerability outcomes. The different outcomes eventually impact the vulnerability context, available livelihood assets and coping/adaptation measures in future.

Despite what the illustration displays, namely that the frameworks depict vulnerability contexts and gender influence on resilience outcomes, the adapted frameworks have not been tested in a research study in Malawi. The role of livelihood assets towards resilience have been studied in SSA, though. However, the same has not been applied in studying resource allocation and the resultant resilience outcomes between male-headed households and female-headed households experiencing similar shocks. Although the framework depicts that gender influences access to assets, choice of coping and adaptation measures, there is no evidence on how the same applies in a matrilineal community. This study therefore helped identify nuances of studying the influence of gender on vulnerability and resilience in matrilineal culture of Mwango Village of Traditional Authority Jenala in Phalombe District in Malawi.

2.8 Theoretical Framework

Even after being subjected to similar climate change-related hazards, people's response to the shocks and their impacts vary across different cultures depending on specific traditions and customs. Cultural ecology theory was adopted in this thesis to explain how matrilineal culture contributes towards building climate change resilience for male-headed households and for female headed households.

Cultural ecology theory was developed by Steward in 1968, and it postulates that society adapts to its environment whether these adaptations institute internal social transformations or evolutionary change (Steward, 2005). The theory analyzes these adaptations, however, in conjunction with other processes of change. It therefore argues that methodologically, there is a need for examination of the interaction between societies and their natural environment using anthropological approaches. This thesis adopts this theory to help elucidate how male-headed households and female-headed households under matrilineal culture interact with their environment, and how the resultant interactions influences the extent of vulnerability to climate change-related shocks, access and use of livelihood assets to recover from climate change-related shocks using informal institutions as well as adaptation strategies being used in response to climate change.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research design and methodology for this study. This research used a sequential mixed methods approach (Ivankova et al., 2006). Rossman and Wilson (1985) indicated that a mixed methods approach does not primarily focus on methods as being important rather on the problem as the most important, and researchers use all approaches to understand the problem. This research therefore combined qualitative and quantitative research methods to decipher information on climate change vulnerability and resilience in the study area.

This chapter has been organized in seven sections. Section 3.1 presents the introduction of the chapter. Section 3.2 describes the study setting and description of the study area. The next section (3.3) details the methodological approach to the study. This section comprises the qualitative study approach and details on selection of study participants, qualitative data collection methods and analysis. Section 3.4 outlines the quantitative study approach; sampling technique; data collection methods and analysis. Section 3.5 elaborates on how validity and reliability of data from this research were attained. Section 3.6 presents ethical compliance for conducting social research. This chapter closes with a section on the challenges encountered during data collection and mitigation measures.

3.2 The study setting

3.2.1 Description of the study site

This study was conducted in Phalombe District. This district is located in southern Malawi and shares boundary with Zomba district to the east, Machinga district to the north, Mulanje district to the south and Mozambique in the East. The population of the district comprises circa 83% of *Lhomwe* tribe that follow matrilineal system of inheritance and uxorilocal post-marital settlement.

Phalombe District has a total population of 429 450 of which 207 006 are males and 222 444 are females. The district has the population density of 342 people per square kilometer, one of the highest in Malawi (NSO, 2020a). This district exhibits the socio-demographic characteristics associated with poverty. For instance, the literacy level for females is 61.4% while for males it is 73.4 % compared to 68.8% for females and 83% for males at the national level (NSO, 2020a). Locally, the prevalence of HIV among females is 18.5% while it is 12.8% nationally; for males the rate is 11.6% against a national average of 8.2% (NSO, 2017). Other studies have attributed high HIV prevalence to transactional sex in fishing communities (MacPherson et al., 2012). Furthermore, 87.9% of working age women in Phalombe are employed against 79.6% nationally. In Phalombe, 82.4% of men are employed compared to 83.3% nationally (NSO, (2017). Of the employed population in Phalombe, 84.6% of women are in agriculture compared to 57.4% at the national level, and 65.9% of males are in agriculture compared to 41.7% at the national level (NSO, 2020b).

The Malawi Vulnerability Assessment Committee (MVAC) identified vulnerable districts to the impacts of climate change in Malawi (GoM, 2018). The two categories are high and low vulnerability (Svesve, 2016). Chikwawa, Zomba, Mulanje, Thyolo, Balaka, Nsanje, Blantyre and Phalombe districts are considered highly vulnerable while Mwanza, Salima, Mangochi, Karonga, Nkhotakota and Nkhatabay districts are considered to be of lower vulnerability (MVAC, 2015).

For this study, Phalombe District was selected considering its suitability to the objectives of the study. Phalombe District has a history of natural disasters and climate change-related shocks (GoM, 2012). Furthermore, most of the rural populations in the districts depend on rain-fed subsistence farming (GoM, 2012). This attribute entails high susceptibility to the impacts of climate change such as drought, prolonged dry spells and floods. In addition, the district is experiencing a high population growth rate of about 2.7%, leading to environmental and natural resources degradation, exploitation of forest and wetland resources (GoM, 2015).

3.2.2 Geographical and socio-economic focus and justification

According to the MVAC (2016) the study area falls in the Lake Chilwa Phalombe Plain. The study area is specifically within Traditional Authority (TA) Jenala. The area is located within the Lake Chilwa Wetland (which is part of the lowest point in the Lake Chilwa catchment). This location implies high vulnerability to flooding. The area is also located on the leeward side of Mulanje Mountain, thus it is prone to dry spells and droughts (GoM, 2015).

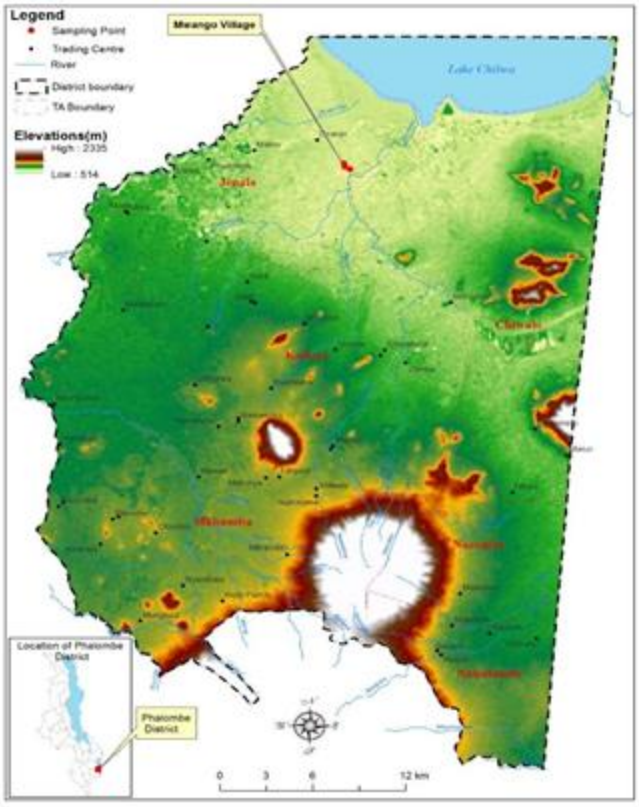

Figure 3. 1 Map of the study area

The area is characterized by very poor households that are unable to meet their minimum annual food requirement of 2,100 kilocalories per person per day (NSO, 2020b). Income-generating opportunities are limited, thus food crops are sold to earn money for immediate use and then the food is later purchased during the lean period later in the year (GoM, 2012). Main crops that are grown in the study area include maize, rice and pulses. Other sources of cash besides sale of crops are livestock, ganyu (casual labor), petty trade, fishing and sale of forest products (GoM, 2016).

3.3 Methodological approach

This study adopted a sequential mixed methods design. This method has been precipitated by the realization that challenges of implementing evidence-based research are sufficiently complex that a single methodological approach is often inadequate (Palinkas et al., 2011). Teddlie and Tashakkori (2003) noted that in a sequential mixed methods approach, qualitative and quantitative methods are used to explore and achieve an in-depth understanding of the situation as well as to confirm hypotheses based on an existing conceptual model and to obtain a breadth of understanding of predictors. Therefore, mixed methods help to generate information by harnessing the benefits of the synergy of both methods (Creswell et al., 2011). Data collection was done in three phases. The first and second phases involved qualitative data collection methods while the third and last phase involved quantitative method namely household survey to collect quantitative predictors following analysis of qualitative data from the two phases.

3.3.1 Qualitative approach

The study primarily used PO to collect qualitative data. This method is useful for studying groups, formal and informal organizations with the goal of understanding how research subjects view themselves, their purpose, their activities, and those with whom they deal (Mc Call & Simmons, 1969). PO affords an opportunity to collect data on a broader range of participants' activities. It also enables researchers to correct various biases as one can actually see the participants' activities, as well as hearing how participants interpret their activities (Kurz, 1983). The other complementary methods that were used along with PO included Focus Group Discussions (FGD), in depth interviews (IDI) and key Informant

Interviews (KII). The first phase was done soon after harvesting when the households had relatively more food from rain fed production while the second phase was done during lean period. The third and last phase involved a household survey.

3.3.2 Selection of respondents for the qualitative data collection

Key Informants were identified through the Assistant District Disaster Risk Management Office (ADDRIMO). The officer listed key personnel that are involved in vulnerability and resilience activities and recommended them for the interviews. The respondents at village level were identified through the Village Development Committee (VDC). They recommended male and female headed households that could be interviewed as well as older people of the community who have rich history of the community. During interviews, some respondents recommended others of similar attributes and the list was revised after informal consultations to confirm the recommendations.

3.3.3 Implementation of PO

The researcher surveyed the community by walking in the village to observe households and livelihood activities as well as food consumption and utilization practices. It also involved visiting places where people were working to source food and income. Some of the places that were visited included a fish market along Lake Chilwa, gardens in the permanent wetland and rice fields in the temporary wetland. The researcher also visited local markets, participated in social gatherings; attended community development meetings and visited the chief's house/court.

The researcher lived in his own house within the community for a minimum of 4 weeks in each phase. While in the village, the researcher participated in community life and interacted with the people informally. Observations were done on livelihood activities, food acquisition and utilization, and management of food shortages. The researcher also observed conflict resolutions at the chief's court and agronomic practices for arable and wetland crops. Notes and pictures were collected onsite. The guide in appendix E was used for this method.

3.3.4 Implementation of KII

Key informants at village level consisted of knowledge custodians at two levels. The first level consisted of Agricultural Extension agents, the Chairperson for the Area Stakeholder Panel (ASP) – the local structure responsible for agricultural development formed under the Decentralization Policy. Other Key Informants were leaders of similar grassroots development structures such as the Village Development Committee (VDC) – responsible for the general development of the area, the Village Civil Protection Committee (VCPC) – responsible for disaster preparedness and management; and the Beach Village Committee (BVC) – responsible for enforcing fishing regulations in the village, as well as local leaders (chiefs). The second level included older members of the village. They were solicited for their historical knowledge of the community and how the welfare of the people has changed due to climate change.

At the district level, the Director of Planning and Development (DPD), the District Agriculture Development Officer (DADO), the District Environmental Officer (DEO) and

Assistant District Disaster Risk Management Officer (ADDRMO) were the key informants. Project officers from the Food and Agriculture Organisation (FAO), World Vision Malawi and Concern Worldwide were also interviewed. FAO had just finished implementing a Strengthening Community Resilience to Climate Change project while World Vision and Concern Worldwide were actively involved in disaster recovery interventions in the area.

The interviews with district stakeholders were done in the last phase of data collection. District Key Informants were asked about their knowledge on vulnerability enablers and resilience activities in the district at large and study area in particular. The local Key Informants were asked their perceptions of vulnerability as well as resilience and how they were working towards building the latter. The KII guide for the study area is attached to appendix A while for district stakeholder in Appendix B. Data from the interviews was collected using an audio recorder.

3.3.5 Implementation of Focus Group Discussions (FGD)

The study primarily targeted household heads in the area for the FGDs. Household heads are main decision makers and are key in managing household resources. Therefore they were considered more reliable and credible. The FGD were disaggregated by gender because Nelson et al. (2002) noted that women and men differ in their strategies to manage livelihood shocks. Furthermore, Mendelberg & Karpowitz (2016) noted that gender disparities in roles within and outside households align males and females differently towards general understanding of livelihood activities. A female Research Assistant

facilitated the FGD with the females in order to ease the difficulty that women could have had in interacting with a male researcher.

The FGDs involved discussions of livelihood activities, access to livelihood assets, vulnerability and resilience to the impacts of climate change as well as cultural dynamics that determine access, use and ownership of livelihood assets. Four FGDs (Average of 10 participants), two for each gender, were conducted during the second phase of data collection. The guide for FGD is attached to appendix C. All the data from the discussions were collected using audio recorders.

3.3.6 Implementation of IDI

The participants for IDI were purposively selected from households within the village. Equal gender representation for these interviews was achieved. Key criteria for selection of the households were relative vulnerability and resources endowment; the nature and diversity of livelihood activities and a previous history of being victims of climate change related shocks. An unstructured checklist was used for respondents identified for one-on-one interviews that were recorded using an audio recorder. For some respondents, interviews were periodic (the researcher could go back for more details or reconciliations between observations and responses during interviews.) Respondents were both male and female, and age was also considered as it helped to understand past and present situations as they relate to vulnerability and resilience. The checklist is attached to appendix D.

Table 3. 1 Participants interviewed during the study

Interviews	Age range (Years)	Male	Female	Total
IDI	21 - 44	7	7	14
Key Informant Interviews (KII)				
Technocrats (Extension agent and Chairperson for ASP)	36 – 42	2	0	2
Local leaders	39 – 57	3	0	3
Older people	51 – 68	4	3	7
District level key Informants (Government, NGOs and UN agencies)	35 – 64	6	1	7
Total		**22**	**11**	**33**

3.3.7 Qualitative Data Analysis and Interpretation

3.3.7.1 Data Transcription

After each phase of qualitative data collection, field notes were typed while the audio data were transcribed verbatim. This process made the data amenable for use in the computer package. Notes and transcripts were kept separately within the same folder for each phase.

3.3.7.2 Data Entry and Coding

Transcribed data and notes were entered in the qualitative data software called NVIVO. This computer software package helps manage rich text-based as well as multimedia

information, where deep levels of analysis on small or large volumes of data are required. The software also helps to minimize hiccups that are common in working with hard copies.

The main themes and the coding framework were created based on the objectives of the study. Codes were determined either by identifying common phrases in the raw data or relative statements or phrases to the initial phrase that constituted the code. Coding was done at two levels namely open and axial coding. During open coding all the raw data were coded so that the sub themes of data can be identified. During axial coding all the sub-themes were merged by interconnecting and linking them under the already organized themes.

3.3.7.3 Data Analysis

Thematic analysis was used in this study. After the data had been coded under the themes, each theme was evaluated against research objectives and compiled summaries. Noteworthy quotations were identified and included in the summaries, which eventually constituted the narratives for each objective. This process was iterative and the phased approach helped to address each research objective thoroughly.

3.4 Quantitative approach

The study used the quantitative approach in the last phase of data collection. Following collection of detailed data using a qualitative approach, the study identified key factors that were investigated for further analysis. This approach helped contribute quantifiable evidence which will be useful for enriching the discussion and conclusion of findings from

the qualitative approach. According to Jones (2007) quantitative research enables readers to assess the strength of the arguments through the statistical evidence supporting it. Using this approach ensured that all the arguments generated from the qualitative strand are buttressed with statistical evidence that allows for generalization beyond interview subjects and other respondents. Data was collected using Computer Assisted Personal Interviewing (CAPI) application on android gadgets.

3.4.1 Selection of respondents for the household survey (Sampling)

Households from within the study area were randomly selected for the household interviews. The sampling frame was obtained from the local leaders who keep records of the total number of households in their village. Stratified proportionate probability sampling was used in this study. Stratification was based on gender and samples from each stratum were calculated proportionate to its population. Sample size was calculated using Cochran (1977) formula below.

$$n = \frac{n_0}{1+\frac{n_0}{N}} \quad \text{Where} \quad n_0 = \frac{z^2 p(1-p)}{e^2}$$

In the formula above n is the sample size while z is the standard normal variate based on the confidence coefficient, N is the population size; e is the margin of error while p is the estimate for population proportions for the group of interest (vulnerable households). Using the formula above, the sample for the household survey was 217 households of which 77 were female led representing 35.5% while 140 were male headed, representing 64.5%. In this study, a male-headed household was defined as a household where the key decision maker is an adult male while a female-headed household was defined as a

household where the key decision maker is a female adult regardless of occasionally available males (in case of polygamy or migrant workers). This sample distribution was consistent with Phalombe district population between male-headed (64.1%) and female-headed households (35.9%) (NSO, 2020a).

3.4.2 Quantitative Data collection Technique

A structured household survey questionnaire was used to collect quantitative data. Themes that were developed during qualitative data analysis guided formulation of specific questions in the household questionnaire. The questions focused on demographic characteristics, livelihood activities, access to livelihood assets and climate change adaptation practices. The household survey questionnaire is attached to appendix F.

3.4.3 Quantitative Data Analysis and Interpretation

After completion, the household survey data was cleaned by cross checking consistency with prior qualitative data and outliers. Where necessary respondents were called back to verify the information in the dataset if responses were contradictory. Statistical Package for Social Scientist (SPSS) and STATA were used during data analysis. Data was analysed in two phases. The first phase involved basic statistical analysis of both measures of central tendency and dispersion. Other analyses such as correlations and cross tabulations were done for objectives 1, 2 and 4. The second phase involved hypothesis testing and regression analysis for objective 2. Various studies have attempted to compute resilience indices in order to guide resource allocations to various dimensions of resilience (Abdul-razak & Kruse, 2017; Antwi-agyei, et al., 2014).

This study attempted the same with gender disaggregation (objective 2). Details for the choice of variables and computation of the indices are in Appendix G.

3.5 Data Validity and Reliability

Cognizant of the need to highlight the extent to which the scores actually represent the variable they are intended to measure, two data (qualitative and quantitative) strands were collected to ensure a high level of consistency. Social science scholars acknowledge that qualitative data has relatively higher validity because of code saturation while quantitative data has high reliability because of the consistency in measurements (Forero et al., 2018; Sürücü & Maslakçi, 2020).

3.6 Ethical Considerations

This research complied with all the necessary guidelines for conducting social research. The research was approved by the Malawi National Commission for Science and Technology (NCST) Ref No: NCST/RTT/2/6. Data collection was preceded by obtaining informed consent from the interviewees. The researcher conducted himself with integrity to ensure that all ethical requirements such as confidentiality and voluntary participation were adhered to throughout.

3.7 Challenges encountered and mitigation strategies

The study was done in an area that is prone to climate change related shocks and thus often targeted for humanitarian assistance by government and other stakeholders. Initially this study was affected by untruthful responses because study participants expected that humanitarian assistance would follow, because the area was affected by dry spells and

floods during the 2018/2019 growing season. The untruthful were responses detected as the researcher continued to live in the area and made observations that contradicted the initial responses. Upon observing the contradictions, the researcher reiterated to the locals by emphasizing that the study was purely academic.

CHAPTER 4

RESULTS

4.1 Introduction

The first results chapter presents findings on **underlying factors that contribute towards climate change vulnerability**. This chapter is organized according to the PAR model that conceptualize vulnerability as a progression from underling factors, dynamic pressures and unsafe conditions on one side, and then climate change hazards on the other side.

The second results chapter presents findings on the **role of livelihood assets in climate change resilience**. This chapter explains how livelihood assets are distributed between male- and female-headed households and also shows how each category of assets is used to recover from erratic rainfall and floods for both male- and female-headed households.

The third results chapter presents analysis on the **evolution of land related institutions and their contribution towards climate change resilience**. Informal land related institutions have evolved over time to allow for individual land ownership and thus create opportunities for long term investments that can enhance livelihood resilience.

The last results chapter presents **climate change adaptation pathways**. There is a shifting in choice of crop varieties from late maturing to early maturing varieties. Although both male- and female-headed households are switching to early maturing varieties, female-headed households primarily focused on varieties that enhance food production unlike male heads who had multiple objectives such as income generation.

4.2 Vulnerability to the impacts of climate change

This chapter presents findings on the progression of vulnerability to the impacts of climate change in the study area. The chapter starts with presentation of the findings on the root causes of vulnerability. This will be followed by section on dynamic pressures that exacerbates vulnerability and then unsafe conditions in which the households in the study area live under. The final section will detail the climate change related hazards that affect the households in the study area.

4.3 Root causes of vulnerability

The root causes are the socio-cultural characteristics of a community are the ultimate causes of disasters. This section will unveil details of the cultural and gender dynamics in the study area that enhances vulnerability. Furthermore, this section will detail food preferences as the underlying condition that exacerbates climate change vulnerability.

4.3.1 Cultural customs on access to land and gender related traditions

Culture and gender were found to be key root causes to vulnerability in the study area. Cultural practices and traditions were identified as key to agricultural production and long-term investment on land. Gender roles and perceptions in the community influence access

to and the use of various resources to sustain livelihoods and investments. The aforementioned factors consequently determine the extent of vulnerability of the people to climate change related shocks.

4.3.1.1 Role of culture on land ownership and use

Land use and ownership in the study area follows a matrilineal traditions. Under this system, there are three main post-marital settlement arrangements called uxorilocal, virilocal and neolocal. The most common arrangement in the village was uxorilocal. This requires men to settle in the village of their wives, where land is owned by the wife and her clan members. This is explained in the following excerpt:

> "When a girl wants to get married and the man has come to marry her, parents give their daughter a field where she and her husband build a house and cultivate their crops". [Village Chief]

Under this arrangement the husband has user rights to the land while the wife has both user and ownership rights. It was explicitly mentioned by the chief that under uxorilocality (locally called *Chikamwini*) the land belongs to the woman and her clan members. The husband may still be considered as the head of the household but cannot make key investment decisions about farmland. During one-on-one interviews, a participant said,

> "The land that is given to the *mkamwini* (husband under uxorilocal) to build and cultivate their crops but the land realistically belongs to the family of his wife. In case of divorce, then the man leaves the wife and children in the village". [35 years old female IDI Participant (Standard 3)]

The village chief further said

> "If the *mkamwini* claims that the land he is working on with his wife belongs to him then he is just proud and arrogant. That *Mkamwini* is supposed to say that there are fields here where we grow our crops, not necessarily claiming ownership".

The husband can only make those claims if he buys, but not on the land that belongs to the clan of his wife. Men are expected to work and invest in the land they have been assigned. The chief indicated that the wife can rent out the field after consulting with her clan members but the *mkamwini* cannot. The wife needs approval from her relatives before she can rent out a field because that land does not necessarily belong to her rather it belongs to her family or clan.

Men who accept the uxorilocal arrangement are fully aware of the stakes under this arrangement. Although it was postulated that men's efforts are driven by commitment to the future of their families, men signaled that lack or no ownership of assets affects their commitment to long-term investments in the land and the general development of the community. During one of the Male FGD a participant quoted a proverb "*Ku chikamwini sumadzala mango*" suggesting that a *mkamwini* does not plant mango trees in his wife's village because he does not know when he will be divorced. It was further learnt that in case of serious illness, biological relatives of the husband are summoned to come and take him back to his village. This tradition instills a sense of temporary residence among men under uxorilocality. Despite this, especially during one-on-one interviews, participants cited some exceptions to these phenomena.

Cognizant of limited ownership of productive assets, especially land, men rather focus on immediate or short-term income generating activities such as fishing just to raise enough income to sustain the household in the short run. Unwillingness to participate in long term investments among men was observed during village meetings to repair a dyke that minimizes flooding in the area. The village chief described men in the village as antagonistic and irresponsible towards their families and village development, evidenced by their lack of availability during developmental activities.

> "I think I once told you that men in this village are proud and arrogant. They do not consider developmental works such as repairing a dyke as important rather they go either fishing or do casual labor that is why most of the developmental work in this village is done by women". [Key Informant/Village Chief]

Cases of neolocal system were also cited. This is a post marital settlement arrangement where the couple settles in neither villages rather they settle in a neutral village. Albeit such cases being reported, rapid population growth has increased demand for land for farming and settlement. High demand for land has resulted in an increase in land value and has consequently resulted in the low adoption of this system as an alternative. The high cost of buying land makes the cost of adopting a neolocal arrangement also high and impossible for most of the locals. The inability to acquire neutral land implies that most households remain under the uxorilocal system where men are less motivated to undertake substantial infrastructural investments to minimize their exposure to floods for instance.

The unavailability of men in vulnerability reduction works reduces the labor and expertise that is needed to minimize the severity of exposure to climate change-related shocks such as floods.

4.3.1.2 Customary land control by local authorities

Although a new Customary Land Act came into force in 2016, old traditional land governance practices for customary land are still being practiced in the study area. Even though land is principally governed by a matrilineal land tenure system, the distribution of land and settling disputes are mainly done by chiefs. A male respondent indicated: "The piece of land where we met at the wetland was idle so it pleased the chief to allocate it to me so that I can be using it."

The local chief indicated that although there are clan lands (*Ambumba*) in the village, the unallocated customary land is controlled by the chief. Prior to the onset of increased demand of land for farming and settlement, the chief distributed land to the clan heads but retained all the undistributed customary land. The unallocated land is therefore offered to users either on quasi-contractual arrangements or as a permanent sale. The chief rents out land at the wetland on condition that the land be utilized in that particular season and a proportion of proceeds especially from rice be paid back at the end of the season.[1]

A migrant couple said,

[1] It was learnt that rice farmers from semi-urban areas come to the area because of the vast wetland that is available for rice production. These farmers pay money to access plots and grow rice and later pay back bags of rice to the chief at the end of the growing season. The same happens to the landless locals in the same village or from surrounding villages.

> In order to acquire land from the chief you pay some money. It is not possible to get land for free here. If you get the land and you are not cultivating it, the chief will give it to someone else. I had a big plot but just because I was not using it, the chief demarcated it and allocated the other portion to other people without giving me any compensation."

Similarly, land in the upland is also being sold. When a male respondent asked about flood victims still living close to rivers, he said, "They are not relocating because they need money to do so." He added, "Nowadays it is not easy to find a place to settle because land is being sold thus those who want to relocate away from flood prone areas must have enough money to buy otherwise, they will still be close to the flooding rivers."[2] This phenomenon constrains resource poor locals from accessing safer land to settle under customary tenure.

4.3.1.3 Role of gender on adoption of livelihood activities

It was learnt that although both male- and female-headed households may be exposed to the same shock, the impact differs between the two. The Agricultural Extension Officer reported as follows:

> "There is a difference in terms of the magnitude of the impact. Generally female-headed households are the most affected, although the initial impact may be the same for both male and female-headed households although at the impact of floods both may lose their houses, female-headed households

[2] Land can also be sold by individual (s) who have ownership rights but it is less frequent due to land scarcity.

> suffer more compared to male-headed households because males in their households are able to run around and find means to recover a bit quicker."

The sentiments were echoed by the traditional leader who said female-headed households are the most affected by shocks such as floods because they have limited livelihood alternatives to recover faster compared to their male counterparts. The chairperson for the VCPC indicated that in a male-headed household, the husband and wife can share responsibilities in their efforts to restore their wellbeing after a shock unlike for female-headed households where only the woman work to restore their wellbeing.

