Strengthening Resilience to Climate Change of Smallholder Farming Households Through Climate Services: A Multidimensional Poverty Based Analysis in East & Southern Africa

PhD Rural Livelihoods

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Declaration of original authorship

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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Abstract

Sub-Saharan Africa (SSA) is particularly vulnerable to the negative impacts of climate change due to a high dependence on rain-fed agriculture and a low capacity to adapt to the ongoing changes. The last decade has seen increasing attention to new strategies and policies that encourage and support adaptive practices to enhance resilience, one of which is the development and provision of climate information.

This research investigates the access to and use of climate information by smallholder farmers in five countries in Sub-Saharan Africa (Eswatini, Kenya, Lesotho, Tanzania and Zimbabwe) focusing on the associations between household characteristics, the use of climate information, and its effectiveness in increasing resilience to climate-induced shocks and stresses. This thesis ultimately aims to advocate for actions and research-for-development that fosters differentiated and context-appropriate rural adaptation pathways.

Data were collected in Eswatini, Kenya, Lesotho, Tanzania and Zimbabwe using the Multidimensional Poverty Assessment Tool (MPAT) to answer several key questions: What is the current access and use of climate information by smallholder farmers in five SSA countries? What are the associations between household characteristics and the likelihood of accessing and using climate information? Is there an association between climate information access and use with increased levels of household resilience and wellbeing? Additionally, this research explores how the research tool, MPAT, reconciles the need for in-depth context-specific data with generalizable data and compares MPAT with other widely used indices and indicators (e.g., HDI, GNI, GHI, GII).

The findings indicate significant inequity in access to climate information within and across the countries in the sample. Households that are generally better off, with higher levels of food security, credit, land ownership, water quality, education, and health, have greater access to climate information. The use of climate information, particularly temperature

forecasts and climate change projections, is associated with higher household resilience. In addition, the majority of households adopt coping strategies, such as relying on aid organizations, national governments, or selling livestock, rather than adaptive strategies like income diversification and off-farm work as their primary response to shocks.

This research confirms the importance of climate information and demonstrates the need to increase the outreach and effectiveness of extension services, making them more farmer-oriented, consultative, inclusive, and collaborative. Climate adaptation strategies should be tailored to meet varying profiles of households, considering their specific needs and characteristics. Strengthening formal sources of support and public safety nets is crucial for enhancing household resilience.

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List of abbreviations

AIS – Agricultural Innovation System

AKIS - Agricultural Knowledge and Information System

CAPI – Computer Aided Personal Interviewing

CCA – Climate Change Adaptation

CI – Climate Information

CIDP – County Integrated Development Plan

CIS – Climate Information Services

CSA – Climate Smart Agriculture

DFID – Department for International Development (replaced by the Foreign, Commonwealth & Development Office, FCDO)

EbA – Ecosystem-based Adaptation

EWS – Early Warning Systems

FAO – Food and Agriculture Organisation

FF – Farmer First

FHH – Female Headed Household

FPR - Farmer Participatory Research (FPR)

FSR - Farming Systems Research (FSR)

GDP – Gross Domestic Product

GHI – Global Hunger Index

GII – Gender Inequality Index

GNI – Gross National Income

HDI – Human Development Index

HoHH – Head of Household

IFAD – International Fund for Agricultural Development

IPCC – Intergovernmental Panel on Climate Change

MPAT – Multidimensional Poverty Assessment Tool

PICSA – Participatory Integrated Climate Services for Agriculture

PRA – Participatory Rural Appraisal

SDG – Sustainable Development Goal

SES – Socio-Ecological System

SHH – Smallholder Household

SLF – Sustainable Livelihood Framework

SOM - Soil Organic Matter

SSA – Sub-Saharan Africa

ToT – Transfer of Technology

UNDP – United Nations Development Program

UNFCCC – United Nations Framework Convention on Climate Change

UNICEF – United Nations Children's Fund

WFP – World Food Programme

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1. Chapter One: Introduction

Climate change is threatening societies, livelihoods and ecosystems globally. With increasing temperatures, the impacts of climate change are severe, widespread, and potentially irreversible (IPCC, 2021; Ripple et al., 2019; Sanderson & O'Neill, 2020). Sub-Saharan Africa (SSA) is classified as one of the most vulnerable regions to these changes (Field & Barros, 2014), primarily due to a high dependence on rain-fed agriculture and a low capacity of populations and systems to adapt to the ongoing changes (Kiboi et al., 2017). Africa's agricultural sector provides for almost 80% of the continent's population and is highly sensitive to climate change (Sonwa et al., 2017). The projected increases in temperature, extreme events, changes in rainfall patterns and aridity threaten almost the entirety (96%) of rain-fed crop production (Serdeczny et al., 2017).

To reduce the negative impacts of climate change, the Paris Agreement converged on the goals of promoting adaptation practices, building adaptive capacity and reducing vulnerability to climate change (UNFCCC, 2015). In the last two decades, the academic literature on adaptation to climate change has proliferated (Berrang-Ford et al., 2011) and became increasingly linked with development (D. Conway, 2011) leading to a variety of new terms such as "mainstreaming adaptation," "no-regrets approaches," "sustainable adaptation," and "community based adaptation" (Burnham & Ma, 2016, p. 1). Such concepts advocate the integration of climate change adaptation into development priorities including poverty reduction, resource management and conservation (Pouliotte et al., 2009), arguing that human development objectives and climate adaptation aims can only be accomplished if undertaken in an integrated manner (Leary, 2008; Schipper & Pelling, 2006; Wise et al., 2014). Moreover, a growing emphasis has been placed on adaptation as a means to enhance the resilience of agricultural systems in order to reduce the risk of both current and future food insecurity (Lipper et al., 2014; Smith & Frankenberger, 2018; Zhang et al., 2016).

Resilience, typically known as “the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences” (Constas et al., 2014, p. 4) is a concept used to describe the dynamic relationship of an entity’s ability to retain its core functions, bounce back, or bounce back better when faced with a catastrophic event and/or persistent stressors (Holling, 1973). Increasing one’s adaptive capacity, i.e. the ability to make informed choices about alternative livelihood strategies based on changing conditions, is a form of building resilience (Béné et al., 2016).

Adjusting and adapting is nothing new for smallholder farmers in sub-Saharan Africa. Researchers have long recognized that smallholders are well-acquainted with the effects of climate change on their crop production and have long adjusted their management practices (e.g. Altieri & Nicholls, 2017; Astier et al., 2011; Ouédraogo et al., 2017). What is new, however, is the intensity and frequency of the changes in the climate. The last decade has seen increasing attention to new strategies and policies that encourage and support adaptive practices, one of which is the development and provision of climate information.

This research focuses on the access to and use of climate information by smallholder farmers in five countries in Sub-Saharan Africa, and the associations between household characteristics, its use and its effectiveness in increasing resilience to climate induced shocks and stresses. It focuses on poor smallholder farmers and has the objective of advocating for actions and research-for-development that fosters differentiated and context-appropriate rural adaptation pathways. The three main objectives are as follows: First, to understand the current access and use of climate information by smallholder farmers in five countries in Sub-Saharan Africa; Second, to explore the associations between household characteristics and the likelihood of accessing and using climate information; and Third, to understand whether climate information access and use is associated with increased levels of household resilience and wellbeing.

1.1 Research Objectives

This section outlines the three main research objectives of the thesis, along with their corresponding research questions. Each objective is preceded with an explanation of how they connect to the existing body of knowledge and how they address current research gaps.

1.1.1 Limited cross-country explorations and limitations in research tools

A systematic review led by Siders (Siders, 2019) revealed that adaptation research covers a wide range of geographic locations, sectors, and scales of analysis, is highly interdisciplinary and fragmented and that empirical studies in adaptive capacity research are isolated by the absence of comparative work and cross-field citation (Siders, 2019). The vast majority of studies on climate information access and use are (appropriately so) very context and site specific. This makes sense due to the evidence that climate information is more valuable when it appropriately meets a user's context specific needs but it also limits the ability to identify any trends and patterns across a region. The unique aspect of this study is that the same research questions were applied to five different countries. This said, there is a deep recognition of the limitations posed by the methodological assumptions involved in using multi-country and cross-country household survey data to identify patterns (further detailed in chapter seven).

In addition to this, the literature review revealed that the practical experience of identifying users of climate information and their needs remains uneven across the field and that there remain gaps in our knowledge related to i.) Which communities can best be served by climate information; ii.) What kind of climate information meets respective user needs; iii.) The most effective method by which to identify these populations and their needs; and iv.) How to generalize knowledge about users and needs (Carr et al., 2020). In response to this, this study considers MPAT's potential in supporting needs identification for climate information strategies.

Rural poverty assessments tend to be either too simplistic and income-focused to produce data that is useful for sector-specific interventions and development programs, or so in-depth that data collection is excessively time-consuming and expensive, and resulting datasets end up being difficult to untangle for project design and monitoring, or evaluation. Related, in-depth survey-based data collection can provide nuanced information about rural poverty in a given area, but collecting such data at a nationally representative scale is typically not feasible. More research is needed to pilot innovative combinations of data collection approaches such as surveys and ethnographic studies.