Gender plays a critical role in determining access to resources that can enable a household to minimize its vulnerability. Male and female respondents during IDIs indicated that access to livelihood resources is controlled by gender perceptions of the community. For instance, fishing is considered a trade for males only. When a female respondent was asked about the possibility for them to be involved in fishing, she indicated that,

> "Fishing for a woman is impossible, this is work for men, even if women are to ask for casual labor to join fishing the owner of the gear will say that they are asking for something unheard of because fishing is for males". [28 years old Female Respondent (Standard 3)]

Women acknowledge that fishing is an alternative livelihood strategy in times of food shortage however, only men can do it. Women instead depend on casual labor (*ganyu*) where they work in other people's fields to supplement food and income in their households.

> "During times of food shortage, men go to the lake and get fish and sell to buy food but for the female-headed households they suffer a bit more because they cannot go fishing like men". [68 year-old female Key Informant (Standard 2)]

Men also indicated that fishing is not a trade for women.

> "Let me say most women cannot fish because it is a tough job, and women cannot manage to do it. Fishermen meet bad weather, dangerous animals like hippopotamus on the lake and women cannot manage to maneuvers the boat in such circumstances, and they are likely to drown because of fear. That is why they cannot join this trade" [40 years Male Respondent (Standard 5)]

Another respondent said,

> "They cannot get into a boat with intentions of going to fish or even using the fishing hooks or baskets. If they want fish then they have to find someone male to go catch the fish for them and for those that are married then they can depend on their husbands". [35 year-old Male Respondent (Standard 4)]

Inheritance of fishing equipment by a widow and the possibility of using it was explored. It was learnt that under the uxorilocal arrangement, the widow cannot directly use the deceased fishing equipment. Rather, the equipment is used by the widow's male relatives, who then give her the fish and income from the enterprise. Since she could not be directly

involved in fishing, male relatives might not give her all the proceeds thus affording them earnings. This was thus an opportunity for possible exploitation.

During both male FGDs, it was unanimously concluded that exclusivity of fishing to males is a tradition that has been inherited from ancestors who perceived fishing as male enterprise. This tradition was based on the notion that men are providers of their families and thus they should engage in even risky enterprises such as fishing where they can drown in cases of an accident or can maneuver dangerous situations on the lake.

Exclusion of women from fishing denies them an opportunity to raise income, unlike for male-headed households. As earlier demonstrated, fishing becomes a vital livelihood activity between March and December of each year – the period when food availability dips especially from August to February. This gender-based barrier thus limits women in female-headed households from access to the food and the financial resources that can smooth consumption during lean periods.

4.3.2 Soil conditions and crop(s) suitability

The type of soils in the study area also aggravate the impacts of erratic rainfall and floods. The study area lies in the perimeter of Lake Chilwa, which is an endorheic lake. Years of erosion and deposition in and within the perimeter of the lake have resulted in an accumulation of heavy clays. The nature of the soils plays a significant role in the ability to grow crops, especially maize. For instance, a 36 year-old female respondent (Standard 6) during IDI said,

> "Times when we have good rains growing any crop is easy but when there are dry spells the soil quickly loses moisture and the crops wilt. This soil is rich in clays and it rapidly loses moisture in case of a dry spell".

A 45 year-old male respondent (standard 8) during IDI also explained:

> "The problem with our soil here is that it requires moderate continuous precipitation in order to grow maize and if rains stop or become erratic then crops wilt and we lose everything".

It was also mentioned that heavy rainfall creates waterlogged conditions that equally thwart maize production. Locals identified this characteristic as exacerbating the impacts of erratic rainfall and flooding, especially on maize production.

4.3.3 Moisture availability in the wetland

The wetland is a critical resource during both the dry and rainy seasons. Rice is cultivated in the wetland during the rainy season while maize and vegetables are cultivated during the dry season from April to December. Moisture availability is thus critical during the dry season. A 64 years old female KII indicated that once perennial rivers such as Phalombe are now becoming seasonal, and it affects small-scale irrigation during the dry season, unlike in the past when water availability was more stable. These rivers have been the source of moisture in the wetland that enables crop production during the dry season. Since water availability in the wetland started declining, irrigation along the wetland is increasingly becoming difficult. Proximity of gardens to the river and lake therefore

determines the possibility of growing crops under irrigation. A 45 year-old male respondent (standard 8) narrated:

> "Maize production during winter cropping depends on moisture levels in the wetland. For instance, if moisture is available, we are able to grow crops and harvest but if moisture levels are very low then we do not harvest maize from winter cropping."

It was observed that few farmers were using motorized pumps to irrigate their gardens while the majority were using pails and buckets to water their gardens. Plots close to the river were being irrigated while those away from the water source were not cultivated because of lack of moisture.

4.4 Dynamics pressure

This study identified four (3) attributes of the study area that constitutes dynamic pressure that aggravates climate change vulnerability. Staple food preference and available financial institutions in the study area.

4.4.1 Food preference

Key informants, especially older people of the village, indicated that in the past maize production was easy and people were harvesting a lot of maize that could sustain households to the next harvesting period. A male adult KII said that food was in abundance in the past unlike in the present time. He further indicated that in the past people used to make granaries of 4 meters in diameter and they could fill them with maize such that they

could eat the maize from one harvesting season to the next. The same is not imaginable now because of increased incidents of food shortages owing to low maize production due to among key factors increased frequency and intensity of the impacts of climate change.

It was noted during most of the interviews that maize production is considered very important because harvesting a lot of maize, unlike rice, implies food security. A participant during the first male FGD said Maize has higher utility than rice because *nsima* (a paste made from maize flour) is considered proper and regular food unlike rice.

Probing the possibility of eating rice as a meal most respondents indicated that rice can be consumed as a meal but it cannot be consumed regularly, as can *nsima*. For instance, a 44 year old female respondent (Standard 4) during one – on – one interviews explained:

> "Our forefathers never depended on rice as a staple so we have followed suit. We grow rice primarily for sale. It is not possible to eat rice continuously; we still need *nsima* at the end of the day".

Rice is relatively easy to cultivate but highly depends on moisture availability in the soil. Although rice is easier to produce, locals consider rice to be a commercial crop rather than a staple. It was noted throughout all the interviews and FGDs that rice is either directly sold to buy maize or bartered with maize. Upon being asked about the possibility of prioritizing rice as a staple instead of *nsima*, one 35 year old female respondent (Standard 4) said "it is not possible to eat rice for both lunch and supper on the same day. If you eat rice for supper you cannot sleep because we start feeling hungry quickly, even the next day you cannot have enough energy to work in your field". A similar feeling was expressed

during the female FGD where a participant said *nsima* can be eaten three times a day for many days without getting bored but the same cannot happen with rice.

It was thus evident that although locals produce both rice and maize, they traditionally prefer *nsima* to rice. This preference has been sustained over the years despite the impacts of climate change that have negatively affected maize production more than rice. A 58 year-old woman (Standard 4) during FGD indicated that "most of the people here depend on *nsima* and yet early cessation of rains is causing reduction in maize production, so people can harvest more rice than maize but they eventually sell the rice to buy maize". Higher quantities of rice that might be produced do not directly entail food security however, since it indirectly implies that the rice will be sold or exchanged with maize for *nsima*.

It was acknowledged that proceeds from the sale of rice do not always translate to equal quantities of maize. A 56 year-old) man with 6 years of primary education during IDI said "for instance if you can sell 10 bags of rice, the money you get can be enough to buy about 4 bags of maize because during rice harvesting prices decline while maize prices are already up". When respondents were challenged to grow more rice so that they can sell more and buy a lot of maize, they argued that not all the income from sale of rice is used to buy maize rather some of it is also used to buy other essential groceries. This implies that maize production remains a determinant of food security as it is often kept for consumption, unlike rice.

4.4.2 Nature of financial services

Vulnerability is also exacerbated by the lack of financial institutions in the study area. The peak of agricultural labor demand coincides with the peak of the lean period and households without food abandon work in their farms to earn income in order to buy food.

Alternatively, some households get high interest loans or usury from loan sharks called *katapila*[3] to buy food instead of abandoning their fields to source food. A male respondent explained that "money lenders give us about MK2500 (3USD) to be paid back with a 50-kilogram bag of rice (with an equivalent price of MK 12000 (15USD) as of June 2020). During harvesting we make sure we pay back so that in case we need them again in future they should be willing to help us." A 37 year-old female respondent (Standard 7) during IDI indicated as follows:

> "We get *katapila* because it is not possible for us to do *ganyu* and work our fields at the same time so we sacrifice *ganyu* for *katapila* in order to buy food and during harvesting season we pay back the loan with bags of rice".

These loans diminish amount of rice they eventually end up with after harvesting in two ways. Firstly, in case of crop failure due to the impacts of climate change borrowers are still required to pay back, even if they fail to harvest the expected rice quantities. A female key informant aged 68 years indicated that some borrowers were once kept in police custody until they sourced the rice and repaid the loan. Secondly, borrowers repay approximately 5 times the value of what was borrowed. This repayment arrangement results into huge decline in quantities of rice they remain with after harvesting. Another female participant aged 28 years during one-on-one interviews said "we fail to develop in

[3] Katapila involves borrowing (MK 4000) for high value rice varieties and (MK2500) for low value ones to buy food instead of doing Ganyu. The loan is paid back with a 50 Kilograms bag of rice.

this area because of *katapila*. The loans are exploitative and we fail to generate enough income from rice production because much of our output is used to repay the loans". These loans create cycles of exploitation that reduce income from rice production and thus deepen food and income scarcity.

4.5 Unsafe conditions

The study identified geographical location of the study area and main livelihood activities as main unsafe conditions that influence climate change vulnerability in the study area.

4.5.1 Physical location – Lowest point of the catchment

The study area is located at an elevation of about 630 metres above sea level. Geographical position in the catchment together with being close to Phalombe River and Lake Chilwa means an increased risk of being affected by floods. In order to verify the perceptions of Key Informants on vulnerability to floods, Dartmouth Flood Observatory (DFO) was used to estimate flooding in the study area. Figure 4 below shows the spatial extent of average flooding from 1985 to 2019.

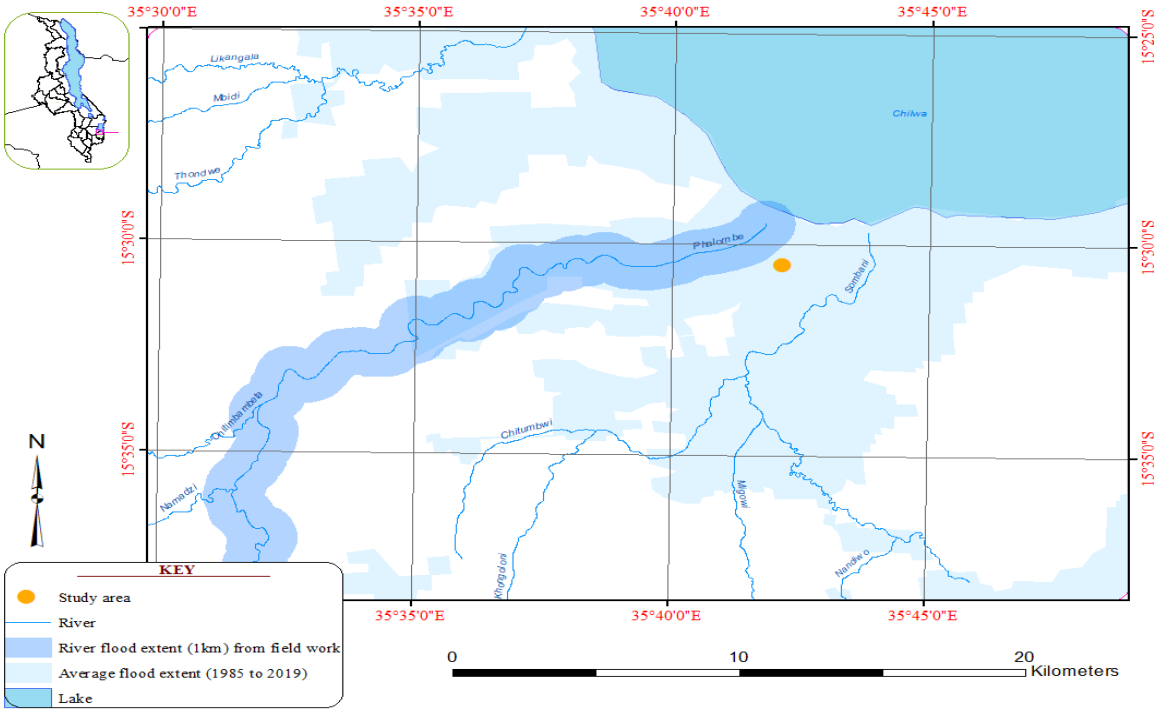

Figure 4. 1Spatial extent that is affected by average flooding. Source Author created using DFO

Figure 4.1 above shows that the study area falls within the flood prone area. This increases its susceptibility to flooding which can either be due to precipitation in the area or flood water coming from the upper catchment. Locals echoed the same on the topographical location of the village and its susceptibility to flooding. For instance, the chairperson for VCPC indicated that "The reason is that this area is flat and low lying, so all the water from the entire catchment flows to this area. We are at the end of these major rivers as such we are the most affected by floods". He further highlighted that "as the water comes from upper catchment it builds up along the way and by the time it gets here, it causes floods."

Although it was established that the extent of being vulnerable to floods varies with distance from the flooding river, other conditions such as the siltation of the river bed due

to poor land conservation practices in the Lake Chilwa catchment were also recognized as a condition that exacerbates vulnerability to floods. The chairperson for the District Stakeholder Panel indicated that “there is a lot of siltation in Phalombe River because of erosion upstream and thus the base has been made shallow, exacerbating the risk of flooding in the surrounding settlements”.

4.5.2 Common Livelihood activities

Livelihood activities form the basis for which households survive in terms of acquisition of food and income. This research explored the main livelihood activities in order to understand how these activities are affected by the impacts of climate change. Table 4.1 below presents primary, secondary and tertiary livelihood activities disaggregated by gender of the household head.

Table 4. 1 Percentage distribution of primary, secondary and tertiary livelihood activities disaggregated by gender

Livelihood activities	Primary			Secondary			Tertiary		
	MHH	FHH	Total	MHH	FHH	Total	MHH	FHH	Total
Farming	59.4	75	64.8	31.4	27.7	30.1	15.7	17.9	16.2
Fishing	12.1	0.0	7.9	24.6	2.8	17	20.5	0.0	15.3
Permanent job	2.1	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0
Casual labor	21.5	21.1	21.3	34.3	61.1	43.7	55.4	57.1	55.9
Livestock	0.7	0.0	0.5	1.5	1.4	1.5	1.2	7.1	2.7
Small business	2.1	3.9	2.8	6.7	5.6	6.3	6	10.8	7.2
Artisan skills	2.1	0.0	1.3	1.5	1.4	1.4	1.2	7.1	2.7
Total	100	100	100	100	100	100	100	100	100

In general, results in Table 4.1 above shows that male-headed households (MHH) have a wider range of primary livelihood activities compared to female-headed households (FHH). Most of the households depend on farming as a primary livelihood activity. Table 4.1 also shows that casual labor is the second most important primary livelihood activities for both male- and female-headed households but fishing is the third most important livelihood activity for male-headed households. Albeit male dominance in fishing, MacPherson et al (2012) reported incidents of females indirectly benefitting from fishing through transactional sex in Malawi. Table 4.1 shows that casual labor is the main secondary and tertiary livelihood activity. Most of the respondents during one-on-one interviews indicated that fishing and farming were the main sources of casual labor. Rain-fed farming, small-scale irrigation and fishing are seasonal. However, since small-scale irrigation starts soon after rain-fed farming, while fishing activities peak between April to November, opportunities for casual labor shift seasonally depending on the peak period of the other livelihood activities that demand extra labor. Illustration of seasonality of the main livelihood activities will be expounded using in section 4.3.

Table 4.1 further shows that other minor livelihood activities include small-scale businesses, artisanal skills and livestock production. Other minor livelihood activity was artisanal skills such as mat weaving. Livestock production was also identified as another minor livelihood activity. Common livestock observed in the area were poultry. Most of the goats and cattle that were observed in the temporary wetland within the village were reported to have been from distant villages, details in chapter 6. The least reported livelihood activity was a permanent job.

Using the seasonal calendar, an inquiry was made to understand the seasonality of the main livelihood activities in the area. Through observation it was noted that not all livelihood activities are pursued at the same time. For instance, farming depends on weather and climatic variables such as precipitation and availability of moisture in the wetland, while fishing is more useful after the farming season, and the availability of casual labor depends on the two aforementioned livelihood activities. Table 4.2 below shows seasonality of the main livelihood activities.

Table 4. 2 Seasonality of main livelihood activities

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Small scale irrigation								
		Fishing									
Casual labor (*Ganyu*)											
Rain-fed farming									Rain-fed farming		

Rain-fed crop production starts around October with land preparation for both arable and wetland crops. Maize is usually harvested in March while early maturing varieties of rice are harvested from the end of March to May and late maturing rice varieties are harvested between June and July. Rain-fed farming is key in determining food and income security in the area. Most of the respondents during IDIs indicated that rain-fed crop production is the key economic activity that determines food and income in the area. Both community and district level KIIs described the area as predominantly dependent on rain-fed crop production.

> "Rain-fed crop production is the most important livelihood activity in this area because it determines food and income availability annually". [Agricultural Extension Agent]

The main crops that are grown under rain-fed farming are maize and pulses in arable land while rice is cultivated in the wetland.

Winter farming is done between April and the onset of rains around late November. It was observed that the timing of small-scale irrigation along the wetland depends on moisture levels and how land was previously used during the rainy season.

> "Winter farming depends on residual moisture so farmers carefully time planting of their crops during this period in order to harvest before the hottest months that is from September to November." [Village Chief]

The type of rice cultivated during rain-fed season also determines the onset of small-scale irrigation. For instance, growing early maturing rice varieties implies the early onset of small-scale irrigation while growing late maturing varieties means otherwise. Most of the local Key Informants indicated that small-scale irrigation along the wetland is the key alternative to rain-fed crop production. Appendix H shows pictures of maize under small-scale irrigation captured in August 2020.

> "Sometimes people engage in winter farming by growing maize and vegetables to partially recover from crop loss during rain-fed production". [Agricultural Extension]

Further inquiries about small-scale irrigation revealed that winter farming is done regardless of the performance of rain-fed farming. Nevertheless, it is very important to most households because it bridges the food security gap if rain-fed crop production fails.

Dependence on fishing peaks from March to December. This period coincides with a period of steady decline in food from rain-fed production. Fishing therefore generates food and income to sustain household food availability during lean periods. Fishing is predominantly done in Lake Chilwa and is dominated by artisanal fishing using nets, hooks and traps (fishing baskets locally called mono). During KII with the BVC chairperson it was reported that fishing is done throughout the year although most of the fishermen reduce their dependence on it during rain-fed crop production season. It was reported during Male FGD that although there are regulations to control fishing during production season, enforcement of those rules is weak in the study area. Despite the acknowledged importance of fishing to most livelihoods by the BVC chairperson, it indicated that overall fish output has declined over the past three decades due to overfishing.

Farming and fishing are the main sources of casual labor (*ganyu*). Resource poor households often resort to casual labor as a coping strategy for food shortages during lean periods.

> "Mostly, I depend on *ganyu* to sustain food availability in my household because rain-fed crop production no longer produces enough food for the whole year". The female participant further said "Women often rely on *ganyu* in crop fields while men go to the lake to either fish or do *ganyu* for wealthier fishermen". [26 year old female – IDI Standard 5)]

Opportunities for *ganyu* are common throughout the year although its demand peaks at the onset of the rainy season because land preparation for maize and rice is done at the same period. Locals with additional income and migrant rice farmers offer *ganyu* to speed their agronomic activities in readiness for the rains.

> "Migrant farmers who rent fields at the wetland offer *ganyu* to locals to speed their work because they do not want to stay longer in the village – they want to finish all their work within a short period and return to urban centers". [VDC chairperson]

Food insecure households divide labor between their farms and *ganyu* to prepare their fields for rain-fed crop production and meet immediate food needs. The BVC chairperson also indicated that fishermen who use gillnets hire additional workers and thus create opportunities for *ganyu* in order to supplement labor demands. It was observed that other homestead activities such as building and burning of brick kilns during the dry season were also sources of opportunities for *ganyu*.

4.6 Climate change related Hazard

Secondary data was used to determine the extent to which the impacts of climate change affect households in Phalombe District in general and in T.A. Jenala in particular. Data from the Department of Disaster Management Affairs (DODMA) show that key climate related shocks include floods, stormy rains and erratic rainfall. Table 4.3 below shows data compiled on the number of affected households from 2011 to 2020 at district and T.A. levels.

Table 4. 3: Affected households by the impacts of climate change in Phalombe district 2011 - 2020

Year	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Floods	526 (102)	5403 (2902)	0 (0)	14287 (5123)	0 (0)	0 (0)	290 (0)	22848 (10078)	5037 (2712)
Stormy rains	1435 (9)	145 (0)	493 (127)	7619 (24)	3443 (2410)	1343 (490)	1602 (309)	3954 (611)	1967 (156)
Erratic rainfall	19338 (0)	18499 (4299)	7641 (2961)	8520 (0)	44418 (11625)	10534 (3817)	36892 (2061)	No Data	No Data

Figures in parenthesis are for Traditional Authority (TA) Jenala. Source: DoDMA (2020)

Erratic rainfall occurs in three main forms namely: the late and unpredictable onset of rains; dry spells during the crop production period and the early cessation of rains. Table 4.3 shows that erratic rainfall has been the most frequent and intense climate change related shock that has been affecting Phalombe District in general and TA Jenela in particular. Results show that 2015/16 recorded the highest population affected by erratic rainfall in Phalombe district: 44,418 households of which 11,625 households were from TA Jenala, while the least number of affected households were reported in the 2014/15 season in which 8,520 households were reported for the whole district and none was reported from TA Jenala.

> "Rainfall season is very tricky nowadays because we are not sure when the rains have started and when the rains have stopped. It is difficult to tell that the rainy season has started and midway crop growth we experience dry

spell and rains stop abruptly before even crops mature". [40 year-old Male–IDI respondent (Standard 4)]

Almost all older key informants indicated that erratic rainfall is more common now than in the past. Farmers further said these phenomena have increased in intensity and frequency resulting in high incidents of food and income insecure households almost annually.

Stormy rainfall has been another impact of climate change that, despite affecting a relatively lower number of households compared to erratic rainfall and floods, has been consistent in the past 10 years. Table 4.3 shows that the highest number of affected households (7,619) by stormy rainfall were reported in the 2014/15 period while the highest number for TA Jenala (2,410) was reported in 2015/16. Apart from negatively affecting farming, stormy rainfall also affects infrastructure, especially the grass thatched houses that are common in most of the rural areas of Phalombe District. The ADDRMO indicated that stormy rainfall creates both immediate impacts in case of destruction of houses and also long-term challenges of food insecurity if crops - especially maize - are damaged.

Secondary data from DODMA showed that flooding destroys houses, washes away crops and also creates water logging conditions that thwart crop growth in arable land and submerge rice in the wetland. Table 4.3 shows that 2018/19 was the period when floods affected 22,848 households in Phalombe District while in TA Jenala about 10,078 households were affected, representing about 44% percent of the entire affected population in the district. Although results show that floods affect a higher proportion of households compared to erratic and stormy rainfall, the frequency of floods is comparatively relatively low. The agricultural extension officer indicated that flooding occurs when there is high

precipitation in the area or in the upper part of Lake Chilwa catchment. He further said that TA Jenala is located within Lake Chilwa wetland, which is a low-lying area where a relatively higher intensity of flooding is common.

Further to historical patterns, the household survey inquired about whether households were affected by the impacts of climate change during the 2019/2020 season. This investigation helped to fill the gap in the wider historical data although the data is only for the study area. Furthermore, the data for the study area also shows additional impacts of climate change that historical data lacks. Table 4.4 below shows the proportions of households that were affected by the impacts of climate change.

Table 4. 4: Experience of the impacts of climate change during 2019/2020

Impacts of climate change	Male-headed Household	Female-headed Household	Total (217)
Erratic Rainfall	88.6	81.8	86.2
Floods	70.0	77.9	72.8
Stormy rains	47.9	53.2	49.8
Fall army worms	79.3	88.3	82.5

The results in Table 4.4 above show similarity with results in Table 4.3 for the severity of erratic rainfall. Table 4.4 shows that in general, most households were affected by erratic rainfall during 2019/2020 season. Results further show that most male-headed households were affected by erratic rainfall compared to female-headed households. In general, these results are complementing the historical data in Table 4.3 that depicts erratic rainfall as a key climate change related shock for most households. The early cessation of rains and

incidents of dry spells were the two main forms of erratic rainfall during the 2019/20 season.

These two incidents negatively affected both arable crops, especially maize (the main staple), and wetland crops, especially rice, because the early cessation of rainfall resulted in a rapid decline of soil moisture which caused wilting of the mid and late maturing rice varieties. The Agricultural Extension agent for the area indicated that precipitation stopped mid-February against the normal cessation time which is often at the end March. The shortening of the rainfall season therefore negatively impacted farming.

Table 4.4 shows that floods were another climate change related shock that affected the area. Analysis shows that most female-headed households were affected compared to male-headed households. Floods not only negatively affect farming but they also destroy houses and other useful infrastructure. During male FGDs, participants identified three points where Phalombe River floods into crop fields and settlement areas.

> "One point is far from our village but the other two are close and once water starts overflowing from those points they flood the villages all the way to the lake." [25 years old Male FGD participant (Standard 6)]

Results show that stormy rainfall also affected most of female-headed households during the 2019/2020 season in the study area. Stormy rainfall affects arable crops, especially maize, if they occur in the middle of the crop production period because they fell crops. I observed that although stormy rainfall caused maize to collapse, the damage was not severe because farmers were able to restore the maize by banding the ridges. Apart from damaging

the crops, respondents associated such a shock with houses collapsing and roofs blowing off, especially in the case of grass thatched houses.

> "As you might have seen, the majority of the people still live in grass thatched houses; it is these people that are often victims of stormy rains" [Village Key Informant – VCPC Chairperson].

Pest infestation, especially Fall Army Worms [*Spodoptera frugiperda*] (FAW), was the least impact of climate change identified in the study area during the 2019/2020 season. Most female headed households were affected by FAW compared to male-headed households. Both farmers and the extension agent indicated that dry spells cause double devastation from the wilting of crops to the multiplication of FAW, which destroy any maize that survives the wilting. Farmers indicated that FAW occur whenever they experience dry spells during the rainy season. However, during observation in September, it was noted that FAW was attacking maize during winter farming (See Appendix H). Farmers and extension agents alike said they are experimenting with various control mechanisms like using ash or fish soup since no clear solution has been identified yet.

4.7 Discussion

According to the Pressure Release Model, disasters are influenced not only by the physical environment but also deeply rooted in social systems. This section presents the discussion of the results and how research findings relate to this model. The discussion has been divided into four parts namely root causes of vulnerability; dynamic pressures; unsafe conditions and the climate change related hazards that are experienced in the study area.