Surveys can be applied to large populations relatively rapidly, but they often encompass assumptions made about a certain population and can overlook critical points of heterogeneity. They are also a particularly challenging tool to use for needs identification as they rest on fixed questions that often reflect the preliminary biases of the survey developer. A survey that assumes a particular need is thus likely to ask questions about that need and any activities associated with that need. On the other hand, participatory approaches such as Participatory Rural Appraisals (PRA) can help to minimize this interview bias. However, the identification of who participates in a PRA still relies on assumptions about vulnerability and are often very place-specific, which challenges the generalizability of the findings to a larger population. Identifying and assessing user needs in a manner that does not submerge information from the users with biases from the designers remains a significant challenge (Carr et al., 2020). As a result, the last chapter of this study examines whether the MPAT findings can be compared with, and complement, other [more prominent] existing tools and approaches.

Objective 1: To what extent does MPAT reconcile the need for in-depth context specific data with generalizable data and be used as a complementary tool for needs identification in climate information research?

Research Questions:

1. How does MPAT compare with other more widely used indices and indicators? (i.e. HDI, GNI, GHI, GII)?

1.1.2 Limited cross-sectoral analysis of socio-economic household characteristics

Estimates regarding access to climate information across Sub-Saharan Africa vary considerably with significant research aimed at understanding the factors that cause this disparity (Vaughan et al., 2019). However, there still remains scope for a more complete mapping of who has access to what kind of information across the region, as well as a deeper understanding of the factors that enable or constrain the access and use of information. The point of departure for this research, therefore, is to map who has access to what kind of climate information across the sample of households in five countries.

Although a number of studies exist on the role that user characteristics play in the access and use of climate services, these studies have primarily focused on identity, such as gender and education of the farmer (e.g Ngugi et al., 2011; Oyekale, 2015). Far less is known about how climate change information access and use interacts with wider socio-economic household characteristics. For example, studies on the associations between household members' health and climate information access and use in Sub-Saharan Africa could not be found. Transdisciplinary research can help to examine and begin to unravel the contextual factors that may influence the perception of climate information by users and its use (Lee et al., 2015; Vogel et al., 2019). This study therefore aims to contribute to the body of literature by exploring the profiles of households in Sub-Saharan Africa that currently have access to, and use, climate information and to help further the understanding of the smallholder farmer context.

The extent of the negative consequences of climate related risks are determined by the social, economic and contextual factors that foster vulnerability and influence the ability of

individuals or communities to adapt to varying climatic conditions. Further information on these vulnerabilities and the dynamic context within which climate information is generated, accessed and used can help understand the flexibility (or inflexibility) to respond to integrate climate information in decision-making processes.

Objective 2: To understand the types of households that currently have access to climate information and the types of households that are more likely to use the climate information that they have access to.

Research Questions:

1. What are the socio-economic characteristics of households in the study?
2. Are there any associations between household characteristics and the likelihood of accessing and using climate information?

1.1.3 Limited evidence of household perception of resilience levels and potential causal pathways

Despite the increasing recognition that adaptation is driven by a variety of stressors, less than half of the adaptation studies included in a review of the literature contained discussions of multiple stressors (Burnham & Ma, 2016). This study contributes to filling this gap in the research by exploring a variety of shocks that smallholder farmers are preoccupied by. Moreover, by looking at eleven dimensions of rural livelihoods, which are included in the MPAT tool, the data provides insights into the multiple stressors that a household currently faces (e.g. low food security, poor health, low asset ownership, low levels of social equality, etc.).

The literature review on resilience and food security revealed that, to date, empirical analyses have paid little attention to the causal pathways through which resilience capacity affects food security in a microeconomic framework (Béné et al., 2016). Resilience has predominantly been measured distinctly from food security where resilience is quantified by

multivariate techniques. Empirical evidence suggests that households with higher resilience capacity tend to have less child malnutrition and better food security but the evidence on this is limited. Although this study does not aim to determine any causal pathways, it seeks to contribute to this literature on the potential associations between levels of resilience and food security.

Objective 3: To understand the shocks that households in East & Southern Africa are most worried about, and how they respond to these shocks.

Research Questions:

1. What are the types of shocks that households are most worried about (e.g. climatic, health related, security related, etc.)?
2. Is there an association between a household's level of resilience and access and use of climate information?

1.2 Thesis Outline

This thesis is based on three core chapters (Chapters Four, Five and Six) each of which is a published paper. These Chapters are preceded by an introductory chapter (Chapter One), a literature review (Chapter Two) and a chapter describing the research methods (Chapter Three). The thesis then ends with a chapter on the main findings and conclusionary remarks (Chapter Seven). The following section describes each chapter in more detail.

Chapter Two: Literature Review

This chapter reviews existing knowledge and literature which provide a framework and a context for this study, and with which the study findings can be considered and discussed. This includes the shifting perspectives on vulnerability and resilience and the approaches to climate information and climate information services as a means to encourage the adoption of adaptive practices. The last section of the literature review presents

observations on the gaps in the literature and details the research aims and objectives of this study.

Chapter Three: Research Methods and Study Design

The methodology is provided in Chapter 3, which discusses the approach and timeline of the study, and describes the research tool used to collect data, the Multidimensional Poverty Assessment Tool (MPAT). The process of data collection is described, including the choice of field locations, sampling procedure, enumerator trainings, ethics, and data quality checking and analysis. A detailed explanation of the values and weightings behind the calculation of MPAT scores is also provided, followed by a practical example for the Food & Nutrition Security Component (which includes the survey questions, the answer codes, the values, the weightings, and the overall score obtained).

Chapter Four: Perceptions of Poverty: Exploring the use of the Multidimensional Poverty Assessment Tool (MPAT) as a complement to global development indicators in East and Southern Africa

Chapter four explores whether MPAT, a thematic, perception-based indicator designed to collect and synthesize a range of data related to rural livelihoods could be used as a proxy for commonly used, national-level, development indicators such as the Human Development Index (HDI), Gross National Income (GNI), Global Hunger Index (GHI), and the Gender Inequality Index (GII).

Some MPAT components were selected and aggregated to create proxies for HDI, GNI, GHI, and GII. These proxies were then compared with the actual global indicators to assess alignment. For instance, MPAT's Farm and Non-Farm Assets components were combined to represent income (similar to GNI), while the Food & Nutrition Security

component was used to compare with the GHI. ANOVA and Bonferroni tests were then conducted to compare MPAT scores across countries and identify significant differences.

Overall, this chapter aims to provide a more nuanced understanding of rural poverty, complementing the broader scope of existing global indicators.

Chapter Five: Climate information access and use among rural smallholder farming households: A multidimensional poverty-based analysis in East & Southern Africa

Chapter five examines 5,322 smallholder farming households' access to, and use of, climate information across Eswatini, Kenya, Lesotho, Tanzania, and Zimbabwe. R (version 4.1.2) was used to conduct regressions with country dummies, estimated coefficients, z value, LR tests and Pseudo R. to attempt to i.) Identify which types of households access climate information, and ii.) Identify which types of households, of the ones that access climate information, actually use one or more sources of available climate information.

A logistic regression was used to evaluate associations between would-be predictor variables and other covariates and the odds (odds ratio) of whether households had access to at least one source of climate information. For those households with access to at least one source of climate information, a generalized linear regression model was then applied with a log link (Poisson family) and the same model covariates where the outcome variable was a count variable for the number of accessible climate information sources households reported to actually use, if any.

Chapter Six: Exploring the types of shocks that smallholder households face in East & Southern Africa and their levels of resilience

This chapter applies a household perspective to explore the main shocks that smallholder farming households in East & Southern Africa are affected by, and their levels of resilience to these shocks. Statistical models (logistic regression in R 4.1.2) were applied to

data collected from 5,322 rural households across Eswatini, Kenya, Lesotho, Tanzania, and Zimbabwe in order to determine socio-economic factors linked to varying resilience levels and to examine relationships between levels of resilience and access to, and use of, climate information. Descriptive statistical analyses were conducted to examine frequencies of each key variable within each country dataset. Logistic regression models were then used to evaluate the impact of selected variables on the level of resilience. The resilience variable was dichotomized, with resilience scores above 43.40 taking 1 (i.e., relatively more resilient) and those below 43.40 taking 0 (i.e., relatively less resilient).

With regard to covariate selection, we wanted to assess if there was a difference in resilience levels when households had particular socio-economic characteristics. The following variables were focused on in particular: i.) Presence of diversified income sources; ii.) Access to credit; iii.) Asset ownership; iv.) Access to healthcare and v.) Access and use of climate information. Logistic regression models were then used to evaluate associations between socio-economic characteristics of households and their level of resilience.

Chapter Seven: Key research findings and implications for policy, limitations, and concluding remarks

This chapter connects the key research findings and discusses the study's limitations. It also offers suggestions for future research and concludes with a discussion of policy implications and final remarks.