4.7.1 Root causes of vulnerability

According to the Pressure Release Model (PAR), the root causes include economic, demographic and power processes, which affect the way resources are located and distributed among the social group of people. In this study culture, gender perceptions, type of soils in the study area and moisture availability in the wetland within the study area are underlying factors that determine susceptibility to climate change related shocks.

Uxorilocal post-marital residence is common in Phalombe district (Kishindo, 2014; Berge et al., 2014). This post marital settlement arrangement has its advantages and disadvantages, however from this study, it was observed that husbands under this arrangement are less motivated to make long term investments at the household and community level to minimize vulnerability to climate change related shocks (see also Ene-Obong et al., 2017). The unwillingness of men to, for instance, repair dykes to prevent flooding, reflects their low motivation to minimize vulnerability. Alternatives such as a neolocal arrangement that ensures a sense of belonging and neutrality in terms of resource ownership and control are available. However, incidents of selling land by chiefs in the area that was also reported by Kambewa (2006) in the same district prohibits the poor from adopting this option and thus limit their opportunities to reduce vulnerability.

Socially constructed exclusionary measures in fishing have been sustained throughout the history of the study area as a means to preserve traditional order and ideals. This study has confirmed the findings of both Chiwaula et al. (2012) and Manyungwa-Pasani et al. (2017)

who report male dominance in the Lake Chilwa fishing industry. Fishing is useful especially during the post rain-fed harvest period because food from production dips and fishing helps generate income to buy food. Food and income shortages due to climate change related shocks are therefore more severe in female-headed households because they cannot earn income from fishing during lean periods. Opportunities to participate in the higher value chain of the fish industry are available, but household and reproductive roles for women, in addition to cultural taboos, hinder their participation in the fishing industry.

Considering that main livelihood activities are rain-fed farming and small-scale irrigation, institutions that regulate land access and use are key to determining the extent of vulnerability to climate change shocks at both the household and community level. The current Land Act has measures that promote the acquisition of customary estates using formal procedures. Findings in this study show that the non-existence of customary estates enables traditional leaders to be renting out or selling land against the law. Findings of this study concur with Kambewa (2006) and Gausi and Mlaka, (2015) who reported similar incidents in Phalombe District and also Kishindo (2014) who reported the same in Balaka district. The current practices around customary land are thwarting expansion of agricultural production for resource poor households that largely depend on farming as a main livelihood activity. The practices also are hindering the relocation of people from flood prone areas, if they do not have enough financial resources to buy land in safer areas. These practices therefore are enhancing vulnerability to floods and also limiting the agricultural production capacity of the households

This study found that the study area is characterized by heavy clays. According to Sagona et al. (2016), Lake Chilwa wetland has heavy clays that have developed through erosion and deposition of clays from the upper catchment.

Heavy clays exhibit fluctuating characteristics under varying moisture levels (Petry & Armstrong, 1989). According to Gang et al. (2019), clays under heavy precipitation lose oxygen rapidly due to water logging, which results in crops drying. The varying characteristics of the clays magnify the impacts of floods and erratic rainfall because occurrence of either shock implies that the soil conditions will rapidly change, making maize growth difficult (Lone & Warsi, 2009). The varying characteristics of the soil are critical for maize production which is the main preferred staple but less problematic for rice especially in the event of floods (Singh et al., 2013; Wang et al., 2017). Declining moisture availability in the wetland has led to decline to irrigation output during winter thus exacerbating destitution once the area gets affected by erratic rainfall.

4.7.2 Dynamic Pressure

The premise of the PAR model is that different pressures over time drive vulnerability and root causes to set up dynamic pressures. In this study key factors that were identified as dynamic pressure include staple food preference and exploitative informal financial services.

The study established that Maize and rice are the main food crops identified in the area. Although it is relatively easy to produce rice considering that it does not need inorganic fertilizer, maize is preferred as a staple as it is the main source of flour for *nsima*. This

correlates with Pauw et al (2018) who indicated that *nsima* is the most preferred staple and regular meal in Malawi. This preference for maize results in "food insecurity" when climate related shocks have negatively affected maize production but not rice. Securing maize through the sale of rice, which is how local people respond, causes a loss of income and creates food insecurity because the rice-selling period coincides with the onset of maize scarcity. Sale of farm produce to buy food was also reported by Madsen et al (2021) who noted that farmers bought food from income they earned from surplus crop sales. Maize preferences reported in this study thus exacerbate vulnerability because households will not substitute rice for maize as a staple rather continue to strive to acquire maize even as production is declining due to the impacts of climate change.

Financial resources are very crucial in abating the impacts of shocks (Elasha et al., 2005). Availability of these resources determine flexibility and speed of recovery when livelihoods are lost due to the impacts of climate change (Driessen et al., 2018). Financial resources can be accessed from formal or formal lending institutions. The advantages of formal lending institutions include clear and affordable lending procedures and repayment conditions. Agrawala and Carraro (2010) indicated that formal financial institutions create support to enable locals to mitigate food and income shortages brought on by climate change. However, the absence of functional formal financial institutions in the study area has created informal exploitative financial arrangements that are deepening the vulnerability of resource poor people. Tchewafei et al. (2020) noted that informal money lenders enabled smallholder farmers acquire needed agricultural input inputs on time in Togo. However, Harvey (2022) in South Africa noted that borrowers from loan sharks were prone to extortion. Although borrowers in this study recognized the exploitative nature of

this arrangement, the increased frequency and intensity of the impacts of climate change have deepened chronic food insecurity which has eventually them to routinely depend on these loans.

The implication of being in such high interest loan cycles is continued loss of income which has rendered households incapable of exiting the vicious cycle of poverty that deepens their vulnerability to the impact of climate change.

4.7.3 Unsafe conditions

The geographical characteristics of the area determine the severity of the impacts of climate change (Ouma & Tateishi, 2014). For instance, low lying areas are characteristically prone to floods (Seenath et al., 2018). Rivers become shallower and thus prone to flooding in low altitude areas. Mohamed and El-Raey (2020) in Egypt reported that major flooding occurred in low lying districts compared to mid altitude and high-altitude areas. Areas close to outlets of rivers such as the study area therefore are prone to flooding. Government reports show that Phalombe and Shire valley districts have been the main flood affected districts in the southern region because of their terrain. Poor infrastructure and settling close to water bodies in such low-lying areas has therefore been the cause of higher statistics of flood victims. Previous studies have showed that local people resist relocating from these flood prone areas because of socio-economic and cultural values (Dewa et al., 2022). Rapid population growth and poor land conservation practices in the Lake Chilwa basin have also increased soil erosion in the upland and sedimentation of rivers downstream that increases the intensity of floods (Kambombe et al., 2018).

Like most of the rural communities in developing countries, the study area depicted high dependence on farming as the primary livelihood activity (Hadebe et al., 2017; Abegunde et al., 2019). Most of the households consider rain-fed crop production as the main livelihood activity which produces maize – the main staple food – and rice – the main commercial crop (Kambewa, 2016). Further to rain-fed crop production, the households also depend on irrigation farming along the wetland during the dry season (GoM/DSOER, 2012). Considering that Malawi experiences unimodal rainfall, rain-fed crop production is confined to a particular period of 3 to 4 months from December to March in the year, which implies that crop failure in this period results in food insecurity for the rest of the year.

Wetlands contribute to the livelihoods of millions of people in Sub-Saharan Africa through small-scale irrigation (Robelo et al., 2019). Although the majority of the households are increasingly depending on the wetland for small scale irrigation, the limited capacity of current irrigation technologies undermines their ability to achieve food security goals. The impacts of climate change, especially erratic rainfall, have reduced the availability of residual moisture and is the main challenge that affects crop yields cultivate in the wetland during dry season. The aforementioned challenges negate the potential of irrigation farming to minimize the severity of food shortages that are often being created by increased frequency and intensity of the impacts of climate change.

Fishing is another alternative livelihood activity that provides income and food to the households (Sene-Harper et al., 2019; Sanon et al., 2020). Proximity to the lake necessitates relatively higher dependence on the fish resources as a source of income (Chiwaula, 2012). Dependency on fishing has been declining due to increased population with a growth rate

of 3.0 for lake dependent population as well as overexploitation of fish resources in the Lake Chilwa (GoM/DSoER, 2012). The study established that there is partial dependency on fishing during the rainy season, which is also the fish breeding season, partly relieves pressure on fish resources; however, the unregulated use of fishing gear contravenes the possibility of sustaining the enterprise. The declining fish industry implies fewer alternatives to farming, which will worsen the vulnerability of households to the impacts of climate change.

Casual labor was also identified as the main secondary and tertiary livelihood activity in the area. Bezner-Kerr et al. (2019) noted that casual labor (*ganyu*) was the reliable source of food and income for vulnerable households especially during lean period. Casual labor has increasingly become a vital livelihood activity because of the declining productivity of rain-fed farming. Livelihood activities such as wetland cultivation and fishing have emerged as alternatives that help people to recover from food shortages and create additional labor demand for casual laborers. Wetland farming and fishing are the main sources of opportunities for casual labor. However, the decline of fishing and the susceptibility of farming to the impacts of climate change is minimizing opportunities for casual labor. The scarcity of casual labor opportunities as a consumption smoothing strategy during lean periods will deepen the destitution of vulnerable households.

4.7.4 Climate change related hazards

Malawi as a country is vulnerable to erratic rainfall, but some parts are more vulnerable than others (GoM, 2018). Phalombe district is highly vulnerable to erratic rainfall and drought (GoM/DSOER, 2012). Erratic rainfall negatively affects crop production and

consequently food security of the affected area. Svesve (2016) attributed food and income insecurity to erratic rainfall in the Lake Chilwa basin. Furthermore, erratic rainfall affects winter farming because of its high dependence on residual moisture (GoM, 2016b). The results of this study show that for the past decade incidents of erratic rainfall have been frequent and have affected a significant proportion in the district. Nathan et al (2020) found that there has been an increasing pattern of erratic rainfall in most parts of SSA. According to the IPCC, the atmospheric global mean temperatures over land and oceans have increased by 0.85 C over the last century, which has affected the frequency of erratic rainfall (IPCC, 2014). Findings from this study show that the area is vulnerable to erratic rainfall that negatively affects the majority of the households that depend on rain-fed farming.

Fall Army Worms (FAW) have been a relatively new climate change related impact for both rainfed and small-scale irrigation in the study area and the entire district at large. Although incidents of FAW date back several decades, there have recently been increased occurrences. According to the International Maize and Wheat Improvement Centre [CIMMYT] (2019) invasive insect pests and diseases are an emerging climate induced crop production limiting factor. The recurring incidents of FAW have become a persistent shock to maize production under both rain-fed crop production and irrigated crops during dry season. FAW is currently the most damaging crop pest affecting maize in Sub Saharan Africa (SSA), where it has spread very widely (Day et al., 2017; Kumela et al., 2019), including to Malawi.

Increased incidents of FAW infestation have contributed significantly to a reduction in maize production. According to D' Agate & Hills, (2018) FAW threatens food security because they swiftly move and destroy crops, causing a significant amount of damage in a short period of time. This reduction differed across districts, but for highly affected districts like Phalombe, yield reduction might have been higher. The consequences of FAW invasions on food security in the SSA region has been worsened by a lack of resistant/tolerant cultivars, and poor capacity to control and manage the pest (Harrison et al., 2019). According to Matova et al (2020) researchers are currently working on immediate and long-term solutions like pesticides to the FAW problem, while most smallholder farmers are relying on mechanical control methods. FAW is therefore likely to continue to cause maize crop losses in Malawi because of the suitability of its climate for the pest's growth and development and the lack of solutions (Keeton, 2018)

Stormy rainfall negatively affects the majority of people in low-income countries as lives, assets, and future prosperity are threatened (Simatele & Simatele, 2015). The extent of damage due to stormy rains is therefore significant and widespread because most of the houses in the study area are grass thatched. According to the Integrated Household Survey 5, about 57% of houses in Phalombe are either semi-permanent or traditional, and are usually built using mud or unprotected mud bricks often thatched with grass or reeds (NSO, 2020b). These housing structures often collapse or get damaged due to stormy rains. Such damage occurs in the middle of the rain-fed crop production season when labor and capital is invested in farming. These phenomena therefore stretch an affected household's ability to recover because of the scarcity of resources and the high demand for labor for rain-fed farming.

Floods cause the loss of livelihoods, decrease earnings, damage capital assets, and thwart the competences of preparedness, response, and recovery to posterior floods (Hossain et al., 2020; Jamshed et al., 2020). Although results show that floods are less frequent compared to stormy rains and erratic rainfall, they have higher intensity especially in the study area. Floods highly impact infrastructure, especially semi-permanent and traditional houses (Mavhura, 2017). The collapsing of such infrastructure along with washing away of crops doubles destitution as loss of houses creates immediate desperation while washing away of crops in arable fields or submerging of rice in the wetland creates food and income insecurity in the long run. Hossain et al (2020) reported that floods have a relatively higher impact on the sustainability of rural livelihoods because of their impact on multiple resources that enhance livelihood wellbeing. Smith and Frankenberger (2018) also associated floods with not only a reduction in food production but also the erosion of capital assets that might have been accumulated over time.

Results show that the impacts of climate change can occur independently or concurrently. For instance, the 8 years data in Table 4.3 shows that 2012/13, 2015/16 and 2016/17 are the only years that the three impacts of climate change did not occur concurrently. These results therefore show that various livelihoods of the rural population are affected by multiple shocks within a given period. It is therefore obvious that the concurrence of the above-mentioned impacts creates multiple vulnerabilities, considering how various livelihood assets and activities are simultaneously impacted within the same period. The analysis and management of the impacts of climate change should therefore not only focus

on the impacts of each shock. They should also consider the concurrence of the impacts and the multiple vulnerabilities they create.

CHAPTER 5

ROLE OF LIVELIHOOD ASSETS IN CLIMATE CHANGE RESILIENCE

5.1 Introduction

This chapter presents the findings that help answer the questions of how the livelihood assets are distributed between male- and female-headed households and how they contribute to recover from the impacts of climate change. Drawing from the capital-based approach (Figure 2.1), this chapter seeks to unravel how households re-organize and revert to pre-shock food security status using livelihood assets in a given period. The choice of time to restoration of food security status was based on literature that shows that food sufficiency is the primary goal of most livelihood activities in rural areas of most developing countries (Gecho et al., 2014; Conceição, et al., 2016; Gassner et al., 2019).

The section starts with presentation of the findings on descriptive statistics of variables that have been selected for estimating indices for the five (5) assets categories of the sustainable livelihood framework. Details of categorization of indicators into asset categories are in appendix G. The analysis compares the variables between male- and female-headed households.

The section further compares the indices for the asset categories between male- and female-headed households. Lastly, the section presents a regression analysis of the time to recovery from the impacts of erratic rainfall and floods against the 5 asset indices of the livelihood assets.

5.2 Descriptive statistics for various assets

The descriptive analysis was done to summarize quantitative variables that constitute the livelihood asset indices. All the analyses were segregated by gender to estimate quantitative distribution of the variables between male- and female-headed households. Below is the summary for the analysis of continuous variables.

Table 5. 1 Independent t-test for the continuous variables

Variable	Male	Female	t - value	Sig
Productive assets (MK)	64142.06 (109849.91)	39259.18 (85865.1)	1.586	0.116^{ns}
Livestock value (MK)	50198.16 (149709.49)	59428.57 (116314.69)	0.36	0.720^{ns}
Habitable houses (Number)	1.19 (0.43)	1.13 (0.34)	1.188	0.236^{ns}
Education (Years)	4.15 (3.38)	2.58 (3.09)	3.452	0.001***
Labor (people 15 – 64 Yrs)	2.06 (1.02)	1.66 (0.91)	2.928	0.004***
Social capital (People)	1.55 (2.38)	3.51 (4.14)	3.81	0.000***
Regular income (MK)	21984.78 (22498.46)	13655.07 (11157.11)	3.609	0.000***
Savings (MK)	18375.76 (18820.63)	23082.35 (15404.88)	0.947	0.349^{ns}
Distance to water (m)	146.78 (174.68)	133.87 (145.33)	0.537	0.592^{ns}

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01) figures in parenthesis are standard deviation (SD)

The value of productive household assets; value of livestock and number of habitable houses constituted the physical assets index. The results show that male-headed households had a slightly higher value of productive assets although comparison of the means shows no statistically significant difference between the two. The value of livestock for female-headed households was relatively higher compared to male-headed households, however, the comparison between the two shows no significant difference. Furthermore, Table 5.1 above shows that male-headed households had more habitable houses compared to female-headed households although analysis shows no statistical difference between the two. Qualitative data showed that ownership of productive assets between male and female-headed households might have been comparable due to cultural traditions around the dominant post marital settlements (uxorilocality).

The educational level of the household head and available household labor partly constituted the human asset index. Table 5.1 shows a statistically significant difference in the average number of schooling years between male- and female-headed households. On average, male heads had more years of formal education compared to female heads. During one-on-one interviews, female respondents indicated that various challenges like lack of menstrual hygiene materials; household chores and the need to take care of younger siblings when parents have gone to fend for the family causes girls to withdraw from formal education a bit earlier compared to boys. Table 5.1 shows that male-headed households have a significantly higher number of people who can work and contribute towards the household's food and income needs compared to female-headed households. Based on the observations during PO, most of the reliable members of the households are the parents and older children. Separation, divorce, or widowhood often implies reduction in the

number of productive laborers. The implication was therefore reduction in household labor that provides for the household in female-headed households.

The number of families and friends within and around the village that can support the household in times of a shock partly constituted the social assets index. Table 5.1 shows that female-headed households have a significantly higher number of friends and relatives they can depend on in times of shocks compared to male-headed households. The dominant uxorilocal post – marital settlement implies that women or wives live among their relations while husbands live amongst somehow strangers or distant relations. Although it is assumed that upon marriage, the husband may equally consider his wife's relations as his own, comments from participants during both male FGDs showed that males under uxorilocality consider themselves as almost strangers.

The income from regular and reliable sources as well as savings also partly constituted the financial index. Table 5.1 shows that male-headed households earn significantly higher incomes on a regular basis compared to female-headed households per month. However, results show no significant difference savings between male-headed households and female-headed households although male-headed households had higher savings.

Distance to the water source was one of the variables under the natural assets index. As earlier mentioned, most of the plot owners along the wetland land either depend on residual moisture or traditional technologies to irrigate crops during the dry season. Common technologies observed during PO include using watering cans and pails. With such technologies, proximity to water bodies was a crucial factor that determined the possibility of irrigation. Analysis shows no significant difference in the distance from the water bodies

(Lake or Phalombe River) to their respective fields between male- and female-headed households.

Apart from the continuous variables, the computation of the assets indices also included categorical variables. These variables were analysed by percentage distribution and chi square estimations. Table 5.2 presents a summary analysis of the percentage distribution of the categorical variables between male- and female-headed households.

Table 5. 2 Proportional distribution of categorical variable

Variables	Male headed household		Female headed household		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Incident of sickness	56	40	17	22.1	73	33.6
Fishing	58	41.4	2	2.6	60	27.6
Membership to groups	99	71.2	52	68.4	151	70.2
Membership to saving groups	33	23.6	17	22.1	50	23
Got *Katapila* (high interest loans)	80	57.1	41	53.2	121	55.8
Own land (Arable)	132	94.3	68	88.3	200	92.2
Own land (Wetland)	120	85.7	66	85.7	186	85.7

In addition to the number of schooling years for the household and the available household labor, incidents of sickness during farming season was included in the human assets index. Labor shortages due to the sickness of a productive member impact household agricultural outputs for that particular year. The study area is within Lake Chilwa wetland and known for water and vector borne diseases such as cholera, malaria, and bilharzia (GoM/DSoER, 2012). The results in the table above show that 40% of male-headed households had a sick person in the household compared to 22.1% for female-headed households. Chi square analysis in Table 5.3 shows a statistically significant difference in the reported incidents of sickness between male and female-headed households. Water and vector borne diseases, especially cholera, were listed among key shocks that affected the study during the FGDs with males.

Table 5. 3 Chi square estimates for the categorical variables

Socio-economic Factors	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Sickness during farming season	7.148	1	0.008^{***}	0.18
Fishing	43.499	1	0.000^{***}	0.448
Village groups	0.185	1	0.668^{ns}	-0.029
Savings group	0.062	1	0.803^{ns}	0.017
Got Katapila	0.308	1	0.580^{ns}	0.038
Own land (Arable)	2.455	1	0.117^{ns}	0.106

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

A household's participation in fishing also constituted the natural assets index. Chi square analysis in table 5.3 shows a significant difference between male- and female-headed households.

Even though females are traditionally excluded from fishing it was learnt during male FGDs that women can participate in the higher level of the value chain like processing and selling in local markets, although their participation is low.

The social assets index also comprised membership of the household in local groups such as farmer groups. These groups are channels through which knowledge and social support flow in the community. In general, about 70.2% of the respondents acknowledged that they were members of local groups. 71.2% were from male-headed households while 68.4% were from female-headed households. Chi square analysis shows no significant difference in membership to local groups between male- and female-headed households. No specific gender related restrictions to join local groups was either reported during interviews and discussions or observed during PO.

The membership of a household in savings groups also constituted the financial assets index. Table 5.2 shows that 23.6% of male-headed households had a member in savings groups compared to 22.1% in female-headed households. Chi square analysis shows no significant difference in membership in financial groups for male- and female-headed households. During PO it was observed that the area had two village savings and loans (VS&L) groups but were only patronized by women. Inquiries on the gender sensitivity of the VS&L groups revealed that males were excluded due to previous incidents of unwillingness to repay the loans. However, interested men were involved through female members of their households. This might explain the comparable distribution of membership to savings groups for male- and female-headed households. Getting loans or usury called *katapila* from informal moneylenders also constituted the financial assets

index. Table 5.3 shows no statistically significant difference between male- and female-headed households who got a loan from an informal moneylender.

The ownership of arable land and plots along the wetland also constituted the natural assets index. Results in Table 5.2 shows that almost all the households owned a plot or more at the wetland with no statistically significant difference. It was observed that along the wetland, tenure rules are dynamic, and the chief may rent out or sell underutilized plots. Therefore, dynamic land allocation arrangement might explain why land ownership along the wetland was comparable.

5.3 Gender disparities on access to livelihood assets

The variables discussed section 5.2 were standardized and calculated into indices based on the five assets groups articulated in the conceptual framework (section 2.7). The available assets determine the choice of livelihood activities that a household pursues in trying to recover from the impacts of climate change. Figure 5.1 shows differences in ownership of assets for male- and female-headed households.

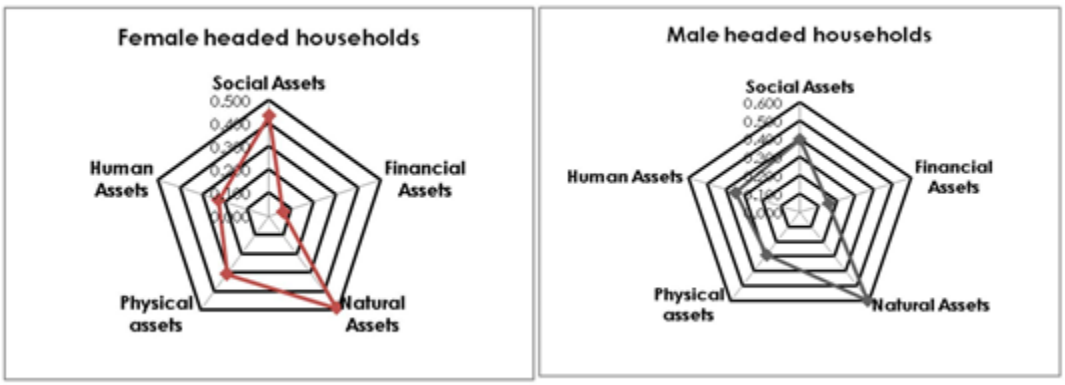

Figure 5. 1 Spider diagram of livelihood assets for male and female headed households

The spider diagrams above present the relative distribution of assets for male- and female-headed households. The diagrammatical presentation shows similar assets distribution for the natural, physical and human assets. The differences are observable for the financial and social assets. To further analyze the different assets endowment between the two types of the households, independent t-test of the means for each assets index was done. Table 5.4 below presents the results of the analysis.

Table 5. 4 independent t-test of assets indices

Asset categories	Male headed	Female headed	t	df	Sig.
Human assets	0.346 (0.175)	0.227(0.155)	4.963	215	0.000***
Financial assets	0.156(0.160)	0.062(0.043)	5.038	215	0.000***
Natural assets	0.593(0.158)	0.488(0.117)	5.076	215	0.000***
Physical assets	0.287 (0.166)	0.307(0.145)	-0.906	215	0.366^{ns}
Social assets	0.396(0.229)	0.435(0.285)	-1.081	215	0.281^{ns}

ns = Not significant, * significant at 10% ($p < 0.1$), ** significant at 5% ($p < 0.05$), ***significant at 1% ($p < 0.01$) (figures in parenthesis are Standard Deviations)

5.3.1 Human assets

Table 5.4 shows a significant difference in human assets between male- and female-headed households. Male-headed households exhibit a significantly higher human resource compared to female-headed households. Most of the respondents in qualitative data cited human assets as key in times of food shortage because the households are able to simultaneously engage in multiple alternative livelihood activities to source food and income. Therefore, if more people work, more income and food are sourced and vice versa.

5.3.2 Financial assets

The analysis shows a significantly higher financial base for male-headed households compared to female-headed households. A higher financial assets base for male-headed households might have come from lucrative enterprises such as fishing. Although financial assets are considered flexible and easy to use within a short period after a shock, qualitative data showed that such assets are rather elusive because they can be used for non-shock recovery expenses such as leisure, especially among male heads.

5.3.3 Natural assets

Results in Table 5.4 above show a significantly higher natural assets index for male-headed households compared to female-headed households. As earlier discussed in section 5.3, access to natural assets, especially land, may be skewed towards females, considering the dominant post marital settlement tradition in the area. However, the exclusion of women from fishing might have been the major contributor towards a higher natural asset index for male-headed households in the area.

5.3.4 Physical assets

The results in Table 5.4 showed no significant difference in the physical assets index for male- and female-headed households. This implies that neither male- nor female-headed households have superiority in terms of access to physical assets. The chief indicated that under the dominant uxorilocal post marital settlement in the area, after divorce or separation, the husband is only allowed to leave with assets he brought into the marriage. Similarly, in case of death of the husband, his relatives are only allowed to inherit assets the husband owned before marrying. The implication is that women eventually inherit almost all the assets that might have been accumulated together with the husband while they were married. This might be the reason for the comparative physical assets endowment between male- and female-headed households.

5.3.5 Social assets

Table 5.1 shows that females have stronger networks of friends and relatives within their locality owing to the uxorilocal arrangement that required men to travel and settle in their wives' villages. However, other variables such as membership in social and religious groups might have levelled the social assets gap for male-headed households. The non-relation ties might be the crucial social capital they may depend on in times of climate-induced shock. An independent t-test in Table 5.4 shows that there was no significant difference in access and use of social assets by male- and female-headed households.

In summary, the results in sections 5.2 and 5.3 show that the distribution of assets to male- and female-headed households varies significantly between male- and female-headed households. Furthermore, the availability of livelihood assets for a given household is influenced by underlying institutional, gender and cultural traditions.