2. Chapter Two: Literature Review

This study is theoretically situated within the human-centric vulnerability framework and conceptualises smallholder farming as a socio-ecological system (SES). The first part of this literature unpacks the relevant terminology. This is followed by a presentation of the relevant literature and the nexus between food security, smallholder farming and climate change. After this, the conceptual frameworks, namely the Sustainable Livelihoods Framework (SLF) and a combined Vulnerability and Resilience Approach are presented. The final section presents a short note on the problem statement and how these fits into the existing literature.

2.1 Unpacking the terminology

2.1.1 Vulnerability

Understanding vulnerability to climate change is an important part of defining the magnitude of a risk and understanding the strategies to deal with it (Kelly & Adger, 2000; Singh, 2014). Vulnerability is commonly defined as a system's exposure to stimuli, sensitivity to this stimuli and adaptive capacity (Füssel, 2007). In addition to this, vulnerability is understood to be a function of different entitlements, power relations, social dynamics and the socio-political landscape within which smallholder farmers are embedded (Mearns & Norton, 2009; Miller et al., 2010; Osbahr, 2007). As livelihoods and contexts are dynamic (e.g. changes in household assets, changes in political landscapes, etc.), vulnerability to an environmental change is not only a result of exposure to stimuli, but also a function of the socio-economic context and dynamics around resource use (Adger, 2006). There is therefore a need for vulnerability research to be system-oriented rather than cause-effect based (Turner et al., 2003).

As a result, rather than examining the impacts of a single stressor, this research applies Turner et al.'s (2003) recommendation to study the elements of vulnerability

(exposure, sensitivity and adaptive capacity) of a bounded system (in this case, smallholder farming) at a defined spatial level (the household), recognising that people are affected by external threats differently, making them vulnerable in distinct ways.

2.1.2 Sensitivity

Sensitivity refers to the degree to which a system (made up of people and/or assets that could be adversely affected) can absorb impacts without suffering long-term harm or other significant state change (Adger, 2006). An integral part of understanding sensitivity is understanding the thresholds of the elements that make up a system- i.e. when these elements become affected by a stressor (Luers et al., 2003). Exposure to stimuli, such as climatic shocks, can be similar for households in a particular area but the sensitivity of these households, however, can differ greatly.

2.1.3 Adaptive capacity

Adaptive capacity is a complex term with a number of different definitions and methods of evaluation. Although there is no one single-established definition, adaptive capacity is broadly defined as "the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014a, p. 1758). Adaptive capacity denotes a system's ability and opportunity to evolve to accommodate shocks and stress (Engle, 2011), resulting in adaptation. As such, adaptive capacity can be understood as a potential to adapt, but not actual adaptation in itself. When a system realises its adaptive capacity, only then can we say that it has 'adapted' to a certain stressors (Brooks, 2003; Luers et al., 2003). In addition to having the necessary resources, more recent research explains that adaptive capacity also entails the willingness and capability of a system to convert these resources into adaptive action (Brown & Westaway, 2011; Cinner et al., 2018; Rosengren et al., 2020).

A number of factors drive and constrain adaptive capacity, often with complex interactions and indirect causal pathways between them (Engle, 2011; Parry et al., 1999; Reid & Vogel, 2006; Yohe & Tol, 2002). Despite the literature that exists on these enabling or hindering factors, the assessment of adaptive capacity remains very difficult given the complexity in quantifying these variables (Adger & Vincent, 2005).

There is a common agreement that adaptive capacity and adaptation are place and context-specific (e.g. Armah et al., 2015; Siders, 2019), which explains why the body of literature on adaptive capacity is vast and varies so much in approaches, frameworks and indicators (Rosengren et al., 2020). Adaptation research more than doubled between 2008 and 2011 (Bassett & Fogelman, 2013), increased by 150 per cent from 2011 to 2014 (Webber, 2016) and still continues to grow (Singh et al., 2020). A systematic review led by Siders (Siders, 2019) revealed that adaptive capacity research covers a wide range of geographic locations, sectors, and scales of analysis and is highly interdisciplinary and fragmented. A review of existing adaption literature had shown that empirical studies in adaptive capacity research are isolated by the absence of comparative work and cross-field citation (Siders, 2019).

2.1.4 Coping vs. adaptation strategies

Smallholder farmers have always had to react to climate related changes, variability and shocks. These reactions are commonly categorised as either coping strategies or adaptation strategies. Coping and adaptation strategies are distinguishable along a temporal scale, where coping is considered a temporary, short-term response to a hazard, while adaptation is more of a long-term, relatively permanent change (Füssel, 2007; Smit & Wandel, 2006; Thomas et al., 2005). Studies have shown that when coping is adequately understood, it can support locally relevant adaptation measures (e.g. Eriksen et al., 2005).

In the face of a shock, vulnerable households employ a range of strategies to deal with the event. Coping strategies take the form of ex-post strategies to cope with the resulting crisis. Examples include liquidating productive assets, reducing food and nutrition intake, withdrawing children from school to assist with farm labour, defaulting on loans, and over-exploiting natural resources. In the short-term, these strategies enable a household to endure a crisis, but in the long term, they reduce a household's capacity to ameliorate its wellbeing and productivity by eroding productive assets and human capacity (Carter et al., 2007; Carter & Barrett, 2006; Dercon, 2004; Dercon & Hoddinott, 2003; Dercon et al., 2005; Hoddinott, 2006; McPeak & Barrett, 2001; Victora et al., 2008; Wood, 2003).

Adaptation strategies, on the other hand, are expected to increase a households' productivity and wellbeing in the long-term and reduce vulnerability to climate change by making individuals, households and communities, better able to adjust to change, moderate potential damages, and deal with adverse consequences (IPCC, 2001). At the farm level, adaptation to climate change can take the form of a variety of possible responses. Examples include changes in crop management practices (e.g. planting dates, crop varieties), livestock management practices (e.g. livestock choice, feeding), land management (e.g. irrigation and water harvesting, soil fertility management) and livelihood strategies (e.g. combination of agricultural and non-farm activities, temporary or permanent migration) (Aryal et al., 2020; Bryan et al., 2013; Cacho et al., 2020; Lasco et al., 2014; Phillipo et al., 2015; Smit & Skinner, 2002). In adaptation research, there exists a common understanding that increasing one's adaptive capacity, i.e. the ability to make informed choices about alternative livelihood strategies based to changing conditions, is a form of building resilience (Béné et al., 2016).

Despite the temporal differences outlined above, coping can lead to adaptation (and subsequently to resilience) and therefore the distinction between the two terms is not always clear.

2.1.5 Resilience

Over the last two decades, the concept of resilience has progressively become mainstreamed in the development discourse (Béné et al., 2016; Hoddinott, 2014; Osbahr, 2007). Resilience, typically known as "the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences" (Constas et al., 2014, p. 4) is a concept used to describe the dynamic relationship of an entity's ability to retain its core functions, bounce back, or bounce back better when faced with a catastrophic event and/or persistent stressors (Holling, 1973). Holling's influential paper on resilience (Holling, 1973) can be perceived as the moment in which the term began to gain increasing popularity, not only in ecology but also in several other disciplines such as disaster risk reduction (Walter, 2004), climate change adaptation (IPCC, 2012) urbanisation (Tyler & Moench, 2012) and social protection (Davies et al., 2013).

As a result of the research conducted on resilience in various disciplines, the concept of resilience became more elaborate over time. Resilience is now no longer thought of as the resistance to change, or the conservation of a current state, but rather a function of two dimensions: i.) adaptive capacity of a system's components, and ii.) transformative capacity of a system's components (Béné et al., 2016). From a social-ecological perspective, resilience is defined as the capacity of socio-economic systems (e.g., smallholder households) to withstand shocks through absorption, adaptation and transformation (Ansah et al., 2019; Folke, 2006).

Resilience capacity is therefore recognised as a combination of three elements. First, absorptive capacity: the ability to recover quickly when exposed to shocks. Second, adaptive capacity; and third, transformative capacity: the enabling conditions for lasting resilience (Béné et al., 2016; Frankenberger et al., 2013).

2.2 A world without hunger

Over 820 million people suffer from food insecurity (FAO, 2019). The negative impacts of food insecurity are vast: it ends lives, diminishes wellbeing, kills productivity and remains a barrier to sustainable development. The concept of food security was defined at the World Food Summit in 1996 as being when "all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2009). The four dimensions of food security are availability (the physical supply of food products), access (the economic and physical access to food through markets and income), utilisation (the nutritional status of individuals) and stability (the availability, access and utilisation of food over time) (FAO, 2009).

Despite the efforts that aim to globally end hunger and malnutrition as part of Sustainable Development Goal 2 (SDG2, Zero Hunger) (UNGA, 2015), the rise in food insecurity is alarming. In the *State of the World's Food and Nutrition Security in the World* (FAO, 2019), the Food and Agriculture Organization (FAO) declared that although the global level of the prevalence of food insecurity has remained unchanged, the absolute number of people suffering from hunger continues to increase. In Africa, the prevalence of undernourishment increased from 17.6 per cent of the population in 2014 to 19.1 per cent in 2019, twice the world average and highest of all regions of the world (FAO, 2020). Sub-Saharan Africa has been declared the region most at risk of food insecurity due to its rapid population growth, stagnant agricultural productivity and dependence on cereal imports (Giller, 2020).