5.4 Gender differences in the contribution of livelihood assets to resilience

In order to understand how livelihood assets contribute towards recovery from the impacts of climate change related shocks, the study inquired about the number of months from the onset of the impacts of floods and erratic rainfall to the time food security is restored. Choice of the two impacts of climate change was based on historical data which shows that erratic rainfall and floods have been the most persistent and severe shocks in the previous decade. The period to recovery ranged from the time the shock (erratic rainfall and floods) occurred to the restoration of pre-shock food security status. Table 5.5 shows analysis of the period to recovery in months for male- and female-headed households.

Table 5. 5 Period to recovery for male and female-headed households after experiencing erratic rainfall and floods in months

Period to recovery (Months)	Male headed	Female headed	T - Statistic	df	Sig
Erratic rainfall	3.49 (1.958)	3.35 (2.043)	-0.118	214	0.906^{ns}
Floods	3.23 (1.943)	4.13 (2.572)	-2.906	215	0.004^{***}

ns = Not significant, * significant at 10% ($p < 0.1$), ** significant at 5% ($p < 0.05$), ***significant at 1% ($p < 0.01$). Figures in parenthesis are Standard Deviations (SD)

Table 5.5 above shows that male-headed households recover relatively quicker from the impacts of floods compared to female-headed households, however, there was no significant difference in the period of recovery from the impacts of erratic rainfall between the two types of the households.

5.4.1 Implications of livelihood assets on recovery from erratic rainfall

In order to determine how livelihood assets contribute towards recovery from erratic rainfall, a simple linear regression was used with time (in months) to recovery as the dependent variable and the five (5) livelihood assets indices as independent variables. The results are in Table 5.6.

Table 5. 6 Regression output recovery from erratic rainfall by gender

Variables	Male headed households			Female headed households		
	Coef.	t	P value	Coef.	t	P value
Natural assets	-1.851	-1.87	0.063*	-1.684	-0.93	0.358
Social assets	-2.510	-3.72	0.000***	-3.039	-4.06	0.000***
Financial assets	2.421	2.49	0.014**	-7.919	-1.62	0.110
Human assets	-1.443	-1.63	0.105	-3.102	-2.23	0.029**
Physical assets	-1.207	-1.29	0.198	-2.130	-1.45	0.151
Constant	6.054	8.27	0.000***	7.512	6.57	0.000***
Significance levels * significant at 10% ** Significant at 5% ***Significant at 1%						

Number of observations= 140

R-squared= 0.167

F (5, 134) = 5.36

Prob > F = 0.000

Number of observations= 76

R-squared= 0.258

F (5, 70) = 4.87

Prob > F = 0.000

The regression analysis results for both male- and female-headed households show that the model is broadly consistent with the estimated results. The model output shows that livelihood assets indices explain approximately 17% of the variance of dependent variables for male-headed households and 26% for female-headed households. The Variance Inflation Factor (VIF) for the model was 1.13 for male-headed households and 1.14 for female-headed households, which implies the non-existence of multicollinearity. In general, regression output shows that livelihood assets contribute to recovery from the impacts of erratic rainfall. Signs on the coefficients show the direction of the relationship, while magnitude suggests the effects on recovery from the impacts of erratic rainfall.

Table 5.6 shows a negative and significant correlation between natural and social assets to the period of recovery from erratic rainfall unlike a positive and significant correlation with financial assets for male-headed households. The results show that a unit increase in the natural assets index for male-headed households can decrease the recovery period by about 1.8 months while a unit increase in the social assets index can decrease the period of recovery from erratic rainfall by 2.5 months. Furthermore, a unit increase in financial assets increases the recovery period from erratic rainfall by about 2.4 months for male-headed households.

Analysis shows that there is a negative and significant correlation between social and human assets to the period of recovery from erratic rainfall for female-headed households. A unit increase in social assets decreases recovery time by about 3 months while a unit increase in human assets decreases the recovery period from the impacts of erratic rainfall by 3.1 months. Unlike for male-headed households, human assets were relatively more important for the recovery of female-headed households from the impacts of erratic rainfall. This phenomenon thus shows that human and social assets are crucial for recovery from the impacts of erratic rainfall for female-headed households.

5.4.2 Implications of livelihood assets on recovery from floods

An analysis for the contribution of livelihood assets to recovery from floods was also done. Table 5.7 shows analysis of the outputs.

Table 5. 7Regression output recovery from floods by gender

Variables	Male headed households			Female headed households		
	Coef.	t	P>t	Coef.	t	P>t
Natural assets	-1.085	-1.07	0.286	-3.645	-1.58	0.118
Social assets	-1.835	-2.65	0.009**	-3.803	-4.03	0.000***
Financial assets	1.258	1.26	0.210	0.562	0.09	0.927
Human assets	-1.599	-1.76	0.080*	-4.108	-2.33	0.022**
Physical assets	1.964	2.05	0.042**	-2.162	-1.17	0.247
Constant	4.393	5.85	0.000***	9.129	6.34	0.000***

Significance levels * significant at 10% ** Significant at 5% ***Significant at 1%

Number of observations= 140
R-squared= 0.108
F (5, 134) = 3.26
Prob > F = 0.008

Number of observations= 77
R-squared= 0.248
F (5, 71) = 4.70
Prob > F = 0.000

The regression model results for both male-headed and female-headed households show that the model is generally consistent, suggesting the estimated results are reliable. The model output shows that livelihood assets explain approximately 11% of the variance of dependent variables for male-headed households and about 25% for female-headed households. Variance Inflation Factor for the models was 1.14 and 1.12 for male- and female-headed households respectively. The VIF shows no problem of multicollinearity. In general, regression output shows that livelihood assets contribute to recovery from the impacts of floods for both male- and female-headed households.

Social and human assets depict a significant and negative correlation with the recovery period from floods while physical assets depict a positive and significant relationship for male-headed households. The results show that a unit increase in social assets will decrease the recovery period by 1.8 months, similarly, a unit increase in human assets will decrease the recovery period from the impacts of floods by 1.6months. However, the results show that a unit increase in physical assets will increase the recovery period by 1.9 months. Results show that the health of household members during crop production and the number of available productive members of the household are important in recovery after experiencing floods. The VDC chairperson aged 52 years indicated that human assets were critical to recovery from floods because of the need for labor to restore livelihoods after a shock.

Table 5.7 shows that social and human assets have a significant but negative correlation to the period of recovery from the impacts of floods. A unit increase in social assets will reduce recovery period from floods by 3.8 months while a unit increase in human assets will decrease recovery period by 4.1 months. These results suggest that female-headed households highly depend on a network of relations and friends as well as household labor endowment to recover from floods.

5.5 Discussion

5.5.1 Assets distributions between male and female headed households

Access and use of livelihood assets are critical for the resilience of rural livelihoods that are vulnerable to the impacts of climate change. Recovery from the impacts of floods and

erratic rainfall rely on resource endowment that enable households to acquire food and income after being affected by the shock (Asmamaw et al., 2019; Gyawali et al., 2020). The assets also determine the choice of recovery strategies and consequently the period to restore food security status. Male- and female-headed households in Phalombe district access different assets differently owing to historical, socio-cultural and economic factors. This discussion therefore seeks to unravel how male- and female-headed households compare/differ on access and use of the livelihood assets for resilience.

5.2.2 The impact of human assets on resilience

Human assets play a vital role in sustaining livelihood (Elasha et al., 2005). The finding in this study concurs with studies in South Africa and Ghana that reported higher human assets in male-headed households than female-headed households (Flatø et al., 2017; Kpoor, 2019). Graetz et al. (2018) found that male-headed households exhibit higher education attainment compared to female-headed households in most African countries. In terms of health, the Integrated Household Survey [IHS5] reported 10.8% incidents of chronic illnesses in female-headed households compared to 7.9% in male-headed households (NSO, 2020b). This study found that male-headed households had about 4.85 members compared to 4.07 for female-headed households. This is similar to IHS5 that showed that male-headed households have about 4.6 people compared to 3.9 for female-headed households (NSO, 2020b). These findings therefore show that male-headed households are better resourced to manage climate change related shocks using human assets than are female-headed households.

The human assets were found to be vital for recovery from erratic rainfall for female-headed but not for male-headed households. However, the same were vital for recovering from floods for both male- and female-headed households. A study in the Philippines by Uy et al. (2011) found human assets to be significant for enhancing climate change resilience. In the same way, a study by Eriksson et al. (2017) in Vanuatu found that human assets are crucial for recovery from the impacts of climate change. Findings from this study show that female-headed households are more dependent on human assets to recover from both shocks because of their pre-existing labor constraints while male-headed households have more labor that becomes critical only when floods destroy their infrastructure.

5.2.3 The impact of social assets on resilience

Social assets form a basic network for rural households to draw various resources and recover from a shock (Endris et al., 2018). In this study there was no statistically significant difference in distribution of social assets between male- and female-headed households. Nguyen et al (2018) found that rural households rely on complex social networks largely comprised of family and friends who mobilize support to enable a household to recover from a range of shocks. However, Pour et al (2018) found weak social assets endowment amongst natural resources dependent communities. Dependence on such networks is determined by complex socio-cultural factors that can either impede or enhance resilience. According to Cerrato and Cifre (2018), males easily connect with a wider community because of their ease of mobility unlike adult females, who often strongly connect with smaller networks within the community. This finding therefore implies that social assets are evenly distributed between male- and female-headed households.

The contribution of social assets to recovery from the impacts of erratic rainfall and floods was found significant for both male- and female-headed households. Social networks are one of the main sources of support in rural communities in times of shocks (Smith et al., 2012; Ntontis et al., 2020). According to Uy et al (2011) strengthening social networks helps households to diffuse the impacts of climate induced shocks. However, MacGillivray (2018) reported there is a non-monotonic relationship between social capital and disaster resilience. The findings here nonetheless suggest that social networks are key assets that locals depend on to recover from the impacts of climate change.

5.2.4 The impact of natural assets on resilience

Rural households in developing countries highly depend on natural resources for survival and recovery from climate change related shocks (De Silva & Kawasaki, 2018; Brown et al., 2019). Berge et al (2014) found that women have more access to land in Phalombe because of uxorilocality. However, there have been increased incidents of sale of customary land as reported by Kambewa (2006) and Chiwaula et al (2012) which has enabled male-headed households to own land under uxorilocal traditions. Findings from this study concurred with Chiwaula (2012) who found male dominance in fishing around Lake Chilwa. These studies therefore show that male-headed households have better access to natural resources that can enable them to manage climate change related shocks better than female-headed households.

Natural assets contribute significantly to recovery from the impacts of erratic rainfall for male-headed households, unlike for female-headed households. Uy et al. (2011) found that natural assets enhance household resilience to shocks.

Similarly, Quandt (2019) observed that natural capital plays a crucial role in building climate change resilience. Results show that since males have unrestricted access to the lake, unlike females, fishing generates for the resources that help them to quickly recover from the impacts of erratic rainfall. These results therefore show that higher access to natural assets by males enhance their ability to recuperate after a shock, unlike female-headed households.

5.2.5 The impact of physical assets on resilience

Physical assets comprise household possessions that are owned as valuables. Physical assets play a vital role in abating the impact of shocks (Hedner et al., 2011). Male- and female-headed households have comparable physical assets. This contradicts findings by Gaddis et al. (2018) who reported that male-headed households are known to own relatively more household assets than female headed households. However, uxorilocal arrangements that are commonly followed in the study area might have caused female-headed households to equally retain higher proportion of household assets in instances of divorce, separation or even death. This implies that both male- and female-headed households have equal bases of physical assets to draw from incase of being affected by climate change related shocks.

Physical assets were found to significantly contribute to a longer period to recovery from floods by male-headed households. Floods wash away crops and damage household assets such as livestock and houses. It was noted that husbands under uxorilocal arrangement were less committed to asset accumulation and long-term investments at the household level.

A study in a Nigerian matrilocal society reported that males were less committed to their families and the village in general because of a low sense of security on their investments (Ene-Obong et al., 2017). The same was echoed during this study where the chief cited the low commitment of men to their families and to village development activities. Physical assets therefore do not significantly contribute towards recovery from floods and erratic rainfall in male-headed households.

5.2.6 The impact of financial assets on resilience

Financial assets are a readily available source to offset losses that are experienced due to various shocks (Jezeer et al., 2019). Results show that male-headed households have a significantly higher financial base than female-headed households. Kpoor (2019) found that male-headed households have relatively higher financial assets than female-headed households in Ghana. Idris (2018) also noted that males easily source financial assets because of their ability to pursue alternative and lucrative livelihood activities, unlike their female counterparts who are largely burdened with household chores in Tanzania. These results therefore show that higher financial resources for male-headed households increase their capability to manage climate change related shocks, unlike female-headed households.

The results also show that financial assets delay recovery from the impacts of erratic rainfall for male-headed households, unlike for female-headed households. A study in Southeast Nigeria found that expenditure and savings patterns for male heads are often focused on immediate consumption needs while the rest of the earnings can be spent outside their homes (Opata et al., 2020).

In this current study financial assets however, do not significantly contribute towards recovery from impacts of floods for both male- and female-headed households. Although financial assets are known to have higher flexibility to be converted to food and other vital assets after the shocks, this study shows that they have lower usefulness in recovery as they can be used in non-recovery expenses.

CHAPTER 6

ROLE OF INSTITUTIONS ON CLIMATE CHANGE RESILIENCE

6.1 Historical evolution of formal land institutions

Formal institutional approaches to customary or informal institutions on land dates back to the establishment of colonial government of Nyasaland in 1891. The colonial administration adapted the British Land laws which formed the basis for categorizing land tenure systems (Mbalanje, 1982). The colonial government recognized public land which was meant for government infrastructure and use; private land which was predominantly owned by white settlers who used the land for commercial farming, and African Trust land or customary land (Pachai, 1973).

Colonial land laws considered customary tenure as traditional lands or African Reserves, which eventually was set aside in 1913 and eventually redefined as African Trust Lands in 1936. Customary land was recognized as African Land Trust under the jurisdiction of traditional leaders, clan heads and individuals of African descent (Ng'ongola, 1967). The colonial Land Ordinance of 1951 recognized customary land as a subset of public land (Mbalanje, 1982). Customary tenure was considered as strictly usufruct or "occupation rights' ' because it was deliberately to discourage the establishment of land rights equivalent to freehold or the concessions claimed by the white settlers (GoM, 2002).

Regardless of the changes by colonialists, local institutions on customary land were maintained. Both patrilineal and matrilineal communities maintained their institutions and local leaders held the rights to allocate land to their subjects (Tembo & Oltedal, 2015).

Prior to the formulation of the first post-colonial land related laws, the Arusha conference in 1961 cited a defect and the uncoordinated customary tenure system in Malawi as a hindrance to individual ownership of land (Ng'ong'ola, 1982). The conference cited insecure tenure under the matrilineal customary traditions as a main deterrent to significant land investment, considering the emerging economic and demographic changes that followed as African countries started to integrate into the world economy (Mbalanje, 1982). The Ministry of Agriculture in Malawi, however, ignored the conference report citing significant agricultural progress in regions characterized by matrilineal systems unlike where patrilineal systems were prevalent (Ng'ong'ola, 1982). Hesitancy to allow individual ownership of land sustained customary institutions, which persisted under customary tenure to present.

The dawn of independence was marked by enactment of two land related laws namely the Registered Land Act 1965 and the Customary Land Development Act 1967 (GoM, 2002). In order to improve integration into the market economy, the Customary Land Development Act primarily aimed at allocating individual land titles to households (Ng'ong'ola, 1982). The experimental implementation of the Act in a matrilineal society of Lilongwe west however failed to achieve its objective because of, among other factors, resistance of people to alter their informal land related institutions/customs to facilitate individual land ownership within customary tenure (Mbalanje, 1982; Pachai 1982).

Consequently, the implementation of the Act resulted into the formalization of clan based rather than household or individual based ownership.

The advent of multiparty in 1994 renewed the quest to reform customary land related institutions. The government acknowledged existing malpractices related to customary land due to unclear laws (GoM, 2002). Regardless of the previous failed attempt to formalize land ownership, the National Land Policy 2002 once again aimed at promoting private land ownership under customary tenure on culturally acceptable terms.

The 2002 Land Policy promoted the comprehensive registration and titling of customary land parcels called customary estates. The policy permitted the granting of exclusive usufructuary rights in perpetuity to individuals or to a corporate entity such as a family, clan, or group where land rights depend on membership of the group regardless of gender (GoM, 2002). The owner was to have full legal status with the right to lease or use as collateral. The policy however, prohibited the sale of land to persons other than members of the lineage group in the first five years following the establishment of a customary estate. Traditional leaders and clan heads were tasked with the role of allocating vacant land and adjudicating land related cases within their jurisdiction but not on customary estates. The policy indicated that there should be Customary Land Committees which were tasked to facilitate the allocation of customary estates at the local or village level while customary land tribunals were to adjudicate customary estates related cases.

The National Land Policy 2002 was operationalized by the National Customary Land Act 2016.

The 2016 Act elaborates mechanisms and statutes for acquiring customary estates. Unlike the 1965 Land Act, where the traditional leaders were to be involved in allocating land, the 2016 Customary Land Act empowers the democratically elected Customary Land Committee to allocate land using formal application procedures. The Act further indicated that adjudication of disputes related to customary estates are to be done in a transparent manner by a Customary Land Tribunal within the village with the provision of appealing its decision to the District Land Tribunal or further to the Central Land Board and finally to the High Court.

In summary, colonial policies did not largely focus on customary land because they mainly focused on private land and its conflicts between estate owners (white settlers) and indigenous people residing on the estates under different conditions (Pachai, 1982). Secondly, the African Land Trust was considered a subset of government land thus it was not considered as a source of major attention because it was managed by traditional structures. Implementation of early post-colonial laws to promote individual ownership encountered difficulties and failed to materialize. In the democratic era policies and acts have stipulated a renewed quest to promote individual ownership of land under customary tenure in the 2002 Land Policy and the 2016 Customary Land Act. In a nutshell, the formal institutions have been transforming, although at a slower pace, towards individual ownership of land.

6.2 Historical evolution of informal (customary) land related laws

During the 1930s several tribes migrated from Mozambique into Nyasaland (Kalinga & Pike, 2000). Regardless of the inheritance and post marital settlement traditions, land was communally owned (Boeder, 1984). Traditional leaders were responsible for allocating land to family or clan heads who subsequently allocated it to their family members. Family or clan heads had the right to exclude others from using the land within their jurisdiction as it was perceived to be their perpetual inheritance (Elias & Akinjide, 1988). Ownership of clan land by an individual or a household was not fixed, rather access and use of land depended on continued use and/or continued status of belonging to the clan (Mbalanje 1982; Kishindo, 2014). These traditions governed all land within Nyasaland during the pre-colonial era.

Throughout the period of colonial rule, customary land was considered as African Trust Land and the colonial administrators recognised the traditional institutions that guided management of customary land (Pachai, 1982). Patrilineal and matrilineal traditions governed land inheritance and its administrations to the dawn of independence. Throughout the period of one party rule from 1963 to 1994, national land laws were changed to suit emerging developmental needs. However, most of the laws barely affected customary land related institutions. The Traditional Authorities were considered as stewards and they administered customary land affairs using traditional institutions on behalf of the Government (GoM, 2002).

Although traditional institutions that guide customary land have persisted over time, various socio-economic, demographic, and environmental dynamics have exerted pressure on the institutions (Place & Otsuka, 2001). For instance, a study by Kishindo (2014) reported sale of customary land in a matrilineal community of Balaka district. Furthermore, studies by Kambewa (2006) and Chiwaula et al. (2012) have also reported similar incidents in the Lake Chilwa basin. Procedures of selling customary land may vary across time and space; however, evidence shows that locals have created local mechanisms for trading land rights. Kishindo (2014) noted that the authority to sell land is borne out of traditional practices that legitimize their sense of ownership of land.

Literature shows that although formal institutions delayed in formalizing individual land ownership rights under customary tenure, informal institutions steadily responded to the demand in the land market (Kishindo, 2014). The failure of formal institutions to solve conflicts on traded customary land further showed that trading of customary land was happening without formal institutions in place. This phenomenon was evident in the legal case in which the trading of land was contested in the court of law (*Kuwali vs Kanyashu*). The case involved a dispute over the ownership of customary land which the claimant contested to have inherited it from her parents while the defendant claimed to have bought it from the relations of the claimant. The court however disputed the buying claim since at that time no one could have title over customary land.

6.3 Description of the land tenure systems in the study area

Three tenure regimes were identified in the study area. The respective tenure arrangements are distinctly different and result from the evolution of customary land institutions over time. To illustrate the three different land tenure regimes in the study area, a map was created as depicted in Figure 6.1.

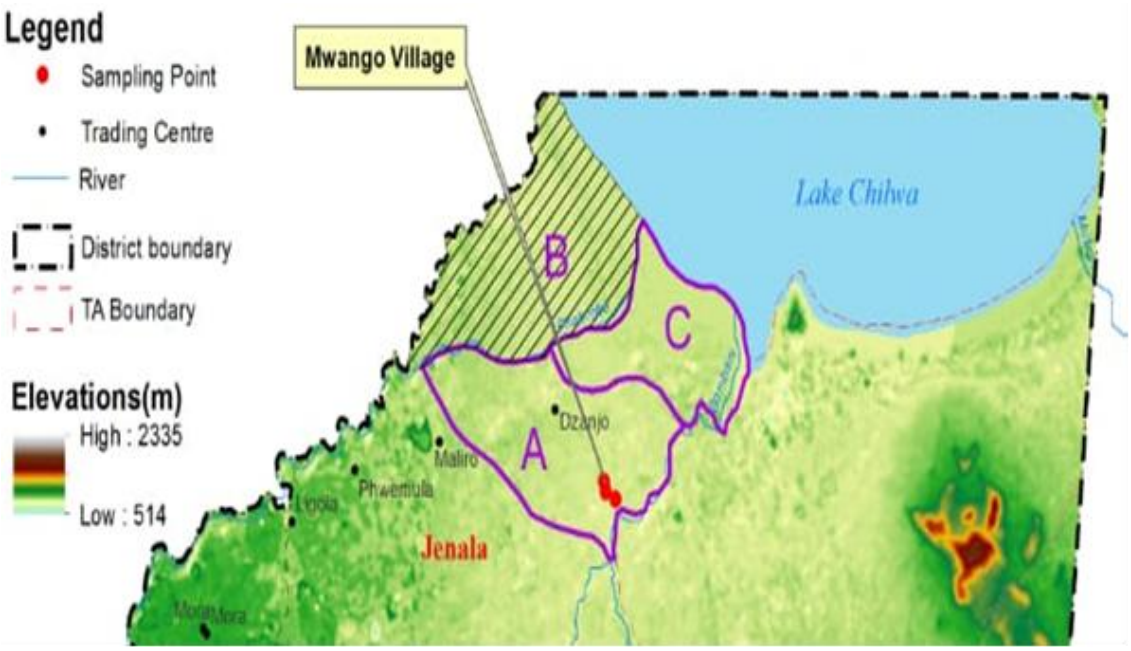

Figure 6. 1 Map of the study area showing land sections under different tenure systems

Section A in Figure 6.1 is the arable land within the village. This section of the village has the oldest and most traditional land ownership rules compared the other two sections B and C. In section A, the initial settlers got land from the Traditional Authority, who allocated the clan head (*Mwinimbumba*) land where he and his clan members settled. In keeping with Lhomwe culture, land has been passed on through a matrilineal system of inheritance.

Under this system, land belongs to the clan but individual parcels within it are inherited by women and girls while their husbands only have user rights. Although land parcels are inherited by women and girls, they (women and girls) do not retain unilateral ownership rather decisions like renting out and subleasing require approval of the entire clan. Under the matrilineal traditions, there are three distinct post marital settlement arrangements, as discussed in Section 4.5.1. Regardless of the existing post marital arrangements, management of almost all the land in Section A follows the matrilineal system.

Section B in Figure 6.1 is the permanent wetland. Previously, this section was communal land for the village. According to the village KIIs, the local leader (the Group Village Headman) started demarcating and allocating individual plots to families about three decades ago. Contrary to the local tradition, the chief decided to apportion plots to each household/family under each clan. Individual plots were allocated to ensure that each family manages their own plot without clan involvement and secondly it was to ease re-allocation of plots after every episode of submergence and subsidence of the plots due to rising and declining levels of water from the lake. Although each household retains user and ownership rights, re-allocation after subsidence by water from the lake imply instability of the tenure. In essence, land ownership in this section is relatively dynamic.

Section C in Figure 6.1 is the temporary wetland. This section has recently been converted to dual usage. Initially this section was entirely used as pastureland during both the wet and dry seasons. The village chief mentioned that he started dividing plots for rice production during the rainy season around 2010. The local leader allocated plots for rice production to individual households on a permanent basis.

Unlike section B where tenure is relatively dynamic and unpredictable, this section has more stable tenure and is relatively more organized. Notwithstanding the stability of tenure there are locally constructed registration arrangements that determine access and use at a given time and in perpetuity.

6.4 Institutional dynamics in arable land

As explained in 6.4 the study area has three types of land management regimes based on the nature of land and institutions that guide access and use. The study area has arable land where the traditional matrilineal system of inheritance influences access and utilization. There are three distinct land ownership and use regimes based on post marital settlement identified in the study area.

Arable land in section A of Figure 6.1 is the oldest section of the village that was occupied and used for agriculture and settlement by the people in the study area. Although Sections B and C were part of the village, Section A was the first section to be used for settlement and farming. This section has been owned and inherited using the traditional matrilineal system which largely follows uxorilocal post marital settlement. Ideally, soon after the wedding, the husband is supposed to build a house in the wife's village and settle. It was however observed that settling was gradual and thus some couples could reside in the husband's village pending the building of the house in the wife's village. Such couples had access to farmland in both villages. Even though the above scenario could be temporarily acceptable, over time clan members in the husband's village deliberately pressure the man to build the house in his wife's village and relocate.

Upon settling in the wife's village, the husband is responsible for making key decisions on livelihood activities but not decisions like renting, sub-leasing or sale of any piece of land being used by his household. The wife has the right to temporarily transfer the user rights for a specific period; however, even such a decision requires approval of the clan members. In case of separation or divorce, the husband leaves the village and has no claim to any productive asset owned while married, including land. In case of the death of the husband, the widows continue using the farmland. However, if the wife dies, the husband can live in the village and use the farmland to raise the children. If he wants to remarry, he is asked to leave the village whilst the land reverts back to the clan members waiting for female children to grow and repossess the land when they get married. The majority of the households in the village follow this tradition.

Virilocal is the second post-marital settlement in the area. Under this arrangement, the wife settles in the village of the husband after the wedding. Virilocality is rare and accepted only under unique circumstances in the study area. The conditions that lead to virilocality may include land unavailability in the wife's village, leadership responsibility for the man in his village, unavailability of girls in the husband's village that can take care of the aged parents, and other non-socio-cultural factors such as livelihood opportunities and safety. In order to implement a virilocal arrangement, a special series of formalities are done locally called *oloka*.[4] This requires the couple to agree on settling in the husband's village. After the agreement, the husband and wife notify their respective clan members to negotiate and agree on the *oloka* modalities.