Food insecurity is intrinsically linked to poverty and constitutes one of the dimensions of deprivation that interacts with and reinforces others, as defined by the OECD; "poverty encompasses different dimensions of deprivation that relate to human capabilities including consumption and food security, health, education, rights, voice, security, dignity and decent

work" (OECD, 2001, p. 10). Globally, extreme poverty continues to be overwhelmingly rural, with an estimated 79 per cent of those experiencing poverty living in rural areas (World Bank, 2018). The proportion of food insecure people is also higher for rural than urban populations (Castaneda et al., 2016; FAO, 2018; Von Grebmer et al., 2018).

Agriculture plays an important role in the rural economy and in the livelihoods of rural households. Through the provision of food and the creation of jobs, the agriculture sector is key to achieving food security, as well as reducing poverty, supporting economic growth and enhancing rural development in sub-Saharan Africa (Asfaw et al., 2018; Danso-Abbeam et al., 2020; Getahun et al., 2023). Agriculture in Sub-Saharan Africa contributes to 25 per cent of the Gross Domestic Product (GDP) and provides for 60 per cent of employment (Modi, 2019). A farming system is described as a dynamic combination of resources that are arranged and managed according to production and consumption decisions made by a farming household (Fresco & Westphal, 1988; Giller, 2013; Kuivanen et al., 2016) and includes choices in regards to crops, livestock, aquaculture, as well as off-farm enterprises.

The agricultural sector in Sub-Saharan Africa is characterized by small-scale producers (i.e. smallholder farmers) (Thornton et al., 2019). Smallholder farming systems are incredibly diverse in their characteristics (e.g. size, resource endowment, etc.), strategy (production and consumption) and in the way in which they operate (Giller, Delaune, Silva, Descheemaeker, et al., 2021), but what typically differentiates these systems from large-scale, profit-driven enterprises are their size, limited access to land, financial capital and inputs, low market participation and high levels of vulnerability (Chamberlin, 2007, 2008). That said, given that each smallholder farming system is influenced by the social and biophysical context in which it finds itself (Tittonell et al., 2010), not all smallholders are

equally land constrained, resource-poor or market oriented. Any effort to understand and respond to smallholder needs must therefore start by recognising this heterogeneity.

2.3 Food security among smallholder households in East and Southern Africa

The definition of a smallholder farmer varies depending on the location and intensification of farming systems but in general terms, smallholders operate on a small piece of land (often less than two hectares) managing mixed crop–livestock systems (G. Conway, 2011; Dixon et al., 2004; Lowder et al., 2016; Nyambo et al., 2019; Samberg et al., 2016; Thornton & Herrero, 2015). Typically, the crops provide for consumption, cash sales, and as residue to feed livestock, while the livestock provides manure for soil fertilization and draft power to cultivate the land (Herrero et al., 2014). While defining historical trends in farm sizes across Sub-Saharan Africa is challenging due to missing or outdated census data (Livingston et al., 2014), evidence suggests that there has been no significant change (or a slight decline) in the average land size per capita over the past 30 years with only a few exceptions (Chamberlin et al., 2014; Jayne et al., 2014).

Although smallholder farming systems are typically managed by family labour, they are not to be confused with family farms. The latter is not limited by size, whereas smallholder farming generally refers to farming on two hectares or less (Lowder et al., 2014). It is important to distinguish the two, particularly in the food security rhetoric, given that small farms account for 84 per cent of all farms worldwide (Lowder et al., 2021) but operate on only around 12 per cent of all agricultural land globally. Despite operating on such a small portion of global agricultural land, small farms produce roughly 35 per cent of the world's food (Lowder et al., 2021). In sub-Saharan Africa in particular, these smallholder farms produce 30 per cent of most food commodities (Lowder et al., 2021). Smallholder farmers produce a great proportion of their country's food (Herrero et al., 2017; Lowder et al., 2021) yet they tend to be the most food insecure themselves and account for the majority of the

world's poor and hungry (Von Grebmer et al., 2018, 2019). For example, 75 per cent of agro-pastoralists in Africa live below the extreme poverty line (de Haan, 2016). Much of this has to do with the reliance that households have on agriculture and the sensitivity of farming systems to climate (Kotir, 2011).

To this day, the majority of smallholder famers are unable to earn a decent living from farming alone (IFAD, 2021a) as a result of compounding, complex and numerous challenges that they face. Extensive literature exists on these challenges which include, but are not limited to, deteriorating environmental conditions, low prices for produce, operating on very small plots of land, poor market access and weak market structures (Cooper & Coe, 2011; Giller, Delaune, Silva, van Wijk, et al., 2021; Kristjanson et al., 2012; Vermeulen, 2014; Woodhill et al., 2020).

2.4 Climate change, rural poverty and food security

For decades, climate change was either contested or assumed to be a problem of the future. Today however, "anthropogenic climate change has become more than some environmentalist bogey; it is now accepted scientific fact" (Adams, 2009, p. 18) and is recognised to be responsible for detrimental environmental and social impacts (Elliott, 2012; IPCC, 2014b; Porter et al., 2014). The IPCC sixth assessment report (IPCC, 2021) attributes detectable changes in temperature, land and water since the middle of the twentieth century to human induced climate change (IPCC, 2021). The impacts of climate change are ample. They range from climate-induced shocks that are immediately apparent, such as floods that surpass the severity of previous experiences, to slower-onset phenomena, such as elevated night-time temperatures which affect agricultural production (Kumar et al., 2022).

Agricultural producers experience climate change largely as variations in the frequency and severity of extreme events, and in new weather patterns (Thornton et al., 2019). Climate change risks come in the form of shocks (such as excessive rainfall and

storms, storm surges and salinization, flooding, extreme heat events, droughts, etc.), but also in the form of climate variability (such as shifts in the timing of rainy seasons and in temperatures) (Thornton et al., 2014). These risks brought on by climate variability (which in themselves result from climate change) are the risks that smallholder farmers face on a daily basis.

The effects of climate change and variability on agricultural production can be felt in variety of ways. Climate models, for example, predict an increase in the frequency, intensity and amount of heavy precipitation (IPCC, 2021) which forces agricultural producers to adjust their methods of production (rain fed and irrigated production in particular) (Kumar et al., 2022). Other changes, such as alterations in minimum and maximum temperatures, or lengthened periods of intense heat, also have significant impacts on agricultural production. For example, higher soil surface temperatures increase the mineralization rate of soil organic matter (SOM) which in turn reduces the soil's capacity to retain water - water that is necessary for plant growth (Kumar et al., 2022). Climate change can also introduce new or worsen existing risks such as plant and animal pests and diseases and price fluctuations of agricultural inputs and products (Thornton et al., 2019) as well as directly impact human and livestock health through increased heat and water stress and lower air quality (Godde et al., 2021; Sillmann et al., 2021).

While climate change and variability can be felt across the world, the effects are not equally distributed. In fact, regions of major exposure often coincide with a high prevalence of poverty and food insecurity. Adverse impacts of climate change on crop yields and on fisheries are strongest in tropical areas, in which food security is already weak (Vermeulen, 2014; Vermeulen et al., 2012). Moreover, climate-related disasters disproportionality impact poorer countries and the poorer populations within these countries (Carter et al., 2007; Hansen, Hellin, et al., 2019). Due to their geographic exposure, low incomes and greater

reliance on agriculture, as well as the limited opportunities to seek alternative livelihoods, smallholder farmers are particularly vulnerable to the impacts of climate change (Altieri & Koohafkan, 2008; Amadu et al., 2020). Although the effect and magnitude of climate change impacts will differ between regions and farming systems (Niang et al., 2014), households already suffering from food insecurity are expected to be the most adversely impacted (Müller et al., 2011; Vermeulen et al., 2012).

In Sub-Saharan Africa, the focus area of this research, climate change models project (with varying confidence) changes in rainfall patterns, increases in temperature and increases in extreme events such as heatwaves, droughts and extremely wet days (Niang et al., 2014). These changes are expected to adversely affect agricultural production and increase the risk of food insecurity in the region (FAO, 2018; Ongoma et al., 2018) as a result of disrupted (and shorter) growing seasons, changes in the presence and abundance of pests and diseases, and changes in the availability of suitable agricultural areas (Alobo Loison, 2015; Niang et al., 2014; Thornton et al., 2011). Given that Sub-Saharan Africa has been portrayed as the most vulnerable region to the impacts of climate change (Abeeb et al., 2023; Kotir, 2011) and that by 2030, it is estimated that up to 118 million poor people in Africa will be exposed to drought, floods and extreme heat (Adepoju, 2022) the geographical focus of this research is of particular importance.

Hansen et al. (Hansen, Hellin, et al., 2019) explain how climate-related risks contribute to rural poverty in three main ways. First, productivity and profitability of existing assets is reduced because of the adoption of ex-ante risk management strategies that discourage the accumulation of productive assets. Second, ex-post climate shocks, households may divert their existing assets in response to the event. Third, risk tolerance tends to decrease when resource endowments decrease, thus contributing to the higher opportunity cost of climate risks for the relatively poor (Carter & Barrett, 2006; Hansen,

Hellin, et al., 2019). In addition, poverty traps may be reinforced at the household level due to constrained economic opportunities as a result of climate risks occurring at a regional or national scale (Barrett & Swallow, 2006; Carter & Barrett, 2006) as well as the influences on food price dynamics (Wossen et al., 2018).

2.5 The conceptual framework

This research revolves around the inherent links between poverty, development and the environment, and is anchored in two frameworks in order to integrate insights and interventions that go beyond disciplinary or sectoral boundaries: the Sustainable Livelihoods Framework (SLF) and the Social-Ecological systems (SES) framework.

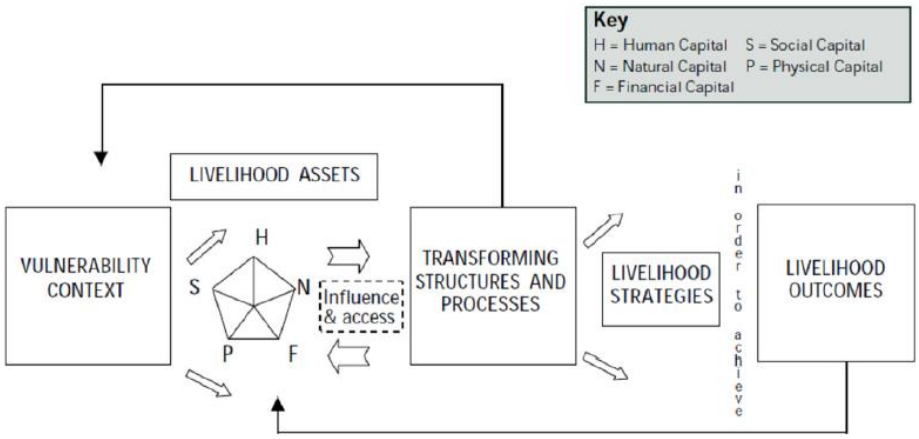
The SLF was chosen as a point of departure to understand coping with short-term stresses, and then adopts a combined vulnerability and resilience approach to understand adaptations to long-term change (Jones et al., 2010; Reed et al., 2013). The SES framework was selected as it considers both the human components (e.g. farmers) and the ecological components (natural resources) of agriculture. An SES framework not only helps to describe the relationship between human and environment systems but also to move away from the artificial and arbitrary nature of delineating between social and ecological systems (Folke, 2006; Singh, 2014).

2.5.1 The Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework (SLF) advocates for a holistic perspective when studying poor and vulnerable livelihoods to better inform interventions and priorities for development and poverty alleviation (Krantz, 2001; Serrat, 2017). A livelihoods perspective allows for the integration of insights and interventions that go beyond disciplinary or sectoral boundaries. Robert Chambers defines livelihoods as ‘the means of gaining a living’ (Chambers, 1995, p. 6). Essentially, a livelihoods analysis is “integrative, locally-embedded, cross-sectoral and informed by a deep field engagement and a

commitment to action" (Scoones, 2009, p. 173). The main reason for which this research will be built within the Sustainable Livelihoods Framework is its definition of poverty, which accommodates broader perspectives on well-being and livelihoods (Baulch, 1996) and the fact that it does not attempt to provide an exact representation of reality but rather endeavour to provide a way of thinking about people's realities that stimulates debate and reflection. The SLF allows for the recognition of the complexity of livelihoods and the links between important issues and how they interact, represented by Figure 2.1 below.

Figure 2.1:Sustainable Livelihoods Framework (DFID, 2000)



As shown in Figure 2.1, the SLF is composed of five main interconnected elements: the vulnerability context, assets, structure and processes, strategies, and outcomes. This research focuses on understanding the vulnerability context of smallholder farmers and their livelihood assets and strategies and how specific strategies used by smallholder farmers may lead to cycles of livelihood improvements or deteriorations (Olsson et al., 2014). The vulnerability context comprises of climate change shocks (including climate variability) but also touches on broader socio-economic shocks that smallholder households might be worried about, such as health shocks, conflicts, economic shocks, etc.

While there is much value to the Sustainable Livelihoods Approach, notably its holistic, non-sectoral, dynamic and people-centred characteristics, it does have its limitations.

One frequent criticism is that it lacks engagement with long-term changes in environmental conditions. However, this has developed with the emergence of climate change adaptation studies focussing on long-term change (Adger et al., 2003).

The term *Sustainable* Livelihoods indicates that livelihoods are durable and resilient to shocks and stresses. However, although the Livelihoods framework has benefitted greatly from a number of vulnerability studies that focus on short-term adaptation, there appears to be a lack of studies that focus on systemic transformations due to long-term changes (Scoones, 2009). As argued by Scoones (2009), other literature may help to develop livelihoods thinking by encouraging debates on sustainability. For this reason, this study draws from the climate adaptation literature to adopt a combined vulnerability-resilience approach.

2.5.2 A Combined vulnerability and resilience approach

Vulnerability and resilience are two distinct approaches within the climate adaptation literature. Although both perspectives are useful in climate adaptation research, this research will adopt an integrated vulnerability-resilience framing in order to draw upon both the actor-centred focus of the vulnerability perspective and the wider-system dynamics from the resilience perspective. The vulnerability approach looks at the necessary human, financial, social, physical (amongst others) assets and resources to reduce the impact of a stressor (Birkman et al., 2009) as well as the entitlements that people have to access these resources (Sen, 1981). While the vulnerability perspective can help us to identify communities that are more at risk of being impacted by change, it has a limited focus on the temporal and changing dynamics that a system might experience (Füssel & Klein, 2006) and therefore insufficiently considers wider systemic issues (Nelson et al., 2007). In contrast, the resilience approach explores different systems and system components, and their relationships (Berkes et al., 2008). It emphasizes that human-environment relations are not conceived as separate systems

and that human systems are both a component and an influencing factor of ecological systems (Cote & Nightingale, 2012). By recognizing that different elements of a system link together at various temporal and spatial scales, the resilience approach acknowledges that changes in one system affect several other systems at different levels.

As both the vulnerability and the resilience approach have theoretical and methodological advantages, scholars have long argued that much can be gained from joining the approaches in research (Janssen et al., 2006). That said, serious exploration of linking vulnerability and resilience within social or social–ecological systems (Adger, 2006; Cutter et al., 2008; Gallopín, 2006; Miller et al., 2010), especially in the field of climate change adaptation (Fieldman, 2011; Nelson & Brown, 2007; Nelson et al., 2007; Nelson & Finan, 2009; Wilbanks & Kates, 2010; Wolf et al., 2010) has only recently been taking place.

When taken separately and out of context (and to their extremes) the vulnerability and resilience approaches can potentially misinform research, policy and practice (Maru et al., 2014). The vulnerability approach for example can frame top-down responses that ignore the desirable resilience and resourcefulness of communities in remote regions as well as treat people as passive recipients, rather than active participants. Likewise, the resilience approach could potentially underestimate the challenge of climate change impacts and by invoking historical resilience; it could also avoid responsibility for rectifying past and current socio-economic and political determinants of vulnerabilities. As a result, there is a large body of research that considers the links between vulnerability and resilience within social-ecological systems (e.g. Folke, 2006; Folke et al., 2010; Gallopín, 2006; Miller et al., 2010; Nelson et al., 2007; Zanotti et al., 2020).

2.6 Climate adaptation in the development discourse

Climatic shocks and variability have always existed but the frequency and intensity at which they now occur brings about the need to innovate. Historically, ‘innovation’ was

considered a technical product or procedure. Over time, the concept considerably evolved and is now broadly understood as "the process by which individuals or organizations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, their country, or the world" (World Bank, 2012).

Conceptualisation of agricultural innovation has also evolved significantly, from the introduction of 'adoption and diffusion models' to 'innovation systems thinking models'. Initially, innovation was anchored in the Transfer of Technology (ToT) approach, which considered a hierarchical linear process between the development of innovations by 'experts' to the diffusion of these innovations to farmers through extension services. This top-down linear adoption model proved ineffective, in part due to (and not limited to) the fact that differing and shifting contexts were not taken into account, and that mono-disciplinary theoretical recommendations were made for multi-faceted problems (Hellin, 2012; Kamara et al., 2023). The evidence of such shortcomings led to the gradual development of new approaches, such as Farming Systems Research (FSR), Farmer First (FF), Farmer Participatory Research (FPR), the Agricultural Knowledge and Information System (AKIS), and most recently, the Agricultural Innovation System approach (AIS).