[4] Oloka literally means crossing over. It implies that the wife is to settle in the village of the husband

Under virilocality, the land is owned by the clan of the husband but the household has user rights for land parcels allocated to it. The couple can decide and use their land for infrastructure and farming. Similar to uxorilocality, the husband is expected to lead in decisions and the implementation of land use activities for the household. The husband has the right to transfer user rights, subject to approval of the clan members. In the case of separation or divorce, the wife returns to her village of origin and the man continues to use the land. When the husband dies, the wife continues to use the land if they had children, and the land is eventually inherited by female children if they will follow uxorilocality when getting married or vice versa. If the couple did not have children, the widow returns to her home village and the land reverts to the clan. Fewer households were found living under this arrangement.

The third post marital tradition in the area is neolocal. This arrangement involves the couple settling in a neutral location after the wedding. Previously neutral land for settlement and farming was acquired from traditional authorities in new locations away from the husband's and spouse's village. Older Key Informants indicated that such arrangements were common in the past when land was abundant, and chiefs were not avaricious. Recently, land is no longer allocated for free rather it is being sold. The neolocal option has therefore been limited to couples with financial resources to buy land for settlement and farming. The process of selling land involves the buyer and the seller as well as the local leaders as notaries. Since land is scarce, most of the clan (*Ambumba*) land is being sold. The process involves the entire clan, whose representatives facilitate the sale.

> "Indeed, clan land cannot be sold by an individual but in our case, we selected a representative who facilitated the deal. Considering that sale of land accords perpetual ownership to the buyer the process was elaborate and other parties in addition to the two parties trading the land were involved. The chief and counsellors from the husband's and wife's families were involved as witnesses." [40 years Female Respondent (Standard 6) – one-on-one interview respondent]

Sale of land under customary tenure does not involve any formal institutions or structures. Nevertheless, the process involves signing land sale documentation between the parties, who keep the copies for future reference. These scenarios have led to 'informal customary estates' associated with neolocal arrangements. Unlike in traditional neolocal arrangements, informal customary estates are documented and informally registered with the local authority (Chief) at the village level where the records are kept by both parties and the village chief. Security and legitimacy of the informal customary estates is higher compared to land acquired through traditional neolocal arrangements.

> "In case of conflicts and uncertainties, people that settled into a village for free can easily be sent away regardless of the capital assets like houses they might have built during their stay. The same is not possible for those who bought land because once they buy the land it becomes their perpetual inheritance and no one can chase them." [48 years old Male Key Informant (Standard 5]

A high sense of land ownership was associated with husbands under virilocal arrangements and with wives under uxorilocal. However, landowners under the 'informal customary estates' associated with neolocal arrangements often referred to the land as 'ours'[5]. The long term land improvements such as soil fertility enhancement and long term soil and water conservation technologies were not observable but rather couples under informal customary estates expressed the freedom they had to use the land to earn income.

> "When we are not able to use the entire land that we bought, I rent out some of the plots to raise money that I may need to buy food and other agricultural inputs. I could not have done this if I had settled in the village where I married" [29 years Male respondent, one-on-one interview (Standard 8)].

6.5 Institutional dynamics for the permanent wetland

Considering that the wetland was previously unallocated communal land, the chief used his authority to allocate plots to each household in part B of Figure 6.1 for irrigation farming approximately three decades ago. Individual households were given usufructuary rights to own plots and grow crops during both the dry and rainy seasons. Either member of the household (husband or wife) who was given the plot retained ownership even after divorce or separation. In case of death, the relatives inherit the plot. A fee was required for the initial allocation but thereafter households freely used their plots. Plots could be lost to other users due to underutilization and during re-allocation after submergence and subsidence of lake water.

[5] Ours meant that the land belonged to the family (that particular household) but not the clan.

Farmers sometimes abandon their plots in this section during the rainy season out of fear of losing their crops due to increasing lake water levels. In such instances, the idleness of the plots during the rainy season does not imply underutilization or abandonment to warrant loss of the plot.

> "If a household decides not to grow rice during the rainy season their plot is left idle because rice production in this area has been failing due to insufficient moisture in some years or floods in some." [56 years old Village Key Informant (Standard 5)].

However, failure to utilize the same during both the dry and rainy season results in the land's reallocation or demarcation to other users. Alternatively, plot owners who fail to utilize their plots during both the rainy and dry season rent them out to meet the condition of continuous use.

During the reallocation of plots after subsidence of water from lake spill-over, plot owners either become victims or victors depending on their relationship with the chief. Incidents of either losing or receiving smaller plots during reallocation were frequently cited during one-on-one interviews with distant relations or unrelated people to the chief. Deceased and unattended or barely used plots are also lost to other users during this process. Since re-allocation entirely depends on discretion of the village chief, there are no appeals over perceived faulty reallocation or loss of land. Claims of nepotism and favoritism were commonly raised by aggrieved parties but there is no court to lodge their complaints.

6.6 Institutional dynamics for the seasonal wetland

Section C in Figure 1 is the seasonal wetland within the study area. Until 10 years ago, this wetland was used as communal pastureland. Single use of the wetland was discontinued to allow for rice production as a secondary use. Dual of use for this section of the wetland involved the chief negotiating with livestock owners. The deal was reached to restrict rice production to the rainy season (December to April) and livestock grazing to dry season (May to November).

Unlike in Section B, the land is not owned by any individual or households; rather all the land is controlled by the chief who acts as the landlord and land users as tenants. User rights are granted at a fee and the renewal of the annual contract is made by payment of 'custom' at the end of rice production period. Custom is the payment of a 50 Kilograms bag of rice to the chief from the proceeds on the allocated plot(s). The conditions apply for both citizens and non-citizens of the village. Annual tenancy can be transferred to the third party in the presence of the chief so that user conditions can be communicated, and the new tenant's details can be recorded.

Another key observation to allocation of tenancy agreements to the plots in this section was local organization on a systematic identification of plots and their respective tenants. It was noted that during plot allocation the tenant's address, next of kin and size of land being allocated were recorded in the plot register logbook. The spatial location of the plots was not recorded in the book because the chief does not have the enabling equipment. Nevertheless records were written in an orderly way such that the chief uses the records to identify marker plots which helps identify other plots.

> "There have been incidents where distant rice farmers fail to locate their plots during the crop production period. Using information from the records I can track the plots and locate them without failing." [Village Chief]

Apart from the purpose of tracking the plots, details in the logbook are used to track tenants for various purposes including collection of 'custom' for re-allocations when tenancy agreements have expired.

The size of the allocated plots depends on the amount of money each individual or household is willing to pay, thus the more the money the more land that can be allocated and vice versa. Payment for the plot was done in two phases. The initial phase was for the actual demarcation exercise and the amount was significantly low. The second phase was paid to confirm the contract and it is significantly high. There was no fixed unit price for the plots however, it was observed that non-citizens of the village pay relatively higher fees.

> "When the chief was allocating plots at the wetland, members of the village were asked to pay between MK 2000 (2.3 USD) to MK 3000 (3.5USD). The same was not for people from distant areas who could pay as much as MK 10000 (11.8 USD)". [35 years One-on-one Male Respondent (Standard 5)]

Payment of this fee determines access to land in Section C of the wetland or not. However, it was noted that village citizens may negotiate for the same and pay in instalments while 'outsiders' could not.

The bottom line to this condition is that the poor and vulnerable without the ability to rent the fields are less likely to access land while financially capable people even from as far as 100 kilometers from the village accessed the land.

6.6.1 Rainy season utilization

Completion of the second payment enables the tenant to start all the agronomic activities related to rice production on the assigned plot. The chief is responsible for any conflicts that may arise between rice farmers and between rice farmers and livestock owners. There are few reported cases of conflicts between farmers especially during the production period. However, cases between rice farmers and livestock owners are common. Livestock kraals are located on the edge of the wetland so once the animals breach the fence they graze on the rice especially at night. Such phenomena result in fines for livestock owners. However, rice farmers lamented the leniency of the chief in the fines which are perceived to be less than the equivalent value lost.

Regardless of the plots being awarded to individuals (either husband or wife), user rights are accrued to the entire household. However, in case of divorce or separation, the actual owner (the one who paid the chief) retains that plot tenancy contract unless one pays with household income, in which case the plot is split between the parties. To avoid divorced people cultivating adjacent plots, the chief re-allocates one party to a similar plot away. Uxorilocal and virilocal traditions do not affect user rights of these plots. If the plot owner dies, his or her relatives can renew the contracts and use the deceased's plot.

These conditions are also applicable to both plot owners from within and outside the village, even those from distant urban areas.

6.6.2 Dry season utilization of the wetland

Upon completion of the rice harvesting season, the entire wetland is used as pasture land until first rains, which mark the onset of rice growing season. It was observed that livestock that graze in the wetland are not only from the village rather from villages from as far as 10 kilometres from the study area. Livestock owners from outside the village first get permission and pay user fees to the chief before starting to graze their animals. Temporary kraals and dwelling units are built by herd boys on the edge of the wetland because livestock from distant locations permanently reside at the wetland throughout the dry season.

Growing crops during the dry season in this section is not categorically prohibited; rather crop owners are responsible for securing the crops from the livestock. Based on the agreement with livestock owners, any attempt to cultivate crops in the area is at the owner's risk and the chief does not attend any claims on crop losses. Despite clear rules on the utilization of this temporary wetland, crop owners frequently complained about livestock damaging their crops and indicated that the chief seems to always side with non-village livestock owners in such cases.

> "One of the main non climate change related problems to farming in this village is crop damage due to livestock. Unfortunately, when cases are taken to our chief they do not end conclusively. Livestock owners almost always

get away with things." [39 Years old Male Respondent – Male FGD (Standard 6)].

6.7 Discussion

6.7.1 Institutions and institutional changes on arable land

The institutions surrounding access and use of arable land are grounded in the culture of the people (Doolittle, 2011). For many generations local communities have considered land as an eternal inheritance and therefore untradeable resource as it forms the basis of their identity. The study found that traditional systems of land access and use are deeply rooted in their matrilineal culture. Previous studies have also established that most rural communities of developing countries still follow traditional land ownership systems (Colin & Ayouz, 2006; Robinson & Gottlieb, 2021). In this study area, rules and regulations on land access and utilization are rooted in the matrilineal system of inheritance and the associated post-marital settlement traditions.

The study shows that uxorilocality and virilocality traditions within a matrilineal inheritance system have persisted and still dominate access to and use of land because of the complexity of the rules and how they are intertwined into a broader cultural matrix of the people in the study area. Resistance to alter land ownership from clan based to individual ownership was acknowledged as one of the challenges faced during the Customary Land Development Programme in Lilongwe west (Ng'ong'ola, 1982). Similar phenomena have been reported in SSA where traditional rules and regulations have been sustained and still dominate land ownership (Pottier, 2005).

However, studies in countries like Ghana have shown that such informal institutions are transforming towards land commodification in response to socio-economic changes (Kansanga, et al., 2019). Nonetheless, the perpetuity of these informal land rules in the study area may create hindrances to sustainable investment towards building climate change resilience because in the current set up fewer males under uxorilocal are motivated to make investments.

Despite the strong and persistent traditional rules and regulations discussed above, results also showed a significant shift in the acquisition of neutral land. Over the years, for instance, the informal institutions have transformed from acquiring free neutral land from traditional authorities to buying. Acquiring neutral land through buying has led to accommodating institutions to necessitate legitimate individual ownership of land under customary tenure. This phenomenon has been reported previously in Phalombe and Balaka districts by Chiwawula (2012), Kambewa (2006) and Kishindo (2014). The observed phenomenon in the study area may thwart building resilience for the poor households that cannot purchase land away from flood prone areas or increase their land for farming to abate food shortages caused by the increased impacts of climate change.

6.7.2 Institutions and institutional changes in permanent wetlands

Utilization of wetlands has increased significantly over the previous decades (Rebelo et al., 2019). Most of the wetlands in Malawi have been considered as Common Property Resources from the pre-colonial era to the present (Mandishona & Knight, 2022). Results of this study show that three decades ago, rules and regulations on access and use of the permanent wetland changed to individual usufructuary rights over allotted pieces of land.

Distribution of land parcels departed from the traditional clan based to individual/household-based ownership. Substituting informal institutions have been created to mitigate challenges associated with clan-based ownership of land. Previous studies in Zimbabwe and Ghana have shown that customary tenure rules are informally being transformed towards individual ownership (Akaateba, 2019; Chimhowu, 2019). This study adds to the evidence on these phenomena. Although land ownership has been narrowed to households or individuals, the current re-allocation mechanism noted in this study was unfavorable to the users and thus it reduces their willingness to invest significantly in their plots despite its potential to increase resilience of food production.

In summary, plot ownership in this section has no cultural/tradition-based constraints. Households have greater freedom to manage and use the plots to earn income and food. As earlier noted, (in results chapter 4) small-scale irrigation in this section plays a vital role to offset the underproduction of food under rain-fed farming that is often triggered by either floods or erratic rainfall. However, unstable tenure undermines the building of climate change resilience through advanced and more sustainable farming technologies.

6.7.3 Institutions and institutional changes in temporary wetland

Substituting institutions have been created to enable accessing and utilizing the temporary wetland in the past three decades. The rules for acquiring and utilizing the land in Section C reflects increasing integration of land into the market economy following its increased demand for agricultural use. Creation of accommodating institutions to facilitate individual ownership of land reflects further adjustments to the existing informal institutions to formalize land transactions.

Multiple usage of the wetland has increased significantly in most countries across the world (Adger et al., 2000). Studies in Africa and South East Asia have reported concurrent and intermittent use of the wetland for crop production and fisheries or grazing (Uwimana et al., 2018; Keshta et al., 2022; Kamal et al., 2018). In this study, rules for wetland utilization were revised to accommodate crop production. Introduction of rice production in the wetland reflects intentions to expand crop production that has been declining by among other factors, land scarcity and climate change. Coulibaly et al. (2015) noted that incidents of erratic rainfall have been the main cause of poor agricultural output over the previous 3 decades. Dual usage has therefore improved overall output from the land and contributed towards enhancement of livelihood sustainability in the midst of climate change.

Land leasing and subleasing has been practiced in various forms across time and space in the world (Lyne et al., 1997; Kidido et al., 2017). A unique arrangement, however, has been observed in this study. Although unallocated customary land was meant for free distribution under customary laws, leasing by local leaders has commonly been practiced. Solicitation of payment in cash or in kind has been reported even in customary land within Malawi (Kambewa, 2006). However, the level of strictness observed in this study shows the increased abuse of power over the wetland by local authorities. Increased demand for land in this section without appropriate formal regulatory structures may result in systematic exclusion of poor and vulnerable households from accessing land resources that can contribute towards building resilient food production through the use of the wetland.

Systematic land registration has been practiced for over a century (Hidayah & Fakrulloh, 2022).

However, few studies have reported informal land registration under customary tenure. For instance, Kalambu (2019) reported local and informal land registration in communal lands in Botswana. The informal registration of the plots serves to minimize conflicts when plots are changing ownership. This increased level of organization through the documentation of plots and ownership is a further improvement on the previous land allocation practices for Sections A and B. The implication of this transformation is the increased level of plot size, and the integrity and reliability of claims based on documented evidence. Despite the benefits of more stable and well defined plots, registration enabled the authorities to maximize the tracking of land users and the collection of payments.

Results of this study concur with Kambewa (2006) who also reported that local leaders were paid cash or in-kind payments for accessing or using wetlands. However, the current study shows a significant variation in the past 10 years from payment of honoraria to solicitation of an additional annual 'custom' from rice yields. Studies show that in areas where land scarcity is a problem, deliberate rules are made to encourage efficient utilization (Lambin & Meyfroidt, 2011). Nonetheless, solicitation of 'custom' by the local leaders reflect the weakness in policy implementation that should prevent such exploitation. Increased demand of payments for use of the wetland has the potential to create unequitable access to land resources that can be used to enhance resilience towards the impacts of climate change through increased crop production.

Studies on multiple usage of common property resources have hinted at the prevalence of conflicts among the users (Saha & Pal, 2019). Most of the conflicts in multiple use of wetlands emerge from unclear rules on resource extraction and limitations within and

between the groups. Study results concur with findings from Ayeni at al. (2019) that reported conflicts and contestations over wetland resources. This study shows unclear rules stipulating when livestock owners can stop and start grazing, which has led to continuous conflicts between livestock owners and rice farmers. Maintenance of the status quo may lead to more conflicts as demand for the wetland by either group increases with time.

Rules of inheritance have been known to form a basis of society's coherence and continuity (von Benda-Beckmann, 2013). Findings from this study show that inheritance of the tenancy contracts under various circumstances have been considered in the local rules for the temporary wetland. Considering matrilineal traditions and uxorilocality, clan rules for inheriting these contracts were revised to enable individuals to claim and continue with the contract after events like divorce, separation, or death. This arrangement thus enables the local leaders and the land users to secure the contract so that user rights can be maintained and future beneficiaries can continue to use the land parcel in perpetuity.

Pasture in the wetland is the common property resource for livestock owners. Results show that livestock grazing maximizes use during the dry season, when pasture is scarce on arable land. Studies on grazing animals in wetland as common property resources are adequately documented (Phethi & Gumbo, 2019; George & Ngole-Jeme, 2022). Several scholars have shown and proposed principles for managing common property resources (Perfect-Mrema, 2022). The results from this study however, depict unusual institutional weaknesses, especially regarding unclear rules on actual dates when one group of users starts or stops using the wetland. Continuity of this status quo is likely going to create conflicts, especially if either group will start incurring losses due to the actions of another.

CHAPTER 7

CLIMATE CHANGE ADAPTATION PATHWAYS

7.1 Introduction

This chapter presents the findings on climate change adaptation strategies. Firstly, the chapter focuses on adoption of early maturing varieties for rice and maize production. Secondly, the chapter focuses on changes in agronomic practices for rain-fed and irrigation farming in order to adapt to the impacts of climate change.

7.2 Vulnerable livelihood activities

As earlier discussed in chapter 4, the study area has four main livelihood activities namely, rain-fed crop production; small-scale irrigation during the dry season; fishing and casual labor. Chapter 4 also has also discussed the main impacts of climate change in the study area, namely erratic rainfall, floods, and stormy rains. The climate change related shocks primarily affect rain-fed and small-scale irrigation. Therefore, this chapter will focus on adaptation practices for rain-fed crop production and small-scale irrigation along the wetland.

7.3 Adaptation strategies to the impacts of climate change

The concept of climate change adaptation has been the focus of scholarly work over the previous decades (Schipper, 2007; Lobell, 2014; Carman & Zint, 2020). This study defines adaptation as the process of adjusting to actual or expected climate and its effects in order to moderate or avoid harm or exploit beneficial opportunities in human systems (IPCC, 2014; Wang et al., 2018; Carman & Zint, 2020). This section explores adaptation strategies in rain-fed crop production, rice production and small-scale irrigation in winter.

Late onset and early cessation of rains have shortened the rainfall season. This has prompted the need for crop varieties that can suit the reduced production season. Rice and maize are the main crops cultivated in the study area. Rice is mostly cultivated in the temporary wetland during the rainy season while maize is cultivated in arable land during rainy and in the permanent wetland during dry seasons. Farmers were asked if they are adopting early maturing hybrid varieties as an adaptation to the shortened growing season. Table 7.1 below presents an analysis output of the responses for the question.

Table 7. 1 Percentage distribution of households that adopted early maturing varieties.

Crops	MHH (140)	FHH (77)	Overall (217)
Rice	56.4	64.9	59.4
Rain-fed Maize	21.4	20.8	21.2
Irrigation maize	15.0	11.7	13.8

The results in Table 7.1 shows that most of the farmers have shifted to early maturing rice varieties while only a few farmers have adopted early maturing hybrid maize varieties for rain-fed and small-scale irrigation. Table 7.1 above also shows that female-headed households (FHH) are more inclined towards early maturing rice varieties compared to male-headed households (MHH). The results show that a higher proportions of farmers are adapting rice production to climate change than maize production. Furthermore, an inquiry on the period of time that farmers had been using early maturing varieties was done. Results of the analysis are in Table 7.2.

Table 7. 2 Period in years farmers have been growing early maturing varieties

Period (years)	MHH (140)	FHH (77)	Overall Mean (217)
Rice	2.06 (1.723)	1.59 (1.198)	1.88 (1.551)
Rain-fed maize	3.40 (2.175)	3.75 (5.848)	3.09 (2.021)
Irrigation maize	2.38 (1.203)	2.22 (1.202)	2.33 (1.184)

The results in Table 7.2 shows that the farmers' decision to shift to early maturing rice varieties has been relatively more recent than maize. The female-headed households have a comparatively shorter period that they have been growing early maturing rice varieties than male-headed households do although Table 7.1 results show that most of the female-

headed households have switched to early maturing varieties. Results above show that male-headed households have been growing early maturing hybrid maize varieties for a longer period than female-headed households have. Considering the results in Table 7.1, male-headed households are more inclined towards adapting maize production to the impact of climate change than female-headed households.

7.3.1 Adaptation strategies to rain-fed rice production

During qualitative data collection, three categories of rice varieties were identified, depending on the time for maturity. The categories were early, mid and late maturing rice varieties. Based on the categorization by the respondents during all four (4) FGDs, the rice variety called Amanda was labelled as late maturing while Tambala and Kidney were considered as mid maturing, and Singa Poussa and Poussa were labelled as early maturing.

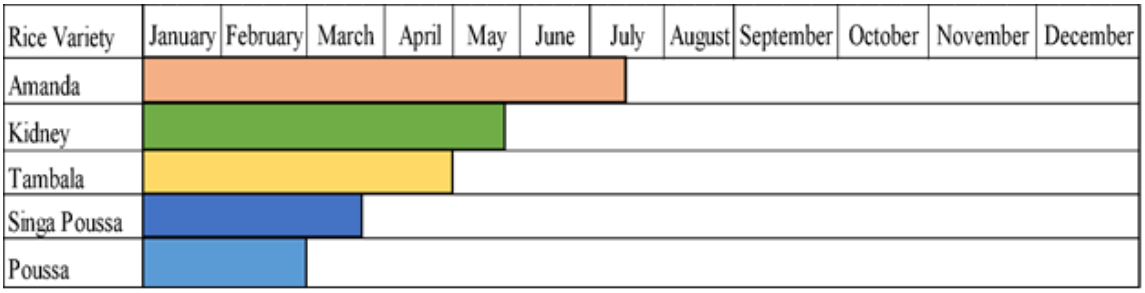

Figure 7. 1 Time scale for different rice varieties cultivated in the study area

As earlier indicated, Malawi experiences unimodal rainfall from November to April. Increased incidents of late onset of rains have caused farmers to delay rice planting until the entire wetland is fully flooded. Almost all the rice farmers during one-one interviews indicated that rice planting starts in January.

Figure 7.1 above shows Singa Poussa and Poussa mature in March while Tambala and Kidney mature between April and May. Amanda matures in July; Poussa, Singa Poussa and Tambala, mature within the rainy season while Kidney and Amanda mature on residual moisture after the rainy season.

The increasing incidents of early cessation of rains, imply that residual moisture starts declining earlier and thus creates moisture stress for the mid and late maturing varieties. Conversely, early cessation of rains have minimal or no effect on early maturing varieties. The agricultural extension agent reported that during the 2019/20 season rains stopped around February. Farmers who cultivated early and mid-maturing varieties salvaged some yields, unlike those who cultivated late maturing varieties whose rice dried up before maturing. Table 7.3 below therefore shows the proportion of farmers switching from late maturing to early maturing rice varieties.

Table 7. 3 Percentage distribution of farmer's shift in the choice of rice varieties

Rice varieties	Past			Present		
	MHH(140)	FHH(77)	Overall(217)	MHH(140)	FHH (77)	Overall (217)
Amanda	24.1	52.0	34.9	16.5	12.2	14.8
Kidney	72.2	44.0	61.2	5.1	2.0	3.9
Tambala	2.5	2.0	2.3	54.4	59.2	56.3
Singa Poussa	1.3	2.0	1.6	22.8	26.5	24.2
Poussa	0.0	0.0	0.0	1.3	0.0	0.8

In general, there is a shift from the late to mid and early maturing rice varieties. Table 7.3 shows that in general most farmers are shifting from Amanda and Kidney to Tambala, Singa Poussa and Poussa. Table 7.2 shows that on average, farmers have been growing early maturing varieties for the past two years. Nonetheless, some started shifting to early maturing varieties as far as 10 years ago. Table 7.4 below further shows reasons for the change in the rice varieties.

Table 7. 4 Percentage distribution of the reasons for adopting early maturing rice varieties

Reasons	MHH (140)	FHH (77)	Overall (217)
Early Maturity	54.4	73.2	58.0
High yielding	10.1	3.6	6.9
Thrive under moisture stress	20.3	17.9	18.3
Aroma/Marketability	12.7	5.4	9.1
Seed availability	2.5	0.0	1.5

Table 7.4 above shows that most of the male-headed households and female-headed households attributed their change in rice varieties to early maturity and the ability of the variety to withstand moisture stress. Other minor reasons include marketability, high yields, aroma and availability of seed. The results show that most of the farmers changed rice varieties to fit the shortened rainy season. Table 7.4 shows that rice farmers are adapting to erratic rainfall/early cessation by adopting early and mid-maturing rice varieties. The agricultural extension agent for the area indicated that although farmers are adopting early maturing varieties, there are major trade-offs in qualities that influence preference.

During all the four (4) FGDs respondents were asked to rank desired attributes in the rice varieties and main reasons for their preference. This was to understand the combinations of traits that are sought in choosing a variety to be cultivated. Figure 7.5 below presents varieties, their traits and rankings by the respondents.

Table 7. 5 Rice varieties and their respective attributes

Rice Variety	Aroma (Marketability)	Yields potential	Labor demand	Water stress tolerance	Maturity
Amanda	High	Medium	Very low	Medium	Very late
Kidney	Very Low	Very high	Very low	High	Late
Tambala	Medium	Medium	High	High	Medium
Poussa	Low	Low	Very high	Low	Early
Singa Poussa	High	High	Very high	Very high	Very early

Table 7.5 shows that the farmers choose a variety to grow in a particular year based on the qualities each variety has and their objective for growing the crop. It was learnt that choice of the variety is arrived at by exploring the combination of traits each variety has and the associated potential risks and gains. Therefore, the farmers decide on trade-offs they make to choose a variety that will meet their objectives. Although Table 7.3 shows that there is a general trend of shifting towards early maturing varieties, such changes are accompanied by giving up equally preferable traits such as labor demand and high marketability/aroma.

The study further explored farm and farmer characteristics associated with adoption of early maturing rice varieties.

Independent t-test and Chi Square analysis were used to identify factors that are consistent with adoption of early maturing varieties. Summary of the analysis for the independent t-test are presented in Table 7.6.