AIS, pioneered by Hall et al. (Hall et al., 2007), is an inclusive and bottom-up approach that places emphasis on the roles of different stakeholders in agricultural innovation processes. In this approach, agricultural innovation is viewed as the result of a process of interactive learning and collaboration between different stakeholders (Klerkx et al., 2009) and recognises that interdependent actors have varying (sometimes conflicting) perspectives and goals. AIS acknowledges that interconnected agents (such as farm organisations, research institutions, extension units, development agencies, processing enterprises, private firms, etc.) contribute jointly or independently to the creation, diffusion and use of agricultural

technologies and influence the process of technological change in agriculture (Kamara et al., 2023; Temel et al., 2002).

2.6.1 Climate information services as a means to support adaptation and managing risk

Climate information (CI) includes historical observations, long and short-term forecasts, and medium- to long-term projections. Climate information services (CIS) encompass the provision of relevant weather and climate information, and a range of services to enable decision-makers to understand and act on the information. 'Weather' is often used to describe the state of the atmosphere at a certain point in time, while 'climate' refers to the statistical distribution of weather aggregated over a period of time (Arguez & Vose, 2011). Climate information includes both scientific information and local knowledge about weather and climate. Local knowledge refers to "the knowledge and practices that are acquired by local people over a period of time through the accumulation of experiences over generations, society–nature relationships, and community practices and institutions" (Kniveton et al., 2015, p. 38). Local knowledge is a fundamental part of climate adaptation, risk management and rural livelihoods but for the purpose of this study, emphasis is placed on the uptake and the use of externally provided scientific climate information to get a more in-depth understanding of its utility given the considerable advances that have taken place in the field of agro-meteorology (Stigter et al., 2013) and the developments in the provision of climate information to increase opportunities of integrating scientific information into decision-making (Adams et al., 2015; Dutton, 2002; Giorgi et al., 2009; Hewitt et al., 2012; Singh et al., 2018; Wilkinson et al., 2015).

Farmers are highly knowledgeable about their surrounding agro-ecologies and have always managed complex systems around agricultural and rural livelihood activities. Variability is a natural element of the climate system, and farmers have historically adapted

to seasonal fluctuations. However, with the evidence that the climate system is changing at an unprecedented rate, one of the major constraints that smallholder farmers face is coping with production uncertainties associated with unpredictable seasonal climate conditions.

The risks associated with climate variability and change can greatly disincentive farmers from taking steps into the unknown and investing in different agricultural practices, technologies and techniques (Hansen, Hellin, et al., 2019). As a result, a number of research efforts have focused on the role that climate information can play to support farmer decision making around managing risk, informing adaptation, planning for uncertainty and improving productivity and profitability (Coulibaly et al., 2017; Dessai et al., 2009; Goddard et al., 2010; Hansen et al., 2011; Jones, Champalle, et al., 2015; Sheffield et al., 2014; Stern & Cooper, 2011; Vaughan et al., 2019). Climate services are increasingly recognized as critical for adaptation as they by provide information on the local climate, inform decision making, support a variety of resilience-building interventions, and provide an enabling environment for adoption of climate smart agriculture (Hansen, Vaughan, et al., 2019).

The growing body of literature on climate information and climate information services explores its value and effectiveness, measured through the uptake of the information and the adoption of new practices (i.e. new and different crops, low tillage, conservation agriculture) and technologies (Hellmuth et al., 2007; Patt & Gwata, 2002; Tall et al., 2018). Seasonal climate forecasts, for example, are assumed to increase the adoption rate of high yielding and climatic risk reducing technologies and activities (Hansen et al., 2011; Kenkel & Norris, 1995; Sheffield et al., 2014). These forecasts are also thought to help farmers adjust their agricultural decisions (input timing and use, sowing period, marketing decisions), and make the most of favourable conditions by adjusting crop choices and efficiently managing inputs such as land, labour, and fertilizer (Hammer et al., 2001; Hansen, 2002; Kenkel & Norris, 1995).

Despite the growing evidence, from both the global North and the global South of the utility of seasonal forecasts, there are also indications that forecasts are not always as useful as anticipated and that there are limitations when considered in the context of farmer decision making and in informing farm management decisions (Hansen et al., 2011; Tall et al., 2018). A number of studies have found climate information use by farmers to be low, noting that challenges, such as saliency and timeliness, must be overcome for these climate information services to effectively improve the livelihoods of vulnerable farmers (e.g. Cash et al., 2006; Hansen et al., 2022; Ingram et al., 2002; Meinke et al., 2006; O'Brien et al., 2000; Patt & Gwata, 2002; PytlikZillig et al., 2010; Tall, 2010).

A variety of factors affect the uptake and use of climate information. These include socio-cognitive constraints (Jones & Boyd, 2011; Singh, Dorward, et al., 2016; Singh et al., 2018), 'usability gaps' between users and producers of climate information (Lemos et al., 2012; Singh, Dorward, et al., 2016; Singh et al., 2018) and a lack of institutional capacity to both deliver and use climate information (Singh, Urquhart, et al., 2016; Tall, Kristjanson, et al., 2014). Moreover, there is evidence that farmers' climate service needs and capacity to act on climate information is very context specific. Research shows that differing climate information needs are linked to the differences in farming systems, gender (Archer, 2003; Ingram et al., 2002; Ziervogel & Calder, 2003), farmer wealth and livelihood activities (Carr & Onzere, 2018; Carr & Owusu-Daaku, 2016; Carr et al., 2016; Tall, Kristjanson, et al., 2014) as well as social norms.

Typically, climate services have been criticized for adopting a linear model where the information is understood as a 'one size fits all' product which neither serves the complex needs and realities of farmers nor utilises their knowledge and capabilities (Vogel et al., 2019). Smallholder farmers in Sub-Saharan Africa tend to be supported by Governmental and/or Non-Governmental extension services in their agricultural production activities, and

these extension services were historically understood to be a bridge between scientists and farmers (Wesley & Faminow, 2014). Over time, however, extension systems increasingly recognised the need to shift to less top-down approaches and more farmer-oriented approaches that emphasize the importance of mutual learning between different knowledge systems (Dayamba et al., 2018; Wesley & Faminow, 2014). In the context of climate risks, this is particularly pertinent as improvements in connecting climate information to users is a priority for advancing climate services (Vaughan et al., 2016). This has led to a renewed emphasis on collaboration with farmers in the development of climate-service products (Bednarek et al., 2018; Buizer et al., 2016; Kirchhoff et al., 2015; Vincent et al., 2020) and a move away from the view that climate-service products are solutions for implementation, rather than tools for farmers to engage with and interpret for their own individual circumstances (Dorward et al., 2021). Alternative approaches such as the Participatory Integrated Climate Services for Agriculture (PICSA) that consider the complex processes involved in decision-making and that focus on empowering the key actor, the smallholder farmer, have shown to improve the effectiveness and contribution of climate services in supporting farmers to deal with the multiple problems associated with climate variability and poverty (Clarkson et al., 2019; Dorward et al., 2021; Giraldo et al., 2021; Klerkx et al., 2012; Staub & Clarkson, 2021).

Within the conceptual framework of Climate Smart Agriculture (CSA), innovation plays a key role in supporting the transition towards agriculture that is adapted to climate change (Lipper et al., 2014). The provision, diffusion and use of climate information is both knowledge-intensive and involves a wide range of actors and is therefore inherently embedded within an AIS approach (Tarchiani et al., 2017; World Bank, 2006). This hasn't always been the case, as climate services typically adopted a linear model where information that was produced by climate (or other) scientists was then disseminated to 'users' (Dorward

et al., 2021; Vogel et al., 2019). A number of research and development organizations have recognised this and developed participatory communication processes and training protocols into structured climate information services activities. For example, the Participatory Integrated Climate Services for Agriculture (PICSA) approach, developed by the University of Reading, has implemented the use of historical climate data in combination with participatory activities to support participants' farming and livelihood decisions (Dorward et al., 2015) in more than twenty five countries in Africa and Latin America. Impact assessments on PICSA as well as other studies are part of the increasing evidence that participatory communication processes are effective at increasing the uptake and usability of climate information (e.g. Clarkson et al., 2017; Patt et al., 2005; Roncoli et al., 2009; Steinmüller & Cramer, 2017).

The majority of the literature on climate information concerns 'short-term information' (e.g. monthly to seasonal predications) and its effectiveness in supporting short-term farm management decisions. Numerous studies found that monthly to seasonal climate information was the type of information most used by smallholder farmers (Singh et al., 2018; Sivakumar et al., 2014; Stone & Meinke, 2006; Ziervogel & Zermoglio, 2009) and that examples of successful uptake consisted in the identification of coping strategies to manage short-term climate risks. Similarly, Cooper et al (Cooper et al., 2008) demonstrated that better management of future climate risks was made possible by the utilisation of short-term information. On the other hand, there exists far less evidence and examples of long-term climate scenarios and models informing decision-making (Jones, Dougill, et al., 2015; Nidumolu et al., 2016). This could be explained by the fact that agricultural decisions, especially by smallholders, typically focus on short time horizons (seasons and years) (Singh et al., 2018).

Studies have shown that barriers in climate information utility and uptake derive from a poor understanding of why end users make decisions. Farmer decision-making is a complex process of iterative adjustments that is influenced by assets, aspirations and socio-cultural environments (Gbetibouo, 2009; Singh, Dorward, et al., 2016). In principle, communities adapt in order to retain their livelihoods, but there are numerous factors that play a role in which decisions are made. The context in which smallholder farmers live (context of state, market and civil society for example) plays a great role in their capacity to adapt successfully. Climate variability and change introduces numerous uncertainties in agricultural decision making, especially in rain fed areas. Communicating information on climate risk, such as with the PICSA approach described above, has the potential to support farmers in anticipatory risk management, decision making and planning.

A number of studies have shown that the value of climate information is highly influenced by decision-maker characteristics and their preferences, particularly when it comes to risk (Cabrera et al., 2007; Letson et al., 2005; Messina et al., 1999). For example, risk averse decision makers are more likely to use and respond to climate information than those who are risk neutral (Cabrera et al., 2007; Cerdá Tena & Quiroga Gómez, 2011; Jones et al., 2000; Marshall et al., 1996). Meza et al. (2008) found that risk-averse farmers tend to use constant low-return, protective strategies in case any year turns out to be extremely bad. In the event of a favourable forecast, these farmers reduced their defensive strategies (i.e. avoiding risk associated with adverse conditions), thus increasing average annual earnings. A favourable forecast enabled them to relax some of their defensive strategies in favourable years, thus increasing average annual earnings (Meza et al., 2008). On the other hand, Letson et al. (2005) argued that forecasts of adverse climatic conditions were most useful for risk-neutral farmers because they used them chiefly to avoid risk, and to engage in defensive responses.

2.7 Research Gaps and Problem Statement

The literature on climate information, its generation and communication, value, the barriers and the enablers surrounding it, and its potential role in risk management is extensive. Initial studies on climate information in Africa explored whether more and better information would lead to higher levels of uptake and also identified some of the conditions that would enhance this uptake (Hulme et al., 2001; Vogel & O'Brien, 2006). The focus of research on climate information gradually shifted away from a technology transfer approach and centred more on the inclusion of intended users in its generation, recognising that climate information and climate information services are more of a process than a solution. The body of literature now broadly recognises the importance of not producing climate information in silos (e.g. for enhanced food security), and instead calls for approaches that value and understand the context in which intended users are embedded (Vogel & O'Brien, 2006). However, with the exception of a few approaches (such as PICSA), points of engagement are still tied to the 'scientist' as expert who is 'delivering' and attempting to embed climate information into the daily lives of smallholder farmers (Vogel et al., 2019).

Extensive literature shows that climate change has the potential to push smallholder farmers into greater depths of poverty and food insecurity through shocks and stresses. Supporting smallholder farmers to protect and enhance their livelihoods in the face of the rapidly changing biophysical environment and conditions is urgent, especially in many SSA countries, where the majority of the population relies heavily for subsistence on agriculture. The need to adapt to this changing climate is undisputed. Ways in which to adapt are also known, and so are the barriers that have so far challenged the adoption of adaptive practices. There do remain, however, some gaps in our knowledge on what more can be done (and how) to enhance the role of climate information in supporting smallholder farmers in their decisions around adaptive strategies.

3. Chapter Three: Research Methods

3.1 Study Area

As described in Chapter One, the primary aim of this research is to explore effective strategies for supporting smallholder farmers in adapting to climate change, with the goal of enhancing their resilience to its adverse effects while safeguarding their livelihoods and ensuring food security. The selection of the study area was guided by three key considerations: First, the region's high exposure to climate change risks, including the occurrence of shocks and stresses; Second, the predominance of smallholder farmers who are heavily reliant on agriculture and particularly vulnerable to climatic variations; and Third, the feasibility of the researcher conducting fieldwork in each country while managing full-time professional commitments.

Sub-Saharan Africa is particularly vulnerable to climate change due to its geographic and socio-economic characteristics. The region experiences high levels of climate variability, including increasing temperatures, unpredictable rainfall patterns, and more frequent extreme weather events such as droughts and floods. These climatic shifts significantly affect agriculture, as most farming in the region is rain-fed. Prolonged droughts, for example, have led to reduced crop yields and food insecurity across various countries in the region (IPCC, 2021; Thornton et al., 2011; Thornton et al., 2019). Agriculture is a vital sector for many Sub-Saharan African nations, employing around 60% of the labor force and contributing an average of 30% to their GDP (Thornton et al., 2011). The IPCC (2021) also projects that agricultural productivity could decline by as much as 50% by 2050 in some parts of Sub-Saharan Africa and that smallholder farmers in Sub-Saharan Africa are some of the most vulnerable populations to climate change and variability.

The nature of the research questions at the household level and the importance of context and location meant that a selection of individual countries had to be made, as Sub-Saharan Africa is far too large of a study area. For this reason, the study area was further broken down into a smaller sample: East and Southern Africa. Undoubtedly, countries in East and Southern Africa are both numerous and immensely diverse. The specific choice and number of countries depended on the researcher's employment with IFAD, a United Nations agency with a mandate to support the livelihoods of small-scale producers in rural areas in developing countries. With contributions from member states, IFAD designs projects in collaboration with recipient Governments. National Governments then implement the respective projects with financing from IFAD in the form of either grants, loans or a combination of both (both concessional and non-concessional). When projects are launched, IFAD requires a baseline study to be conducted, in order to monitor and ultimately evaluate the progress towards the achievement of the project goals. Part of the researcher's assignment with IFAD was to design and implement baseline surveys in five countries in East and Southern Africa: Eswatini, Kenya, Lesotho, Tanzania and Zimbabwe. It is for this reason that data from those specific five countries were used for this PhD research. Figure 3.1 below presents the geographical location of the study area in each of the five countries, and Table 3.1 describes the number of households interviewed in each zone. A brief description of each IFAD project and the targeted beneficiaries is presented below.

Figure 3.1: Map of Study Area

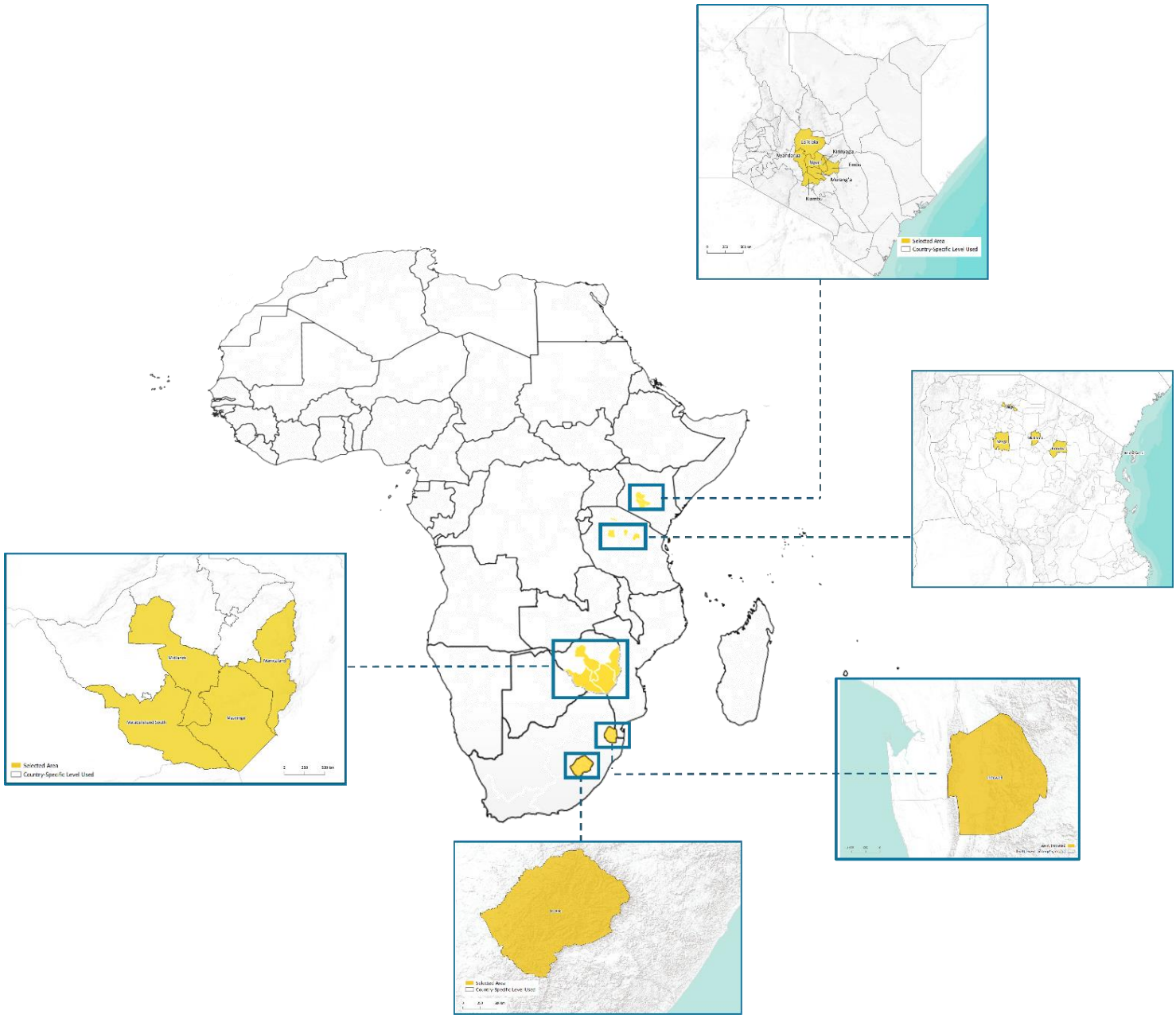


Table 3.1 below provides an overview of where the surveys were conducted. In Eswatini and Lesotho, the surveys were conducted nationwide whilst in Kenya, the survey covered parts of 7 counties within 3 sub-catchments of the upper Tana River. In Tanzania, 28 villages across 5 districts were surveyed and in Zimbabwe, the survey was conducted in 4 provinces.