Table 7. 6 Independent t-test of variables associated with adoption of early maturing rice varieties

Variable	Adopters	Non-adopters	T - value	Sig.
Education of Household Head (Years)	3.72 (3.455)	3.41 (3.226)	0.670	0.503^{ns}
Contact with extension agents	1.74 (1.212)	1.34 (0.729)	2.739	0.007***
Experience in farming (Years)	15.89 (10.885)	16.52 (13.744)	0.377	0.707^{ns}
Amount of maize harvested (Kgs)	135.24 (397.336)	35.18 (71.929)	2.212	0.028**
Number of plots at the wetland	1.87 (0.996)	1.33 (0.705)	3.958	0.000***

Table 7.6 shows higher contact with extension agents was associated with adoption of early maturing rice varieties. Results in the table above also show that adopters of early maturing rice varieties harvested relatively more maize than non-adopters. The adopters had relatively more plots to grow rice than the non-adopters. Most farmers indicated that they do not mix different varieties in one field. Thus, the more the fields the farmers could have the more they were willing to cultivate early maturing varieties.

Furthermore, the categorical variables were analyzed using Chi square analysis. Results of the analysis are in Table 7.7.

Table 7. 7 Chi Square estimation variables associated adoption of early maturing rice varieties

Variable	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Gender	1.491	1	0.222^{ns}	0.083
Membership to formal groupings	7.133	1	0.008^{***}	0.182
Pattern of maize yield (Rainfed)	15.795	2	0.000^{***}	0.272
Access to weather information	18.893	1	0.000^{***}	0.295

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

Results in Table 7.7 show that membership to formal groupings, perceived patterns of maize yields from rain-fed farming and access to weather information were associated with adoption of early maturing rice varieties. It was observed during PO that most of the rice seed was not bought from agro-dealers but rather from fellow farmers within the local groupings. The farmer's perception of the declining maize yields pattern was associated with adoption of early maturing rice varieties.

Most of the rice farmers during one-one interviews indicated that early maturing rice varieties helps mitigate maize shortages that are created by erratic rainfall. Results also show a significant relationship between adoption of early maturing rice varieties and access to information on weather forecasts.

The binary probit model was used to analyze factors that are associated with the decision to adopt early maturing rice varieties. Analysis included the assessment of the marginal effects the independent variable had on the dependent variable. Table 7.8 presents a summary of the analysis.

Table 7. 8 Determinants of adoption of new rice varieties in response to climate change

Variables	Coeff	Std. Err.	t - statistic	P- value	dy/dx	X
Education of household head	0.1560	0.0371	0.42	0.674	0.0052	3.6564
Extension	0.1676	0.1151	1.46	0.145	0.0568	1.5951
Farming experience	0.0034	0.0120	0.29	0.771	0.0011	15.8037
Maize harvested (Kgs)	0.0036	0.0014	2.64	0.008***	0.0012	104.5430
Number of plots at wetland	0.3030	0.1337	2.27	0.023**	0.1028	1.7117
Gender of household head	0.4526	0.2585	1.75	0.080*	0.1536	1.3497
Group membership	0.5210	0.2623	1.99	0.047**	0.1860	0.7239
Pattern of maize yield (Rain-fed)	-0.3900	0.2537	-1.54	0.124	0.1324	2.1350
Access to weather forecasts	0.6196	0.2714	2.28	0.022**	0.2248	0.7669
Constant	-1.3467	0.7574	-1.78	0.075		
Significance levels * significant at 10% ** Significant at 5%***Significant a 1%						
Log likelihood	-84.2311					
LR chi2(9)	44.92					
Prob > chi2	0.0000					
Pseudo R2	0.2105					
y = Pr(Adoption)	0.7151					

The results in Table 7.8 above show that the independent variables in the model accounts for about 21% percent of the variation in the dependent variable. This proportion is within range of previous studies (Chandio & Yuansheng, 2018).

The results in table 7.8 shows that the quantity of maize harvested by a household, the number of plots a household has in the wetland, the gender of the household head, group membership and access to weather forecasts positively influenced the decision to adopt early maturing rice varieties. The marginal effects show that a unit increase in the amount of maize harvested increased the likelihood of adoption by 0.1% while an increase in the number of plots in the wetland would increase the likelihood of adoption by about 10%. Results further show that female-headed households were 15% more likely to adopt early maturing rice varieties; being in groups increased the likelihood of adoption by 18.6% while access to weather forecasts increased the likelihood of adoption by 22%.

7.3.2 Adaptation strategies to rain-fed maize production

The farmers were asked if they are changing the maize varieties they grow as a response to the increased intensity and frequency of erratic rainfall. This was to determine whether farmers consider early maturing hybrid maize varieties as an adaptation measure to climate change. Table 7.9 below shows the percentage distribution of responses from male- and female-headed households.

Table 7. 9 Percentage distribution of farmers switching from late maturing to early maturing varieties

Varieties	Present			Past		
	MHH (140)	FHH (77)	Overall (217)	MHH (140)	FHH (77)	Overall (217)
Late maturing/Local	30	43.8	34.8	70	56.3	65.2
Early maturing/Hybrid	70	56.3	65.2	30	43.8	34.8

Table 7.9 above shows that farmers are switching from late maturing local varieties to early maturing hybrid maize varieties. Table 7.2 shows that on average farmers have been cultivating the early maturing hybrid varieties for the past 3 years although some date back as far as 25 years. The table above also shows that farmers are progressively inclined towards early maturing hybrid varieties, although some farmers during one-on-one interviews said that some local varieties in the area are equally early maturing.

> "We have local varieties such as Mkamwiniyenda that equally mature early like the hybrid varieties that are sold at the market. We plant them on the same day with Kanyani (SC 403) and they mature at the same time." [45 years old Female IDI respondent (Standard 4)]

The existence of such local varieties might have contributed towards lower adoption of early maturing hybrid varieties.

The study also focused on the reasons for adopting early maturing hybrid varieties, cognizant that other farmers argued that there are other equally early maturing local varieties. Table 7.10 below presents reasons for switching to early maturing hybrid varieties.

Table 7. 10 Percentage distribution of reasons for adopting early maturing hybrid varieties for rain-fed maize production.

Reasons for changing in Rain-fed	Male (140)	Female (77)	Overall (217)
Early maturing	46.6	75.0	57.5
High yielding	36.7	18.8	30.3
Storability	6.7	0.0	3.4
Water stress tolerant	3.3	0.0	2.2
Affordability	0.0	6.3	3.2
Other	6.7	0.0	3.4

Unsurprisingly, more than half of the sampled farmers adopted hybrid varieties because they were interested in early maturity traits. Results show that female-headed households were more interested in the early maturity trait than male-headed households were. High yielding traits were equally sought in the hybrid varieties and results show that male-headed households were more interested in this trait than female-headed households were. Storability is one of the attributes that male-headed households hailed as driving factor. Specifically, farmers indicated that they prefer varieties that cannot easily be damaged by pests (especially weevils) after harvesting. Furthermore, most females hinted that lower seed prices was the reason for their choice.

Farm and farmer characteristics associated with adoption of early maturing hybrid maize varieties was determined using the Independent t-test. The analysis output is in the Table 7.11.

Table 7. 11 Independent t – test for the variables associated adoption of early maturing hybrid maize varieties for rain-fed crop production.

Variable	Adopter	Non-adopter	t	Sig.
Education of Household Head (Years)	4.07	3.47	-1.071	0.285^{ns}
Education of the spouse	3.61	2.16	3.105	0.002**
Household labor	2.00	1.89	-0.635	0.526^{ns}
Household Dietary Diversity Index	0.02	0.02	-0.447	0.656^{ns}
Extension	1.89	1.50	-2.258	0.025**
Period of stay in the village (Years)	32.22	33.01	0.258	0.796^{ns}
Amount harvested	105.86	91.26	-0.269	0.788^{ns}
Total value of household assets	67342.11	43536.63	-1.411	0.160^{ns}

Table 7.11 above shows that adoption of early maturing hybrid varieties for the rain-fed season was associated with education of the spouse and contact with agricultural extension agents. Results show that the households with more educated spouses were highly associated with the adoption decision. Although most households are male-headed in a matrilineal community, the results indicate more involvement of educated spouses in choice of maize variety for rain-fed production. Furthermore, the decision to adopt early maturing hybrid maize varieties was highly associated with frequency in which the household was in contact with extension agents. The chairperson for the ASP revealed that farmers are hesitant to adopt hybrid maize varieties because they still prefer local varieties, but those who heed advice from extension agents slowly adopt the new varieties. Chi square analysis was also done to establish the association between adoption of early maturing hybrid maize varieties and categorical variables. Results are in table 7.12.

Table 7. 12 Chi square for the variables associated with adoption of early maturing maize varieties for rain-fed production

Variable	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Gender	0.013	1	0.991^{ns}	0.008
Main Livelihood Activity	10.397	6	0.109^{ns}	0.219
Land access in upland	2.194	1	0.139^{ns}	0.101
Pattern of maize yield (Rainfed)	5.071	2	0.079^{*}	0.154

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

Results in Table 7.12 above shows that patterns of maize yield from both rain-fed and irrigation are highly associated with the decision to switch from local to early maturing hybrid varieties.

Specifically, the results suggest that the perceived declining pattern of maize yields under rain-fed production are prompting adoption of early maturing hybrid varieties. This finding concurs with statistics in Table 7.9 where high yielding potential is the second most desirable trait sought by farmers that are switching to early maturing hybrid maize varieties for rain-fed production.

The binary probit model was used to estimate the contribution of farm and farmer characteristics to the decision to adopt early maturing hybrid maize varieties. Results of the analysis are in the table 7.13.

Table 7. 13 Determinants of adoption for early maturing hybrid maize varieties for rain-fed production

Variable	Coef.	Std. Err.	z	P>z	dy/dx	X
Extension service	0.2325	0.1149	0.02	0.043**	0.0635	1.5855
Quantity of maize harvested	0.0004	0.0003	1.28	0.200	0.0001	94.9896
Gender of household head	0.1755	0.2579	0.68	0.496	0.0479	1.3472
Pattern of rain-fed maize yields	-0.5880	0.2715	-2.17	0.030**	0.1605	2.1554
Ownership of arable land	-1.3405	0.6043	-2.22	0.027**	0.4856	0.9741
Main livelihood activity	-0.1197	0.0766	-1.56	0.118	0.0326	1.9741
Dietary diversity	-37.0537	17.0900	-2.17	0.030**	10.1194	0.0257
Household labour	0.0686	0.1133	0.61	0.545	0.0187	1.9326
Education of household head	0.0124	0.0358	0.35	0.729	0.0033	3.6218
Education of spouse	0.1307	0.0425	3.07	0.002***	0.0357	2.4301
Constant	1.7537	1.1276	1.56	0.120		

Significance levels * significant at 10% ** Significant at 5%***Significant a 1%

Log likelihood	-87.4060
LR chi2(10)	29.93
Prob > chi2	0.0009
Pseudo R2	0.1462
y = Pr(adoption)	0.1919

In general, the model outputs show that the variables contribute about 15% of total variations. This is slightly lower than the 17% that was reported by Lunduka et al. (2019) in a similar study in Zimbabwe. The results in Table 7.13 shows that contact with extension agents and education of the spouse positively influence the decision to adopt early maturing

hybrid maize varieties for rain-fed production. Analysis of the marginal effects of the independent variables suggest that a unit increase in contact with extension agents in a week increased the likelihood of adoption by about 6.3% while a unit increase in education of the spouse increased likelihood of adoption by about 3.5%. Additionally, results also show that the perceived declining yield pattern of maize during the rain-fed season will increase the likelihood of adoption by about 16% while ownership of arable land decreases the likelihood of adoption by about 49%. Similarly, decreasing dietary diversity contributes about 10% towards adoption.

7.3.3 Adoption of early maturing hybrid varieties for small-scale irrigation

The results in section 4.3 show that small-scale irrigation is an alternative to rain-fed farming and farmers rely on either residual moisture or low cost technologies to grow maize along the wetland to supplement rain-fed production. This section explores adoption of early maturing hybrid varieties of maize under small-scale irrigation along the wetland. Table 7.14 below presents analysis for the decision to switch to early maturing hybrid maize varieties.

Table 7. 14 Percentage distribution of farmers that have shifted from local maize varieties to early maturing hybrid varieties for small-scale irrigation along the wetland

Variety	Past			Present		
	MHH (140)	FHH (77)	Overall (217)	MHH (140)	FHH (77)	Overall (217)
Local	57.1	77.8	63.3	47.6	22.2	40
Hybrid	42.9	22.2	36.7	52.4	77.8	60

Results in Table 7.14 show that farmers have changed from local to hybrid early maturing maize varieties for small-scale irrigation. Table 7.2 shows that on average, farmers have been growing hybrid maize along the wetland for the past two years, although some started about 5 years ago. Table 7.14 in general shows that about 40% of farmers still maintain local varieties while about 30% have switched to hybrids. The results show that some farmers still prefer local to hybrid varieties for reasons already articulated in section 7.3.2. The study further explored the reasons for switching to early maturing hybrid varieties for small-scale irrigation farming. Table 7.15 presents summary statistics of the analysis.

Table 7. 15 Reason for switching varieties for irrigated maize production

Reason (s) for changing	MHH (140)	FHH (77)	Overall (217)
Early maturing	66.7	55.6	66.1
High yields	19.1	33.3	24.2
Affordable seed	9.5	11.1	7.4
Other (Specify)	4.76	0.00	2.38

Table 7.15 above shows that early maturity is the main purpose for switching the varieties for both male- and female-headed households. In addition, farmers also grow early maturing hybrid varieties because of high production potential. Other minor reasons for choosing hybrid varieties include affordability of seed and other reasons such as storability and seed availability.

Independent t – test and chi square analysis were used to assess the relationship between various farm and farmer characteristics and the decision to switch from local to early maturing hybrid varieties for small-scale irrigation farming. Table 7.16 below presents analysis output for the independent t – test.

Table 7. 16 Independent t – test for the quantitative variables for adoption of early maturing hybrid maize varieties under irrigation farming

Variable	Adopter	Non-Adopter	t	Sig
Education of Household Head (Years)	4.2	3.5	-1.064	0.289^{ns}
Household labor	2.2	1.87	-1.682	0.094*
Farming experience	16.8	16.04	-0.318	0.751^{ns}
Period of stay in the village	32.33	32.93	0.163	0.871^{ns}
Value of household assets	89362.5	42111.72	-2.376	0.019**

Results in table 7.16 show that availability of household labor and household assets are the main factors that are associated with the decision to switch from local varieties to early maturing hybrid maize varieties for small-scale irrigation farming. The results suggest that households with more productive members and assets were highly associated with the adoption decision.

Furthermore, Chi square analysis was used to assess the association between categorical variables and the decision to switch to early maturing hybrid maize varieties for small-scale irrigation. Results of the analysis are in table 7.17.

Table 7. 17 Chi-square analysis output for variables associated with switching to hybrid varieties in irrigated maize farming.

Variable	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Gender	0.457	1	0.499^{ns}	0.046
Pattern of maize yield (Rain-fed)	3.81	2	0.149^{ns}	0.133
Pattern of maize yield (Wetland)	4.263	2	0.199^{ns}	0.145
Access to weather information	3.924	1	0.048^{**}	0.134
Adopted new maize varieties (Rain-fed)	64.121	1	0.000^{***}	0.544

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

Results in the Table 7.17 shows that access to weather forecast information and adoption of early maturing hybrid varieties for rain-fed crop production were associated with the decision to adopt early maturing hybrid varieties for small-scale irrigation along the wetland. Farmers who were more knowledgeable of the weather patterns and had adopted hybrid varieties for rain-fed farming were inclined towards adopting early maturing hybrid varieties for small-scale irrigation.

In order to estimate the contribution of farm and farmer characteristics to the decision to adopt early maturing hybrid varieties for small-scale irrigation farming the binary logit model was used. Summary results of the analysis are in table 7.18.

Table 7. 18 Determinants of adoption for early maturing hybrid maize varieties for small-scale irrigation production

Variables	Coeff	Std. Err.	z	P>z	dy/dx	X
Gender	-0.6257	0.3945	-1.50	0.113	0.0572	1.3142
Pattern of maize yield (Rain-fed)	-0.1522	0.4440	-0.34	0.732	0.0139	2.1600
Adopted new maize varieties (rain-fed)	2.0610	0.3741	5.51	0.000***	0.4439	0.2171
Household labor (15 – 65 Years)	0.3144	0.1525	2.06	0.039**	0.0287	1.9828
Education of household head	0.0899	0.0512	1.76	0.079*	0.0082	3.7657
Farming experience of household head	0.0361	0.0163	2.22	0.026**	0.0033	15.2000
Access to weather forecasts	0.8768	0.6119	1.43	0.152	0.0554	0.7828
Pattern of maize yield (Irrigated)	0.1693	0.3770	0.45	0.653	0.0154	2.2057
Total value of assets	0.0000	0.0000	1.23	0.218	0.0000	122975
Constant	-3.6315	1.3286	-2.73	0.006		
Significance levels * significant at 10% ** Significant at 5%***Significant a 1%						
Log likelihood	-39.0210					
LR chi2(9)	65.5					
Prob > chi2	0.000					
Pseudo R2	0.4563					
Y = Pr(Adoption)	0.0430					

In general, the model outputs show that the variables contribute about 45% of total variations, which is significantly higher than about 10% previously reported by Jaleta et al (2018) in Ethiopia.

The results in Table 7.18 shows that adoption of early maturing maize varieties for small-scale irrigation is influenced by adoption of the same for rain-fed production, available household labor, education of the household head and farming experience of the household head. Analysis of the marginal effects of the independent variables suggest that a unit increase in adoption of early maturing hybrid maize varieties for rain-fed production will increase likelihood of adoption of the same seed for small-scale irrigation by about 44% while a unit increase in available household labor will increase the likelihood of adoption by about 2.8%. Additionally, Table 7.18 also shows that a unit increase in education of the household head will increase the likelihood of adoption by about 1% while a unit increase in the number of farming years will increase the likelihood of adoption by about 0.3%.

7.4 Climate change adaptation practices for rain fed crop production

Like most of the climate change vulnerable districts, Phalombe District has had climate change adaptation and resilience projects. The previous projects aimed at enabling the vulnerable communities to withstand and recover from climate change related shocks. The Food and Agriculture Organisation [FAO] and Malawi Government implemented a project from 2015 to 2019 that aimed at enhancing climate change adaptation in Phalombe district. This study therefore sought to understand adoption of climate sensitive adaptation practices for maize production.

Overall, about 39% of the farmers adopted climate change adaptation practices of which 35.5% were male-headed while 46.1% were female-headed households. The results show that female-headed households were more willing to adopt climate change adaptation practices than male-headed households. Table 7.19 below presents summary statistics for adoption of the commonly promoted climate change adaptation practices in the area.

Table 7. 19 Percentage distribution of climate change adaptation practices for rain-fed maize production

Adaptation strategy	Proportion of adoption			Period of use		
	MHH	FHH	Overall	MHH	FHH	Overall
Change in planting dates	26.4	20.8	24.4	3.16 (1.44)	2.44 (1.26)	2.94 (1.42)
Plant spacing	6.4	6.5	6.5	2.38 (1.68)	2.8 (1.48)	2.54 (1.56)
Pit planting upland	2.9	2.6	2.8	2.25 (0.95)	3.5 (0.71)	2.67 (1.03)
Ridge spacing	5.0	7.8	6.0	3.86 (2.97)	4.67 (5.28)	4.23 (4.02)
Manure	17.1	11.7	15.2	3.21 (2.19)	2.78 (1.09)	3.09 (1.94)
Conservation Agriculture	1.4	2.6	1.8	2.5 (0.71)	4.00 (0.00)	3.25 (0.96)

Results in the Table 7.19 above show that most of the male and female farmers changed planting dates in response to late onset of rains. On average, farmers had been using this strategy for about 3 years; results show that females started using this strategy a bit earlier than male farmers did. Manure application is the second most common adaptation practice that has been practiced relatively longer by male-headed households than by female-headed households. The Agricultural Extension agent indicated that two main types of manure that were promoted in the study area were compost and farmyard manure. Most farmers mentioned beneficial roles of manure in terms of enhancing yields.

Plant spacing and ridge spacing were also reported in the area. These adaptation strategies were touted as means to maximize productivity while reducing evaporation of water from the soil during dry spells. The farmers acknowledged improved yields per unit area because of these two practices. However, most of the adopters could not associate these practices with reduced severity of moisture stress. Results also show that few farmers adopted conservation agriculture (CA) and pit planting.

Independent t – test and chi square analysis were done to determine association between farm and farmer characteristics and adoption of climate change adaptation practices. Analysis outputs for the independent t – test are in table 7.20.

Table 7. 20 Independent t – test for adoption of climate change adaptation practices for rain-fed farming

Variable	Adopter	Non-adopter	t	Sig.
Education of the HH head (Years)	3.83	3.49	-0.733	0.464^{ns}
Household labor (Number of people)	1.88	1.94	0.415	0.678^{ns}
Land size for maize field (Acres)	1.22	1.35	0.39	0.697^{ns}
Household Dietary Diversity Index	0.027	0.025	-3.521	0.001***
Extension service (Visits/week)	1.76	1.47	-1.952	0.052*
Farming experience (Years)	16.36	15.78	-0.344	0.731^{ns}
Time of living in the village (Years)	34.35	31.75	-1.009	0.314^{ns}
Amount harvested (Kgs)	70.53	111.46	0.88	0.380^{ns}
Total value of household assets (MK)	58950.09	42084.27	-1.153	0.251^{ns}

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

Results in Table 7.20 show that household dietary diversity and contacts with the extension agent were significantly associated with adoption of climate change adaptation practices. The results thus show that households with more diverse diets were associated with the adoption decision. Similarly, farmers who had more contact with agricultural extension agents were more associated with adoption of climate change adaptation practices. Additionally Chi-square analysis was used for categorical variables (Table 7.21).

Table 7. 21 Chi square outputs for adoption of climate change adaptation practices for rain-fed farming

Variable	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Membership to formal groupings	0.064	1	0.801^{ns}	0.017
Gender of household head	0.013	1	0.911^{ns}	0.004
Pattern of maize yield (Rain-fed)	13.042	1	0.001^{***}	0.248
Pattern of maize yield (Wetland)	10.397	2	0.006^{***}	0.228
Land ownership (Upland)	5.096	1	0.024^{**}	0.154

Table 7.21 shows that the perceived declining patterns of yields for both rain-fed and irrigated maize were associated with adoption of climate change adaptation practices in arable farming. Results also show that adoption of climate change adaptation practices was associated with access to weather related information and ownership of arable land.

The binary probit model was used to estimate the contribution of farm and farmer characteristics to adoption of rain-fed agronomic practices. Results of the analysis are in table 7.22.

Table 7. 22 Determinants of adoption of climate change adaptation practices for rain-fed farming

Variable	Coeff	Std. Err.	z	P>z	dy/dx	X
Extension service	0.062	0.1002	0.62	0.536	0.0241	1.6539
Gender of household head	0.4756	0.2300	2.07	0.039**	0.1855	1.2967
Pattern of maize yield Rain-fed	-0.6781	0.2423	-2.8	0.005***	0.2645	2.1758
Adopted new maize varieties (rain-fed)	0.8154	0.2568	3.18	0.001***	0.3165	0.2253
Household labor	-0.3004	0.1115	-0.27	0.787	0.0117	1.9890
Value of household assets	-0.0000	0.0000	-1.12	0.264	0.0000	119780.0000
Ownership of arable land	-0.7083	0.4929	-1.44	0.151	0.2754	0.9396
Dietary diversity	24.1125	13.6950	1.76	0.078*	9.4053	0.0262
Group membership	-0.0072	0.2246	-0.03	0.974	0.0028	0.7088
Constant	0.5022	0.9476	0.53	0.596		
Significance levels * significant at 10% ** Significant at 5%***Significant a 1%						
Log likelihood	-104.2182					
LR chi2(9)	39.54					
Prob > chi2	0.000					
Pseudo R2	0.1595					
y = Pr(adoption)	0.4159					

The model outputs show that the variables contribute about 16% of total variations. This is within the range of previous studies that found Pseudo R to range from 15 to 30% (Piedra-Bonilla et al., 2020).

The results in table 7.22 shows that the gender of the household head, the maize yield pattern under rain-fed farming, the adoption of early maturing hybrid varieties and dietary diversity are associated with the decision to adopt climate change adaptation practices for rain-fed farming. Table 7.22 shows that female-headed households increased the likelihood of adoption by about 19%, while perceived declining pattern of rain-fed maize yields increased the likelihood of adoption by 26%. Analysis further shows that adoption of hybrid varieties for rain-fed production increased the likelihood of adoption by 32% while dietary diversity increased the likelihood of adoption by 9.4%.

7.5 Climate change adaptation practices for maize under irrigation in winter

Apart from the climate change adaptation practices discussed in 7.4 above, other climate change adaptation practices were promoted for irrigation farming along the wetland. Specifically, the policy actors promoted varying planting methods to maximize use of residual moisture in the soil. The study therefore sought to establish how farmers have changed planting practices in response to the impacts of climate change. Table 7.23 below shows analysis outputs.

Table 7. 23 Changes in planting methods for small-scale irrigation in response to climate change

Irrigation practice	Past			Present		
	MHH (140)	FHH (77)	Overall (217)	MHH (140)	FHH (77)	Overall (217)
Mound	5.5	3.0	4.6	0.8	10.1	0.5
Flat surface	19.3	16.7	18.3	10.4	0.0	10.3
Pits (Holes)	75.2	80.3	77.1	88.8	89.9	89.2

The three crop planting methods under small-scale irrigation farming in the wetland were observed in the study area. In general, results show a general pattern of switching from planting on the mounds or flat surface to pit planting. Most of the irrigation farmers indicated that pit planting has become necessary because of sharp decline in moisture levels during dry season. Farmers further indicated that pit planting was the ideal method to reach the moisture below the surface and retain it after irrigation – especially those that irrigate with simple technologies like pails and buckets.

Independent t-test and Chi square analysis were used to assess the relationship between farm and farmer characteristics and changing of planting methods for small-scale irrigation along the wetland. Results of the t-test analysis are in the table 7.24.

Table 7. 24 Independent t – test for adoption of climate change adaptation practices for irrigation farming

Variable	Adopter	Non-adopters	t	Sig.
Education of Household Head (Years)	4.08	3.51	-0.919	0.359^{ns}
Household labour (People)	2.16	1.83	1.925	0.056*
Distance to water source (metres)	180.19	125.17	1.746	0.083*
Access to extension service (Days/Week)	1.43	1.64	1.034	0.302^{ns}
Dietary diversity	0.023	0.026	1.770	0.078*
Total value of household assets (MK)	41960.00	53805.18	0.607	0.544^{ns}

Table 7.24 shows that available household labor, distance from the field to the water source and dietary diversity are associated with the decision to use pit planting. Results show that adopters' fields were relatively further from water bodies than non-adopters. Similarly, adoption was associated with higher endowment of household labor. Conversely, households with lesser dietary diversity were associated with adoption.

The Table 7.25 presents outputs for the Chi square analysis to determine the association between changes in planting methods and categorical variables.

Table 7. 25 Chi square analysis for adaptation practices for small-scale irrigation farming

Variable	$\chi 2$	Df	P - Value	Phi/ Cramer's V
Gender	7.169	1	0.007^{***}	0.194
Membership to formal groupings	3.96	1	0.047^{**}	0.145
Pattern of maize yield (Rain fed)	9.19	2	0.010^{**}	0.221
Pattern of maize yield (Wetland)	2.86	2	0.239^{ns}	0.125
Adoption of hybrid for rain-fed	0.252	1	0.825^{ns}	0.036

ns = Not significant, * Significant at 10% (P <0.1) **significant at 5% (P < 0.05), ***significant at 1% (P < 0.01)

Table 7.25 shows that gender, membership in formal groups and the pattern of maize yield from rain fed production are associated with changes in planting methods along the wetland to adapt to the impacts of climate change. Results show that female-headed households are more associated with a change in planting method than male-headed households. Results also show that membership in formal groups in the village is associated with a change of planting methods. Table 7.25 further shows that perceived decreasing pattern of maize

yields from rain-fed production is associated with changing planting methods under small-scale irrigation.

The binary probit model was used to analyze the contribution of farm and farmer characteristics to the decision to adjust small-scale irrigation planting methods to adapt to climate change. Summary results of the analysis are in table 7.26.

Table 7. 26 Determinants of adoption for climate change adaptation for small-scale irrigation practices

Variables	Coef.	Std. Err.	z	P>z	dy/dx	X
Extension service	-0.4367	0.1908	-2.29	0.022**	0.0778	1.7417
Gender of household head	-1.0565	0.4381	-2.41	0.016**	0.1882	1.3167
Pattern of rain-fed maize yields	-0.3881	0.3923	-0.99	0.323	0.0691	2.1583
Household labour	0.155	0.1835	0.84	0.398	0.0276	1.8667
Total value of household assets	-0.000	0.0000	-1.48	0.139	0.0000	141358.0000
Dietary diversity index	-87.779	27.3470	-3.21	0.001***	15.6421	0.0270
Membership to groupings	-0.7725	0.3574	-2.16	0.031**	0.1721	0.7417
Education of household head	0.0584	0.0499	1.17	0.242	0.0104	3.9333
Pattern of wetland maize yields	-1.1314	0.4456	-2.54	0.011**	0.2016	2.0917
Adoption of hybrid maize varieties for rain-fed	0.4916	0.4125	1.19	0.233	0.1024	0.2417
Distance to water source	-0.0002	0.0009	-0.24	0.813	0.0000	139.5790
Constant	6.7492	1.9189	3.52	0.000***		
Significance levels * significant at 10% ** Significant at 5%***Significant a 1%						
LR chi2(11)	39.77					
Prob > chi2	0.0000					
Pseudo R2	0.3051					
Log likelihood	-45.3056					
y = Pr(adoption)	0.1021					

The model outputs show that the variables contribute about 30% of total variations. This is also within range of previous studies such as (Piedra-Bonilla et al., 2020). Table 7.26 shows that female-headed households were 19% more likely to change planting methods for climate change adaptation than male counterparts while contact with extension agents increased the likelihood of adoption by 8%. Higher household dietary diversity increased the likelihood of switching planting methods to adapt to climate change adaptation by 15.6 percent while membership to formal groupings increased adoption by 17%. Results also show that perceived declining pattern of maize yields from the wetland increased the likelihood of switching planting methods by 20%.

7.6 Discussion

This section details the discussion of adaptation strategies that farmers are using to minimize the severity of the impacts of climate change on crop production during both rain-fed and irrigation farming. The discussion will start with a synthesis of the adoption of early maturing crop varieties and factors that influence the adoption decision. Secondly, the discussion will focus on the adoption of climate change adaptation practices for rain-fed and irrigated maize production. The discussion will finish by focusing on the factors associated with the adoption of climate change adaptation practices.

7.6.1 Adaptation strategies to the impacts of climate change

Different climate change adaptation practices have been adopted depending on the nature of the ecosystem, livelihood activities, and the nature and intensity of the impacts of climate change. In developing countries, common climate change adaptation practices are in farming because of its importance to the majority of their populations as well as their

susceptibility to climate change related shocks. The study found that adoption of early maturing varieties was a key adjustment to sustain agricultural production in the midst of increasing frequency and intensity of the impacts of climate change. Other scholars have reported the same adaptation strategy in SSA (Agesa et al., 2019; Antwi-Agyei & Nyantakyi-Frimpong, 2021). There are commonalities in the adaptation strategies because of the similarities in the livelihood activities; the socio-economic environment; and the nature of climate change related shocks.

7.6.2 Adoption of early maturing rice varieties for rain-fed crop production

Rice production in developing countries depends on floodwater from rainfall (Shrestha et al., 2022). This high dependence on rainfall has also been one of its key vulnerabilities to erratic rainfall and early cessation of rains. This study found that most of the farmers are switching to early maturing varieties to suit the shortening growing season due to early cessation of rains. Onyeneke (2021) in Ebonyi state, Nigeria, reported increased adoption of early maturing rice varieties among smallholder farmers due to erratic rainfall. A study in northern Ghana also reported increased adoption of early maturing rice varieties to avert the impacts of climate change (Zakaria et al., 2020). Similarly Jin et al. (2020) in Sierra Leone reported the high adoption of early maturing rice varieties as a means to withstand the impacts of erratic rainfall.

Studies have been done to establish a preference for rice varieties between male- and female-headed households. For instance, Mehar et al. (2017) found that female-headed households in eastern India chose rice varieties based on cooking quality and moisture stress tolerance. However, Mogga et al. (2018) in South Sudan reported male dominance

in decision making concerning choice of rice varieties for commercial purposes. In this study, female-headed households were more inclined towards early maturing rice varieties while male-headed households were inclined towards varieties with high yielding potential, stress tolerance and high marketability. The results therefore show that female-headed households prefer varieties associated with food security benefits while male-headed households focus on commercially beneficial traits. The preferred early maturity traits for female-headed households were because they wanted to harvest and sale or barter with maize in order to get quick relief from intense food shortages. While males aimed at selling the rice for income generation as other preferred traits included aroma and marketability.

Land size and ownership determines the possibility of adopting early maturing varieties. Zeng et al. (2018) reported a strong association between land size to adoption of early maturing rice varieties. Studies by Mustapha et al. (2012), Doung and Thanh (2019), Lu et al. (2021) and Zakaria et al. (2020) confirmed this observation for adoption of early maturing rice varieties. Socio-cultural and institutional dynamics that determine land ownership might differ from place to place but size and tenure security enable adoption of more responsive varieties to the new climate change phenomenon.

Access to weather forecasts has been considered as one of the key elements for climate change adaptation. Abid et al. (2019) reported that farmers' access to weather forecasts influenced the adoption of climate change adaptation practices in Pakistan. Similarly, Acevedo et al. (2020) noted that access to weather forecasts influenced the adoption of early maturing rice varieties. Secondary data (table 4.2 in section 4.4) shows that erratic

rainfall has affected most households in terms of thwarting food production for most households in Phalombe district. Therefore, the awareness of weather forecasts enables most farmers to make necessary adjustments in their crop production practices to abate the severe impacts of climate change. Informed decision-making based on credible weather forecasts enables systematic adaptation of crop production to the impacts of climate change.

Food security also determines the decision of the household to adopt climate change adaptation practices and technologies. Food security in this study was measured by the amount of maize produced and the household dietary diversity. Results in this study shows that the adoption of early maturing rice varieties is associated with acquisition of the product (rice) that can be sold to buy maize. Other studies have also shown that adoption of early maturing rice varieties positively influences food security (Bairagi et al., 2020; Olounlade et al., 2020 and Lu et al., 2021). In the aforementioned studies, rice contributes directly to food security, however, in the current study, adoption of early maturing rice varieties increases rice outputs that are largely sold or bartered with maize. This implies that food security and adoption of early maturing rice varieties have a positive relationship for smallholder farmers.

Community groups, either formal or informal, form crucial networks through which information and resources flow (Mishra, 2020). Dependence on formal and informal networks is common in rural communities in developing countries (Martikke, 2017). Connectedness to such networks keep the households in touch with community resources and up to date information. This study found an association between membership to such

groupings and adoption of early maturing rice varieties. The study by Seini (2020) in Ghana also found that adoption of rice production technologies was associated with group membership. Chapter 5 showed that there is high connectedness among the people in the study area and thus resources like seed and knowledge of agronomic practices possibly flow through community groups and influence adoption of early maturing rice varieties.

Gender has been identified as one of the factors that influence adoption of early maturing rice varieties in this study. In Ghana, a study by Abdul-Rahaman et al. (2021) found that gender influenced adoption of early maturing rice varieties similar to the current study findings. Another study by Mujawamariya et al. (2022) in Madagascar reported that gender influences choice of rice varieties. A study by Mehar et al. (2017) noted that gender preferences for the early maturity varieties are emboldened in the specific characteristics that are attractive to each gender considering the varying roles for males and females in the households of developing countries.

7.6.3 Adoption of early maturing maize varieties for climate change adaptation

Smallholder farmers are increasingly recognizing the importance of early maturing varieties as incidents of erratic rainfall are becoming more frequent and intense (Antwi-Agyei & Nyantakyi-Frimpong, 2021). This study found that a higher proportion of male-headed households adopted early maturing maize varieties than female-headed household. This finding concurs with a study by Fisher and Carr (2015) in Uganda who noted that female-headed household were adopting early maturing varieties less than male-headed households. In contrast, Sinyolo (2020) in South Africa found higher adoption rates of early maturing maize varieties among female-headed households than male-headed

households. Gebre et al. (2019) and Worku et al. (2020) did not find significant evidence of gender difference in the rate and intensity of adoption of improved maize varieties. These findings show that adoption of early maturing varieties is influenced by gender in a given context and varying dynamics in adoption between male-headed households and female-headed households might be due to unique characteristics in the study area.

Education of key decision makers in the household is recognized as one of the driving factors for adoption of early maturing maize varieties. In this study, the education of the household head as well as the spouse were found to significantly influence the adoption of early maturing varieties. In this study area, matrilineal culture enables spouses especially women to have leverage in decision making especially under uxorilocal traditions. A study by Lunduka et al. (2019) in Zimbabwe also showed that the education of the household head significantly influenced the adoption of improved maize varieties. However, a study by Abdoulaye et al. (2018) in Nigeria found that the education of the household head had no significant impact on adoption of improved maize varieties. However, most scholars argue that education improves the adoption of technology (Asfaw & Admassie, 2004; Nicholls, 2018; Yigezu et al., 2018).

Agricultural extension agents are considered as the bridge between agricultural innovators and farmers (Mapiye et al., 2021). Chavas and Nauges (2020) reported that extension agents significantly influence the decision to adopt agricultural innovations. Mwangi (2019) also reported that access to extension services is important to technology adoption. Similarly, this study found that adoption of early maturing maize varieties was highly influenced by contact with extension agents. This phenomenon shows that increased

adoption of early maturing maize varieties for climate change adaptation can be achieved through a vibrant extension service.

Most of the rural households in developing countries depend on household labor for farming and other livelihood activities. A study by Khan et al. (2019) reported that hybrid varieties require higher labor input that local varieties. In this study it was found that household labor influenced the adoption of early maturing maize varieties. This finding concurs with Challa and Tilahun (2014) who reported that households with more labour adopted modern technologies. Similarly, a study by Simtowe et al. (2019) in Uganda found higher labor endowment in households that adopted drought tolerant maize varieties. These findings show that early maturing maize varieties have associated labor demand for effective adoption.

Previous studies show that households that adopted early maturing varieties reported higher yields and thus were more food secure (Jaleta et al., 2018; Lunduka et al., 2019; Manda et al., 2018). Other studies have also shown that some farmers adopt early maturing varieties upon perceiving increased incidents of food insecurity (Lamessa et al., 2019). This study found that farmers with higher food output adopted early maturing seed varieties. It also found that farmers that perceived declining yields also adopted early maturing varieties to bolster food production security. Adenle et al. (2019) reported that smallholder farmers in vulnerable areas prioritize food security by adopting early maturing maize varieties to enhance and sustain food availability.

Land is the critical factor in crop production. This study established that land ownership influenced the adoption of early maturing rice varieties. This study's findings concur with Uduji and Okolo-Obasi (2018) who reported a positive relationship between adoption of agricultural innovations and land ownership. However, Abdoulaye et al. (2018) and Bedeke et al. (2019) found no relationship between land ownership and adoption of drought resistant maize varieties. The socio-cultural context of this research study area, however, requires more stable land ownership to motivate male-headed households to adopt farming technologies like early maturing varieties.

This study has found that farming experience influences adoption of early maturing maize varieties as an adaptation strategy to erratic rainfall. However, this finding contradicted Uduji and Okolo-Obasi (2018) and Adoulaye et al. (2019) who reported that more farming experience had a negative impact on adoption of farming technologies. Nonetheless, the study by Gebre et al. (2019) concurred with the current study and reported that household heads with longer farming experience were more likely to make unilateral decisions to adopt improved maize varieties. In general, more experienced farmers do not adopt early maturing maize varieties unless their experience can be coupled with relevant knowledge, especially in climate change and the importance of adaptation technologies and practices.

7.6.4 Adoption of agronomic practices for climate change resilience

Adoption of climate change adaptation practices that have the potential to simultaneously improve agricultural productivity while minimizing the impacts of climate change (Lokonon & Mbaye, 2018). Climate change adaptation strategies provide a cushion from environmental shocks that thwart smallholder farming in sub-Saharan Africa (Akinyi et al.,

2021). According to Bedeke et al. (2019) adoption of climate change adaptation strategies increases agricultural productivity and climate change resilience. The main themes of climate change adaptation strategies currently being promoted in developing countries include crop management, irrigation and water management, and farm management (Shaffril et al., 2018; Akinyi et al., 2021).

Studies in the SSA region show evidence of the promotion and adoption of pit planting. For instance, Ndlovu et al. (2020) reported the adoption of pit planting for climate change adaptation in Zimbabwe while Wouterse (2017) reported the same in Niger and Mkisi (2014) in Malawi. In this study, a higher proportion of male-headed households adopted pit planting compared to female-headed households. This finding agrees with Chobowa et al. (2020), who also found a higher proportion of male adopters. Pit planting as a moisture conservation strategy is in tandem with the goal of reducing moisture stress that enables crops to grow regardless of low moisture in the soil. This adjustment ensures sustained crop production in the midst of the impacts of climate change, especially erratic rainfall.

One of the main forms in which erratic rainfall occurs is the late and unpredictable onset of rains. In the absence of credible weather forecasts, farmers are always unsure about when to plant (Mubiru et al., 2018; Guido et al., 2020). This study identified a change in the timing of planting as one of the adjustments to counter the impacts of the late and unpredictable onset of rains. This finding concurs with Cui and Xie (2022) who reported a similar phenomenon among maize farmers in China. Farmers plant upon observing adequate and consistent precipitation. However, delaying planting until there is sufficient

precipitation is in itself a vulnerability factor because the adequacy of rains and assumption of its continuity is arbitrary and not scientifically substantiated.

Climate change adaptation practices or technologies are expected to boost adaptive capacity (resilience), food security, and contribute to climate change mitigation in resource-poor smallholder farming systems (Nyasimi et al., 2017). These practices or technologies encompass a set of practices that are suitable to local climatic, socioeconomic, and cultural conditions. This study identified changes in plant and ridge spacing, manure making, mulching and zero tillage in the study area. Evidence shows that the use of such technologies effectively abates climate related shocks, especially those that create moisture stress (Thakur & Uphoff, 2017). Despite low adoption, the continued use of these technologies and practices has the potential to build climate change resilience in the area.

Conservation Agriculture [CA] has also been identified as a climate change adaptation strategy for farming populations vulnerable to erratic rainfall and droughts (Motaroki et al., 2020). CA is a collection of practices and technologies that enhance soil productivity and minimize the severity of climate related shocks, such as moisture stress and excessive moisture (Steward et al., 2018). This study found that male-headed households were more inclined towards enhancing soil fertility through manure application while most female-headed households focused on moisture stress minimization strategies. In contrast, Kimaru-Muchai et al. (2020) reported that female-headed households were less interested in reducing the risks of losing crops due to dry spells in Kenya while Danso-Abbeam et al. (2019) reported higher adoption among male-headed households in Ghana.

Most studies have attempted to estimate the contribution of climate change adaptation practices to food security (Di Falco et al., 2011; Wiebe et al., 2019; Diallo et al., 2020). This study however, explored the contribution of household food security to the decision to adopt climate change adaptation practices in maize production. Analysis revealed higher food security status was associated with the use of climate change adaptation practices for maize farming. The study did not endeavor to establish causality but the association of the two shows that adoption of climate change adaptation practices has the potential to significantly improve adaptation to the impacts of climate change for rural households that highly depend on smallholder agriculture.

Farmers' perceptions of potential or expected food patterns based on their previous experiences, determine measures that can be adopted to improve food production and climate change adaptation (Singh, 2020). Similarly, in this study, perceived maize yield patterns by the farmers were associated with adoption of climate change adaptation practices. The ability to assess patterns of yields enabled farmers to adjust maize production practices in order to minimize losses they previously experienced under convention farming practices. Knowledge of declining maize yield patterns therefore prompted the decision to make necessary changes to suit the current altered crop production phenomenon and maintain food production.

Agricultural extension services have been acknowledged to play a crucial role in the diffusion of agricultural innovations (Weyori et al., 2018). This study also identified an association between the adoption of climate change adaptation practices with the frequency of meetings with agricultural extension agents. Makate et al. (2019) also reported the

significant contribution of extension services to the adoption of climate change adaptation practices by smallholder farmers in Southern Africa. These findings therefore demonstrate the importance of extension services in promoting adaptation practices that eventually help build resilience to the impacts of climate change.

Membership in formal and informal groups in rural areas is one of the key elements of social capital from which the community members benefit. Khanal et al. (2021) found no significant relationship between membership in groups and adoption of climate change adaptation practices. However, in this current study group membership was found to be associated with adoption of climate change adaptation practices. Social capital helps community members share knowledge, practices and experience in different livelihood activities, including farming. Results of this study therefore show that a stronger connection of farmers through group membership can enable households to speed up the adoption of climate change adaptation practices, which can contribute to resilience.

The impact of gender on adoption of climate change adaptation practices has been explored in various studies. Contribution of gender to adoption of climate change adaptation practices varies across time and space. For instance, Makate et al. (2019) found that the adoption of climate change adaptation practices was not influenced by the gender of the household head while Bedeke et al. (2019) found higher adoption of climate change adaptation strategies by male-headed households in Ethiopia. In this study, evidence has shown that the gender of the household head influences the adoption of climate change adaptation practices. The study was done in a matrilineal community where females are

custodians of land and thus female-headed households were more willing to adopt the technologies and practices than male-headed households were.

Studies have shown that climate change adaptation strategies are promoted in packages and thus adoption of one component influences adoption of other elements within the package. For instance, Zougmoré et al (2018) noted that promotion of climate smart agriculture was done along with hybrid varieties. This finding concurs with the current study that found that farmers that adopted hybrid varieties also adopted other climate change adaptation practices such as pit planting, conservation agriculture and manure application. This finding therefore shows complementarity of the climate change adaptation practices which help minimize adverse impacts of climate change while enhancing crop yields for smallholder farmers.

CHAPTER 8

CONCLUSION, RECOMMENDATIONS AND ORIGINALITY

8.1 Introduction

This chapter concludes the findings of this study. The chapter reflects on the findings of the study against the theoretical and conceptual background of the study. The chapter further points towards areas of further research and recommendations.

8.2 Vulnerability context of the study area

The study has demonstrated that cultural factors are pivotal in determining extent of vulnerability to the impacts of climate change for male- and female-headed households exposed to similar shocks. The cultural ecology theory indicates that different groups of the society interact differently with their environment while responding to environmental changes. In this study, male- and female-headed households respond to climate change differently due to cultural and traditional practices that influence access to livelihood resources and activities. The study has demonstrated that gender disaggregated analysis is pivotal in understanding climate change vulnerability using cultural ecology theory and PAR model.

The study has added knowledge to the vulnerability analysis debate by showing that households subjected to same climate related hazards can exhibit different vulnerability outcomes due to underlying cultural factors. Given that the study was limited to matrilineal cultural context, other studies can explore the same in patrilineal settings to compare the findings.

The study recommends diversification of livelihoods away from climate sensitive food and income sources especially for female-headed households. This can be achieved by increasing women's involvement in among others, fish value chains that are currently dominated by men. The study also recommends increased access to financial resources through formal lending institutions for both male- and female-headed households to enable them buy land and relocate away from floods prone areas and make long term investments to reduce flood vulnerabilities. Considering that dependence on *nsima* has been embedded in their food traditions, promotion of alternatives should be systematic to ensure smooth transition to other staples such as rice. The study also recommends introduction of formal lending institutions with moderate interest rates and flexible lending conditions.

8.3 Enabling institutional environment for building climate change resilience

Varying interactions between people and their environment to adapt to environmental changes is regulated by rules and regulations on access to and use of resources. The findings have concurred with the HCIA that argues that institutional evolution trajectories adopt unique paths over time. The study has illustrated the evolutionary trajectory of the informal institutions on customary land due to increased need for its commoditization.

Although current state of formal institutions on customary land is sufficient to formalize individual ownership and trading of rights, the study has showed that informal institutions still dominate. The institutional transformation is not necessarily skewed towards a particular gender group, however, the study found that male-headed households have higher financial assets base that can easily enable them to buy land under customary tenure unlike their female counterparts. In the long run less female-headed households may have individual land thus have limited ability to build climate change resilience. These findings have added to knowledge on land tenure and climate change resilience in rural communities of developing countries by demonstrating how gender might contribute to long term less resilience to female headed households devoid of deliberate interventions to increase their ability to buy land. Given that the scope of the study was limited to matrilineal traditions in a very remote area, further research can explore the same across the country to make more broad policy recommendations.

It can therefore be recommended that there should be vibrant popularization of the National Land Policy and Land Act 2016 to formalize land acquisition and ownership arrangements for more equitable allocation and use of land. Promotion of the formal land regulatory rules should be accompanied with women empowerment to enable them own land and secure their tenure to increase their ability to build climate change resilience.

8.4 Access to livelihood assets for recovery from the impacts of climate change

Although the cultural ecology theory does not specify nuances on how societies respond to environmental changes, this study has showed that there is a difference on how male and

female-headed households interact with their environment to abate impacts of climate change.

Culture and gender perceptions influence access to livelihood resources that enables households to recover from the impacts of climate change. Male-headed households have a broader range of livelihood assets compared to their female counterparts. The study has therefore showed that female-headed households have a narrow asset base to draw from in order to recover from climate change shocks compared to male-headed households. The difference in interaction with the environment by different groups (in this study being male- and female-headed households) to adapt to environmental changes as noted in the cultural ecology theory arises from cultural traditions on inheritance; control and access to resources as well as gender perceptions in the study area. An article was published on these findings to contribute to the knowledge on the subject matter. This study was limited to one area with unique cultural characteristics thus future studies can expand to more diverse cultures to analyze resources distribution between male- and female-headed households and how they impact resilience building.

Considering lower access to natural assets especially fishing that help abate food shortages during lean period, women can be trained and financed to participate in the higher levels of fish value chain to earn income. Financial gains from participating in fish value chain can be invested in village savings groups to strengthen their social cohesion as well as mutual dependence to recover from the impacts of climate change. This intervention can therefore broaden resource base for female-headed households and thus diversify their means to recover from the impacts of climate change.

8.5 Response mechanism to the shocks or hazards

Gender of the household head determines preference and choice of adaptation strategy. The study has showed that female-headed households are keener to adopt early maturing varieties compared to male-headed households because of higher household food security responsibility on females (especially women) unlike on males. These findings therefore support the observation by Aryal et al. (2020) who noted that adaptation strategies differ between male- and female-headed households due to contextual issues such as gender norms and perceptions. The study has therefore showed that culture determines roles and responsibilities that consequently determine choice of technologies and practices to adapt to the impacts of climate change. The study has contributed to the knowledge of climate change adaptation by adding nuances on drivers and preferences of technologies and practices between male- and female-headed households. Comparative studies can explore choice of climate change adaptation practices between male and female-headed households in areas with different climate change related shocks.

Currently various climate change adaptation practices are continually being adopted and used by the farmers in the study area. This study shows that improving technological innovations and adequate out-scaling using appropriate channels, can increase adaptation to the impacts of climate change with purposive targeting of the population groups considering their respective preferences to the technologies and practices. The study has shown that gender roles and preferences should be highly considered in out scaling of

climate change adaptation strategies because of the food security burden that females have at household level compared to male heads.

Promotion of the interventions should deliberately aim at increasing awareness of multiple benefits of early maturing hybrid maize varieties beyond their adaptability to a shortened growing period. Deliberate gender mainstreaming in climate change adaptation must be done to ensure that climate change resilience does not leave vulnerable groups like female-headed household behind.

8.6 Originality of research

The original contribution of this research to the body of knowledge on gender and climate change resilience is fourfold. Firstly, the research enhanced the understanding of the underlying conditions to overall climate change vulnerability. Most debates and scholarly discourse analyze vulnerability quantitatively, however, this study has used qualitative approach to unveil how culture and gender perceptions influence severity of climate change vulnerability in a traditional matrilineal communities of developing countries like Malawi. Culture and its traditional land administration practices determines access to and security of land for farming and settlement. The study has demonstrated that gender roles and perceptions influences livelihood activities a household can adopt thus exacerbates or reduce destitution in the event of climate change related shocks. The study has also highlighted food preference as a critical factor to vulnerability. Over dependence on *nsima* as the only staple aggravates destitution in the event of crop (maize) failure due to the impacts of climate change. In this regard, this study has uncovered the often overlooked factors that create underlying conditions to household vulnerability.

In terms of formal and informal institutions for customary land, the study has articulated that albeit existing formal land related institutions, informal ones still dominate in the study area. The informal institutions on customary land have evolved over time and are currently oriented towards trading of land rights. Although the evolutionary trajectory does not particularly favor a specific gender, male-headed households have higher financial resources to buy land unlike their female counterparts. This study therefore shows that informal institutions have created an opportunity to more secure tenure which can reduce climate change vulnerability. Considering that most land transactions are done informally, this study highlights the needs for speedy formalizations of the processes to regulate land trading to enable vulnerable groups like female-headed households to own land.

Distribution and use of livelihood assets to avert impacts of climate change has been central to the debate of climate change resilience. The study has added the gender aspect to the debate on differential assets distribution and how they affect speed of recovery from the climate change related shock between male- and female-headed households. The study has showed that male-headed households have a broader livelihood assets base to recover quickly from climate change related shocks compared to female-headed households. This uneven distribution stems from socio-cultural limitations that preclude women from accessing and using some resources. The inadequacy of these resources consequently makes female-headed households less resilient compared to their male counterparts. The study therefore highlight the need for gender disaggregation during resilience analysis to outline nuances that can lead to specific solutions to build resilience for both male- and female-headed households.

Climate change adaptation studies have been carried out in different parts of the world. In developing countries studies have largely focused on factors that influence choice of adaptation practices and technologies. This study has added to the debate by highlighting specific gender related drivers that are associated with choice. This study has showed that female-headed are often burdened with household food security priorities thus they choose technologies and practices that guarantee food availability unlike males who may have other priorities such as income generation. The study has therefore hinted that promotion and out scaling of climate change adaptation practices and technologies has to consider core priorities of people being targeted for higher adoption and effective utilization to meet the need of those specific groups.

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APPENDICES

Appendix A. Village Key Informant Interview Guide

Background

1. What are the common marriage and inheritance practices in this area?
2. How to these traditions impact household and community actions by men and women?
3. Has there been changes in the way people choose these traditions
4. What do you think is prompting changes
5. How do households acquire land for settlement and farming?
6. What is the staple food for this community
7. What are the other crops people grown and for what purpose
8. How can you describe food security status of this community
9. What factors do you think have contributed to this situation

Livelihood activities and climate change

10. What are the main livelihood activities in this area?
11. How are they affected by the impacts of climate change?
12. What has been the pattern of the impacts of climate change the past 10 years?
13. What enhances severity of the impacts of climate change in this area?
14. Which households are affected the most between male and female headed households?
15. How do people manage food shortages that occur due to impacts of climate change

Local development structures

16. Are there local development structures in this village
17. What are the roles of those development structures
18. Can you describe their working relationship amongst themselves and with chiefs

19. How do the help in times of climate change related shocks?
20. What is their working relationship with NGOs and government?

Appendix B. DISTRICT KEY INFORMANT GUIDE

1. What are common impacts of climate change in this district?
2. What has been the historical pattern of these climate related shocks
3. What factors exacerbated vulnerability?
4. At the moment what are interventions are being implemented to reduce vulnerability?
5. Is the food adequate? If not how are you managing the situation?
6. What is the food security status in this district?
7. What are the means people are using to abate food shortage?
8. What is making others less destitute in terms of water food availability?
9. What climate change resilience interventions are being implemented in TA Jenala?
10. Can you describe effectiveness of such interventions?
11. What is affecting adoption and use of the solutions from Government/NGOs and how?
12. What do you think Government/NGOs need to change in their current interventions to increase adoption and why?
13. Before Government and NGOs started implementing resilience interventions, how were the people in TA Jenala recovering from shocks?
14. Do the people in TA Jenala have locally developed solutions to food insecurity problems?
15. How can you describe effectiveness of such solutions?
16. How do you compare utilization of Government/NGO solutions vs local solutions? What is the reason for the preference?
17. What are common food preferences and utilization in this district? How did these habits/practices started and why? Are you aware of their impact on food and water availability?
18. Can you change these behaviors to improve food utilization? if yes how? If no why not?

Appendix C. GUIDE TO FOCUS GROUP DISCUSSION

History and Background

1. What is the common tribe in the area?
2. How did the people settle in this area and what brought them to this location?
3. How is land acquired and inherited in the area?
4. How does that affect control and use of land for the men and women in the area?

Climate change

5. How can you describe climate change?
6. What have been the changes you have noted?
7. And how are these changes affecting your livelihood?
8. What are the factors that determine vulnerability to the impacts of climate change?
9. What are the means which people are using to abate food shortage?

Resilience

10. How do people recover from food shortages due to climate change
11. What are enablers of climate change resilience?
12. How do households recover and withstand impacts of climate related shocks
13. How can you describe effectiveness of such recovery practices?
14. What affects adoption and use of those practices and how?
15. What are common food preferences in this community?
16. How did these habits/practices started and why?
17. Are people aware of their impact on food and water availability?
18. Can the behaviors change to improve food utilization if yes how? If no why not?

Appendix D. ONE TO ONE INTERVIEW

Introduction and background

1. What is the common tribe in this area
2. What are common marriage and inheritance practices in this area?
3. How do the people (men and women) perceive these traditions

Climate change

4. What are the common impacts of climate change in this area?
5. How have you been affected by impacts of climate change?
6. What are the common livelihood activities in this area
7. How are the impacts of climate change affect these livelihood activities
8. What makes people suffer the most due to the impacts of climate change in this area?
9. How do you sustain food availability in your household amidst impacts of climate change?
10. Is the food is inadequate, how are you managing the situation?
11. If food is adequate what are contributing factors to your status?

Resilience

12. What do you do to recover and withstand impacts of climate change?
13. What are common livelihood activities used to recover from climate shocks?
14. Do the people in this community have locally developed solutions to food insecurity?
15. How can you describe effectiveness of such solutions?
16. What are current food utilization practices in this your household that affect food availability?
17. How did these habits/practices started and why?
18. Are you aware of their impact on food availability?

19. Can you change these behaviours to improve food utilization? if yes how? If no why not?

Appendix E. Guide to Participant Observation

Appendix F. Household questionnaire

INTRODUCTION: I am……. from Chancellor College. I have come here to interact with you on how you generally live in this community. I would like to learn a number of things from you ranging from impacts of climate change, food and water security, climate change adaptation and what organisation are doing here to build resilience. I would like to urge you to be free in this interview because the aim of this discussion is to help us understand the challenges faced and how best they can be rectified to the benefit of all. The information that I may get from you will be kept confidential and will not be used for any other purpose apart from the one stated above. Your cooperation will be highly appreciated. *Are you willing to participate in this study? Yes [ ] No [ ] (If no thank the person and look for another respondent*

SECTION A – SOCIAL DEMOGRAPHIC CHARACTERISTICS

A1. Name of Enumerator		
A2. Group Village Headman	1 = Mwango 2 = Njobvu 3 = Dzanjo 4 = Chimombo	
A3. Name of Respondent		
A4. Gender of respondent		1 = Male 2 = Female
A5. Age of respondent		
A6. Marital status of respondent		1 = Single, 2 = Married (Monogamy) 3 = Married (Polygamy) 4 = Separated 5 = Divorced 6 = Widowed
A7. Are you the head of the household		No = 0, Yes = 1 **If yes go to A.9**
A8. Relationship to household head		1 = Head 2 = Spouse 3 = Child 4 = Other relatives
A9. Gender of Household head		1 = Male 2 = Female
A10. Age of Household head		
A11. Education of Household Head (Years)		

A12. Education of the spouse (Years)		
A13. Household size Adults (16 years & above)		Male [ ] Female [ ]
Children (16 years and below)		
A14. Do you have a cell phone?		No = 0, Yes = 1 Number_____
A15. Is this house your own?		1=Own, 2 = Rented
A16a. House characteristics (Wall)		1= Burnt bricks, 2=Unburnt bricks, 3= Mud 4= grass
A16b. House characteristics (Roofing)		1=Iron sheets, 2= Grass, 3= Other
A17. What is your main source of livelihood (Number 1)		1= Farming 2= Fishing 3= Permanent job 4= Ganyu 5= Livestock 6=Small business 7= Artisan skills (e.g mat weaving)
A18. What is your main source of livelihood (Number 2)		1= Farming 2= Fishing 3= Permanent job 4= Ganyu 5= Livestock 6=Small business 7= Artisan skills (e.g mat weaving)
A19. What is your main source of livelihood (Number 3)		1= Farming 2= Fishing 3= Permanent job 4= Ganyu 5= Livestock 6=Small business 7= Artisan skills (e.g mat weaving)
A20. For how long have you been farming?		
A21. For how long have you been fishing?		
A22. How did you become a citizen of this village?		1= Birth 2= Marriage (Chikamwini) 3= Marriage Chitengwa 4 =Bought land 5=Non-citizen
A23. What is your resident status in this village?		1= Resident 2= Immigrant (business/fishing) 3 = Migrant worker 4 = Hired laborer
A24. How long have you lived in this village		

SECTION B – COMMON IMPACTS OF CLIMATE CHANGE

B1. From your experience do you think climate have changed over the years? [__] 1 = Yes, 0 = No

B2. What are common impacts of climate change do you experience in this area

Impact of climate change	Rank	Frequency past 10 years	Season of impact	Experienced during 2019/20?	Crops affected	Estimated loss	Period to recovery
Dry spell/Early cessation of rains							
Floods							

Stormy Rains							
Fall army worms							
Bugs (Gaba)							

Codes Period of attack 1 = Rainfed 2 = Dry Season 3= Both

Codes for crops affected 1=Maize 2=Rice 3=Peas 4=Leafy vegetables

B3. Have you ever lost a house due to Floods/Stormy rainfall or strong winds in the past 10 years? [__] 1 = Yes, 0 = No

B4. Have you ever lost household assets due to Floods/Stormy rainfall or strong winds in the past 10 years [__] 1 = Yes, 0 = No

SECTION C – HOUSEHOLD RESOURCE ENDOWMENT AND LIVELIHOOD ACTIVITIES

Section C1 – Resource Endowment

Human Capital

C1. How many people in this household work and contribute to food and income needs? [_____]

C2. How many are involved in skilled work [_____] how many are into non-skilled work [____]

C2. Do you have any of the productive people that is chronically ill? [_] 1=Yes 0 = No (If No go to C4)

C3. How many of the productive people are chronically ill? [_____]

C4. Was there any sick person in this household during crop production period? [____] 1=Yes 0 = No (If No go to C6)

C5. For how long was the member sick? [_____] Weeks

C6. Has any adult (16 and above) migrated out of this household in the past 12 months [____] 1=Yes 0 = No

C7. People that can help in times of need	Within the village	Outside the village
Relatives		
Friends		

Social Capital

C8. Do you belong to any formal/informal grouping in this village? [_] 1=Yes 0 = No If (If No go to C10)

C9. Grouping	Membership? (1 = Yes, 0 = No)	Leadership? (1 = Yes, 0 = No)	Get any assistances during food shortages (1 = Yes, 0 = No)
Church			
Savings and Loan			
Governance committees (e.g VDC)			
Sports group			
Political parties			
Clubs and Associations (NGOs)			
Farming clubs			

C10. Do you receive remittances from relatives from elsewhere [____] 1=Yes 0 = No if yes MK_____/Year

C11. Have you contributed towards funeral/burning oven/wedding/chieftaincy this year? [____] 1=Yes 0 = No

Natural Capital

C12. Does your household have land to grow crops (Upland)? [____] 1=Yes 0 = No (**If No go to C14**)

C13. How many plots (Upland) of land do you have? [_____]

Plot	**Size**	**Ownership status**	**Period of ownership (Years)**
Plot 1			
Plot 2			
Plot 3			
Plot 4			

Codes for ownership status 1=Own (Chikamwini) 2= Own (Chitengwa), 3= Own Bought, 4= Clan land (Ambumba) 5=Rented

C14. Does your household have land at the wetland? [____] 1=Yes 0 = No (**If No go to C17**)

C15. How many plots (Wetland) of land do you have? [_____]

Plot	Crops grown 2020	Location 1= Chikaonga 2 = Across river	Size of plot (Acres)	Ownership status	How many times did you grow crops in 2020	Distance from water source (m)	Quantity harvested (1)	Quantity harvested (2)
Plot 1								
Plot 2								
Plot 3								
Plot 4								

Codes for crops: 1=Rice, 2=Maize, 3= Legumes, 4= Vegetables, 5= Tubers, 6= Tomatoes, 7= Others

Codes for ownership status 1=Own (Chikamwini) 2= Own (Chitengwa), 3= Own Bought, 4= Clan land (Ambumba) 5=Rented

C16. Did you grow any crop during rainy season in the wetland plots? [____] 1=Yes 0 = No

C17. What was the main crop [___] 1= Rice, 2=Maize, 3=Vegetables, 4=Tomatoes, 5=Others

C18. How much did you harvest [_____] Kgs

C19. What has been the pattern of wetland dry season crop production? [___] 1=Increasing, 2=Decreasing, 3 No Change

C20. What do you think is the reason for the pattern? _____

C19. Do you have limited access to the irrigation water? [____] 1=Yes 0 = No

C20. What is the main source of energy for cooking? [__] 1=Own forest 2= wetland 3=Crop fields 4=Village forest 5= Other

Physical Capital

C21. What is your main source of domestic water [___] 1=Borehole 2 =Well 3= Tap 4=River

C22. What is the main source of energy for lighting? [___] 1=Battery 2= Paraffin 3= Firewood 4= Other

C23. How many habitable houses do you have? [____]

C24. Have you ever rebuilt your house after a climate related shock in the past 10 years? [____] 1=Yes 0 = No

C25. How long did it take to rebuild [_____] Months?

Financial Capital

C26. Do you or any member of the household belong to Savings and Loan group? [___] 1 = Yes 0 = No

C27. If yes, how much have you saved to date? MK_____

C28. Do you or any member of the household has a bank account? [____] 1=Yes 0 = No

C29. How much balance do you have at the bank MK? _____

C30. Did you offer *Katapila* last year? [____] 1=Yes 0 = No **C27b.** How much did you lend? MK_____

C31. Did you get *Katapila* last year? [____] 1=Yes 0 = No **C28b**The katapila was for how much? MK _____

C32. What is the main regular source of cash into your household? _____

C33. How much do you earn from that regular source in a month? MK_____

SECTION D – LIVELIHOOD AND INCOME SOURCES

D1. Livelihood source	Income in the past 12 months (Sold)	Months sold
Rainfed agriculture dependent sources (Crop sales)		
Maize		
Rice		
Peas		
Tomatoes		
Leafy vegetables		
Onions		
Sale of livestock		
Cattle		
Goats		
Chickens		
Pigs		
Fishing and or fish trading		
Fishing		
Fish trading		
Ganyu		
Ganyu in the village		

Ganyu at the lake		
Ganyu in crop fields		
Other sources		
Small scale businesses		
Humanitarian assistance		
Rent out land		
Renting out irrigation equip		
Any other sources		

SECTION E – CROP PRODUCTION: Section E1 – Upland crop production

E1. Crop grown	**Date Planted**	**Crop variety**	**Seed rate**	**Area**	**Soil type**	**Quantity fertilizer**		**Intercrop?** 1=Yes 0= No	**Amount harvested**
						Basal	**Top dressing**		
Maize									
Rice									
Chick peas									
Cow peas									
Other crops									

E2. What has been the pattern of rainy season maize production? [___] 1=Increasing, 2=Decreasing, 3 No Change

E3. What do you think is the reason for the pattern? _____

E4. What has been the pattern of wetland dry season crop production? [___] 1=Increasing, 2=Decreasing, 3 No Change

E5. What do you think is the reason for the pattern? _____

Section E2 – Fishing

E2. Is any member of your household involved in fishing? [____] 1 = Yes 2 = No **(If no go to E7)**

E3. Which months are peak period for fishing (Range) _____

E4. How much money is raised from fishing per week during peak periods? MK. _____

E5. Which months are lowest in terms of fishing? (Range) _____

E6. How much money is raised from fishing per week during low periods? MK. _____

E7. What impacts of climate change affect fishing 1._____ 2._____ 3._____ **Codes**: 1 = Floods, 2 = Dry spells/Early cessation of rains, 3= Erratic Rainfall, 4= Stormy Rains, 5=Strong winds, 6= Drought, 7 Heatwaves

E8. What has been the pattern of fishing over the past 10 years? [___] 1= Increasing, 2= Decreasing 3= No change

E9. What might be the reasons for that pattern? _____

Section E3 – Ganyu

E10. Is any member of your household involved in ganyu? [____] 1 = Yes 2 = No **(If no go to E15)**

E11. Which months are peak period for ganyu (Range) _____

E12. How much money is raised from ganyu per week during peak periods? MK. _____

E13. Which months are lowest in terms of ganyu? (Range) _____

E14. How much money is raised from ganyu per week during low periods? MK. _____

E15. What impacts of climate change affect ganyu 1._____ 2._____ 3._____
Codes: 1 = Floods, 2 = Dry spells/Early cessation of rains, 3= Erratic Rainfall, 4= Stormy Rains, 5=Strong winds, 6= Drought, 7 Heatwaves

E16. What has been pattern of Ganyu availability for the past 10 years? [__] 1= Increasing, 2= Decreasing 3= No change

E17. What might be the reasons for that pattern? _____

Section E4 – Small scale businesses

E18. Is any member of your household involved in ganyu? [____] 1 = Yes 2 = No **(If no go to F1)**

E19. Which period do you make the most from the business? Peak period? _____ Low periods? _____

SECTION F – ADAPTATION STRATEGIES – CROP PRODUCTION STRATEGIES

F1. – Have you changed your rainfed crop production practices in response to climate change? [__] 1 = Yes 2 = No

Adaptation strategy	**Have you changed**	**Past**	**Present**	**Reason**	**For how long**
Timing of planting (Maize)					
Plant spacing (Maize)					
Pit planting (upland)					
Ridge spacing (Maize)					
Manure					

Conservation Agriculture					

F2. Have you changed rice varieties in response to climate/weather variability? [__] 1 = Yes 2 = No **(If no go to F4)**

F3. What main rice varieties were you growing before starting experiencing impacts of climate change?

Past rice variety	**Reason for growing it**	**Present rice variety**	**Reason for changing**	**Period**

Rice varieties 1= Amanda, 2=Chiringa, 3= Tambala, Singa Pusa, 4= Pusa

Reasons for growing it 1=Aroma, 2= Marketable, 3= High yielding, 4= Early maturing, 5= Otupa

F4. Have you changed rainfed maize varieties in response to climate change? [__] 1 = Yes 2 = No **(If no go to F5)**

Past maize variety	**Reason for growing it**	**Present maize variety**	**Reason for changing**	**Period**

Maize variety: 1= Local, 2= Hybrid

Reasons for growing it: 1= Taste, 2= Poundability, 3= Storability (Osafumbwa msanga), Early maturing, 4= High yielding

F5. Have you changed wetland maize varieties in response to climate change? [__] 1 = Yes 2 = No **(If no go to F6)**

Past maize variety	**Reason for growing it**	**Present maize variety**	**Reason for changing**	**Period**

Maize variety: 1= Local, 2= Hybrid

Reasons for growing it: 1= Taste, 2= Poundability, 3= Storability (Osafumbwa msanga), Early maturing, 4= High yielding

WETLAND UTILIZATION

F12. How were you planting crops (under irrigation) in the wetland before you started experiencing impacts of climate change? [____] 1= Mound, 2= Flat surface, 3= Pits (holes)

F13. How are you planting crops in the wetland now? [____] 1= Mound, 2= Flat surface, 3= Pits (holes)

F14. Why have you changed?
_____

F15. What are main limitations to irrigation across Phalombe river during dry season?_____
_____
_____

F16. What are main limitations to irrigation in Chikaonga during dry season?_____
_____
_____

F17 What changes in crop production have you made in response to pest infestation (FAW/Gaba)

_____
_____
_____

COPING STRATEGIES TO FOOD SHORTAGES

F18. How many months did you consume Maize harvested from own production (Rainfed)? [____]

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

F19. Which months did you consume Maize you produced under rainfed?

F20. What were your coping strategies after you run out of food? (3 Main) 1.____ 2.____ 3._____

Codes: 1=Purchase 2=Reduce frequency of meals 3=Ganyu 4=Remittances 5=Food for work 6=Begging from relatives 7=Food handouts 8= Rent or sell land 9= Stay without eating 10=Sell livestock 11=Migration 12=Consume seed for the next season 13=Consume immature crops 14=Consume undesirable foods 15= Other specify

F21. How many months did you consume (Rice to Maize) from own production (Rainfed)? [_____]

F22.. Which months did you consume Rice/Maize you produced under rainfed?

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

F23. What were your coping strategies after you run out of food? (3 Main) 1.____ 2.____ 3.____

Codes: 1=Purchase 2=Reduce frequency of meals 3=Ganyu 4=Remittances 5=Food for work 6=Begging from relatives 7=Food handouts 8= Rent or sell land 9= Stay without eating 10=Sell livestock 11=Migration 12=Consume seed for the next season 13=Consume immature crops 14=Consume undesirable foods 15= Other specify

F24. How many times do you grow crops in the wetland? [___] (**If once then Skip F28 to F 30**)

F25. How many months did you consume maize produced or bought from wetland farming 1 [_____]?

F26. Which months did you consume maize you produced from wetland 1?

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

F27. What were your coping strategies after you run out of food? (3 Main) 1._____ 2.____ 3._____

Codes: 1=Purchase 2=Reduce frequency of meals 3=Ganyu 4=Remittances 5=Food for work 6=Begging from relatives 7=Food handouts 8= Rent or sell land 9= Stay without eating 10=Sell livestock 11=Migration 12=Consume seed for the next season 13=Consume immature crops 14=Consume undesirable foods 15= Other specify

F28. How many months did you consume maize produced or bought from wetland farming 2 [_____]?

F29. Which months did you consume maize you produced from wetland farming 2?

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

F30. What were your coping strategies after you run out of food? (3 Main) 1.____ 2._____ 3._____

Codes: 1=Purchase 2=Reduce frequency of meals 3=Ganyu 4=Remittances 5=Food for work 6=Begging from relatives 7=Food handouts 8= Rent or sell land 9= Stay without eating 10=Sell livestock 11=Migration 12=Consume seed for the next season 13=Consume immature crops 14=Consume undesirable foods 15= Other specify

SECTION G: ASSETS OWNERSHIP

G1. Do you own the following household assets?

Asset	**Do you own?** 1= Yes 2= No	**Number owned**	**Present value (MK)**
Radio			
Cell-phone			
TV set			
Chairs			
Bed			
Mattress			
Table			
Bicycle			
Motor Cycle			
Cattle			
Goats			
Sheep			
Pigs			
Chickens			
Ducks			
Boats			
Nets			
Fishing baskets (*Mono*)			
Hooks (Mbedza)			
Irrigation engine			
Treadle pump			
Watering cans/Pails			

SECTION H – LIVESTOCK PRODUCTION (Large ruminants eg goats, pigs and Cattle)

Livestock	H1. Period in livestock production	H2. Grazing challenges (rainy season)	H3. Grazing challenges (dry season)
Cattle			
Goats			
Pigs			

H4. How has climate change impacted livestock production?

_____

H5. What changes have you made in livestock production in response to the impacts of climate change?

_____

SECTION I – SOURCES OF INFORMATION

I1. How many extension agents do you have in this area? [____]

I2. How often does the agricultural extension agent come in this village? [____]

I3. Do you have access to weather related information? [___] 1 = Yes, 0 = No **(If no go to I5)**

I4. Where do you learn seasonal forecast? _____Dairy forecasts? _____

I5. If you do not have access to weather forecast how do you decide on your agronomic activities

_____

SECTION J – NUTRITION

How many times did you eat the following food in the past 7 days?

Food group	Examples	Response 1 = Yes, 0 = No
Cereals (Nsima/Rice etc)	Nsima, rice, bread, porridge	
Vegetables	Green vegetables	
Fruits	Ripe mangoes, papaya, guavas	
Tubers (Cassava/Potatoes)	Cassava, white potatoes, yams	
Legumes	Beans/Peas etc	

Meat	Beef, pork, goat meat, chicken	
Eggs	Chicken, birds, duck	
Fish	Fresh or dried fish	
Milk	Fresh or powder milk	

Appendix G: Choice of variables for contribution of indices to recovery

Choice of variables

The sustainable livelihood framework (SLF) was used to organize variables under five types of assets (Table 2) (Erenstein et al., 2010; Quandt, 2019). The variables were selected using both a literature review and prior analysis of the qualitative data.

List of household survey livelihood resilience variables

Variables	Quantitative indicator	Rationale	Source
Physical	Value of productive assets	Assets can be sold to smoothen consumption.	Fang et al., 2014 and Pour et al., 2018
	Value of owned livestock	Livestock can be sold to smoothen consumption if hit by shock.	Pour at al., 2018
	No. of Habitable houses	More houses are alternatives if one falls due to floods or stormy rainfall.	Qualitative research
Human	Education of household head	Educated household heads able to make informed decisions.	Soltani et al. (2014)
	Productive people in the household	More labour helps pursue several livelihood activities at the same time.	Ellis (2000)
	Sickness during farming season	thwarts agriculture production – main livelihood activity	Qualitative research
Social	Relations and friends to the household	Immediate sources of help when household cannot manage a crisis	Quandt, 2019
	Membership to formal/informal groups	Network of people that can support a household to offsets impacts of a shock	Soltani et al. (2014) & Pour et al., 2018

Financial	Membership to savings group	Access to finances to build other assets or mitigate impacts of a shock	Panman et al., 2021
	Whether the household got *Katapila* (Loans)	*Katapila* result into losses during rice harvesting because of high interest.	Qualitative research
	Income from regular source in a month	Regular income entails ability to build other assets to offset future shocks	Pour et al., 2018
	Savings by the household	Saving can be used to manage immediate impacts of shocks	Panman et al 2021
Natural	Size of owned arable land	Key productive asset that determines rainfed crop production	Qualitative research
	Ownership of a plot at the wetland	Irrigation in the wetland is the alternative to rainfed crop failure.	Quandt, 2019
	Distance from water body to the garden	High dependence on residual moisture and low cost irrigation technologies require proximity to water source.	Qualitative research
	Involvement in fishing	Fishing is one of the lucrative livelihood activities that smoothens consumption.	Qualitative research

Indices computation

Quantitative data were organised using Microsoft Excel. Analysis was done using the method for computing the Human Development Index (UNDP, 1994; Pandey & Jha, 2012; Quandt, 2018). This involves the identification of variables under each of the five livelihood assets categories. Maximum and minimum values under each variable are determined and then an index is computed using the equation (1) below. Results from this standardization range from 0 to 1, where 0 is least desirable and 1 is the most desirable state.

$$I_{ij} = \frac{\mathrm{Max}X_i - Xij}{MaxX_i - MinX_i} \quad (1)$$

Where

Xij is the value attained by the jth Household in *i*th variable

Max *Xi* is the maximum value in the data series *i*

min *Xi* is the minimum value in the data series *i*

For continuous variables, the computation involved calculating as illustrated in formula (1). However, for categorical variables, no calculation was done because the answers were yes or no (coded as 1 for yes and 0 for no in the dataset). For the variable of getting a loan (*Katapila*) under financial assets, the question was asked in reverse so that 'yes' could denote 'did not get the loan' while 'no' meant did get the loan. This was to ensure that getting a loan is depicted as an undesirable condition and vice versa because needing a loan already indicates vulnerability.

In order to compute an index for each livelihood asset category, a composite index was created by an additive method from variables standardized under each category by the equation (2) below. Computation was done for each household and then analysed for male and female headed households.

$$C_i = \sum I_{ij} \tag{2}$$

Where

C_i is the index from ith livelihood asset

*I*ij is the index of from the individual variable

Regression of indices against period to recovery

The simple linear regression function was used to estimate the contributions of the livelihood assets indices to recovery from the impacts of erratic rainfall and floods for both male and female headed households. Recovery from floods and erratic rainfall was conceptualized as reverting to pre-shock status in terms of food security at the household level. The choice of food security status as a measure of recovery was based on literature that considers it as a primary goal of most livelihood activities in rural areas of most developing countries (Conceição et al., 2016). The recovery period was therefore determined as the number of months from the onset of food scarcity due to the shocks to the time food security starts reverting to pre-shock status. Five livelihood asset indices were considered as independent variables (equation 3).

$$Rec_{(Months)} = \alpha + \beta 1x1 + \beta 2x2 + \beta 3x3 + \beta 4x4 + \beta 5x5 \tag{3}$$

Where

$Rec_{(Months)}$ is the number of months to recovery from a shock (floods or erratic rainfall)

α Is the constant

β_1 to β_5 are the coefficients

x_1 to x_5 are the livelihood asset (Physical, Human, Financial, social and Natural)

Appendix H. Maize growing under winter small-scale irrigation

Appendix I. Maize attached by Fall Army Worm (Capture along the wetland in June)