Table 3.1: Location of data collection

Country	Country Population (World Bank, 2023)	% of Population rural (World Bank, 2023)	Year data collected	No. of Households surveyed	No. of Households used in data analysis	Sampling Approach	Location of survey
Eswatini	1m	76%	2018	1200	1,198	National	National
Kenya	49m	73.4%	2017	1002	996	Subnational (3 out of 8 provinces)	3 sub-catchments of the upper Tana River in parts of 7 counties (Murang'a, Nyeri, Laikipia, Nyandarua, Kiambu, Kirinyaga, Embu)
Lesotho	2m	72%	2017	1320	1,292	National	National
Tanzania	60m	65.5%	2019	850	846	Subnational (5 out of 31 regions)	28 villages in 5 districts (Nzega, Magu, Mkalama, Kondoa, Micheweni)
Zimbabwe	15m	68%	2018	1000	990	Subnational (4 out of 10 provinces)	4 provinces (Manicaland, Midland, Mat South, and Masvingo)
Totals				**5376**	**5,322**		

3.1.1 The Upper Tana-Nairobi Water Fund Project in Kenya (UTNWF)

The Upper Tana-Nairobi Water Fund (UTNWF) was designed in 2017 by the Government of Kenya and IFAD to address water security issues in the Upper Tana River basin in Kenya. This region is crucial as it supplies 95% of Nairobi's water and 50% of Kenya's electricity through hydropower. However, the watershed faces significant challenges such as soil erosion, deforestation, and unsustainable agricultural practices, which threaten water quality and availability. The project aimed to improve water quality and quantity by

investing in upstream watershed conservation. The rationale is that it is more cost-effective to prevent water problems at the source rather than addressing them downstream. By implementing sustainable land management practices, the project seeks to reduce sedimentation in rivers and reservoirs, enhance water flow, and improve the livelihoods of local communities.

The primary beneficiaries of the UTNWF are local farmers and communities in the Upper Tana River basin who will benefit from improved agricultural practices and increased water availability. The indirect beneficiaries include downstream water users, including the residents of Nairobi, who will gain from enhanced water quality and reliability. Hydropower producers are also expected to benefit from the project through reduced sedimentation and more consistent water flow.

The UTNWF project aimed to engage at least 21,000 smallholder households across three sub-catchments, directly benefiting approximately 100,000 individuals. This initiative is expected to have a cascading impact on the entire population of 5.3 million inhabitants in the Upper Tana catchment. Women make up about 51% of both the direct beneficiaries and the overall population in the catchment area.

The implementation of the project began with a scale-up phase in 2017 and continued through various phases, including a transition phase in 2020. The project became an independent entity in September 2021.

3.1.2. The Wool and Mohair Promotion Project (WAMPP) in Lesotho

The Wool and Mohair Promotion Project (WAMPP) in Lesotho aimed to enhance the resilience of rural communities by implementing climate-smart rangeland management practices to improve grazing land quality and productivity. It focused on boosting livestock production through better breeding, feeding, and animal health practices, while also providing training and support to farmers. Additionally, the project sought to develop

effective marketing strategies for wool and mohair, establishing market linkages and improving the value chain to increase farmers' incomes.

The project targeted smallholder farmers and poor rural dwellers across all 10 administrative districts of Lesotho, with a special focus on women and young people. Special attention was paid to smallholder farmers, who are the primary producers of wool and mohair. These farmers often face challenges such as limited access to resources, markets, and technical knowledge. The project also prioritized women and youth, recognizing their vulnerability to poverty and food insecurity. Specific interventions were designed to empower these groups through targeted incentives and capacity-building activities. Overall, WAMPP aimed to directly benefit approximately 50,000 smallholder farmers primarily involved in wool and mohair production. WAMPP ran from 2016 to 2023.

3.1.3. The Land Degradation and Food Security (LDFS) project in Tanzania

The Land Degradation and Food Security (LDFS) project in Tanzania was designed in 2017 and implemented over a five-year period from 2017 to 2022, with an extension into 2023. LDFS aimed to reverse land degradation and enhance food security in semi-arid regions by implementing sustainable land and water management practices, promoting climate-smart agriculture, and strengthening local institutions. The project focused on improving soil fertility, increasing agricultural productivity, and enhancing the resilience of rural communities to climate change, with a particular emphasis on supporting smallholder farmers, pastoralists, and vulnerable groups such as women and youth.

The project focused on semi-arid regions of central Tanzania, including the districts of Mkalama, Nzega, Kondoa, Magu, and Micheweni. The target group included smallholder farmers, pastoralists, and rural communities who were most affected by land degradation and food insecurity. Overall, LDFS targeted approximately 3000 beneficiary households.

3.1.4 Climate-Smart Agriculture for Climate-Resilient Livelihoods (CSARL) project in Eswatini

The Climate-Smart Agriculture for Climate-Resilient Livelihoods (CSARL) project in Eswatini aimed to enhance food and nutrition security through diversified, climate-resilient agricultural practices and sustainable land and water management. Targeting 37 chiefdoms across Eswatini, the project focused on smallholder farmers, particularly women and youth, and aimed to improve their livelihoods by increasing agricultural productivity and market access. The project, implemented from 2017 to 2023, directly targeted approximately 50,000 smallholder farmers by promoting sustainable practices and strengthening local capacities to combat land degradation and enhance resilience to climate change.

3.1.5 The Smallholder Irrigation Revitalization Programme (SIRP) in Zimbabwe

The Smallholder Irrigation Revitalization Programme (SIRP) in Zimbabwe aimed to enhance the resilience of smallholder farming communities by revitalizing 6,100 hectares of existing smallholder irrigation schemes across the provinces of Manicaland, Masvingo, Matabeleland South, and Midlands. The project, implemented from 2017 to 2024, targeted approximately 27,700 poor rural households. It focused on improving productivity and climate-resilient crop production through sustainable land and water management practices, better market access, and the adoption of climate-smart agricultural techniques. The programme also aimed to reduce the vulnerability of smallholder farmers to food and nutrition insecurity, climate change effects, and economic shocks.

3.2 The research design

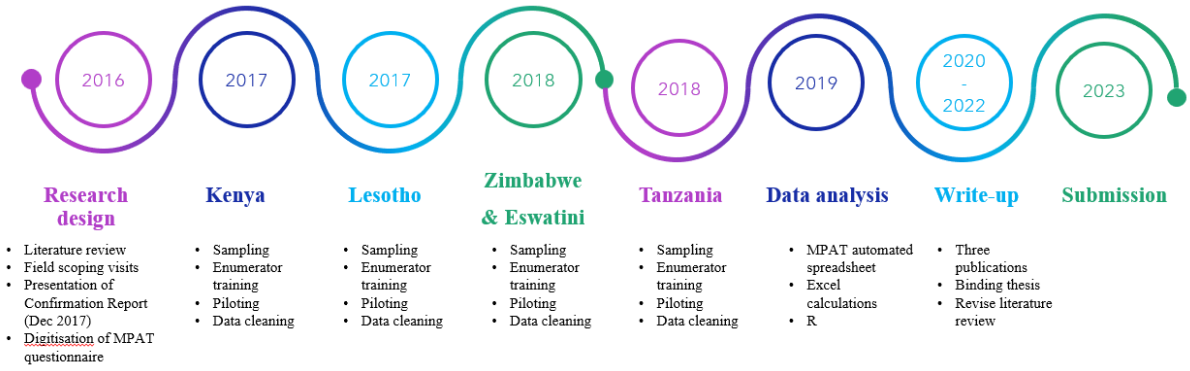
The initial step in the research process involved defining the research questions, which were informed by a comprehensive literature review conducted during the first year of the PhD program. Relevant literature was continuously consulted throughout the program,

both in the context of the researcher's professional work and to further refine and adapt the study's objectives.

In 2016, during the research design process, the researcher was residing in Lesotho as part of their employment with IFAD and had the opportunity to engage with smallholder farmers who were beneficiaries of an IFAD-funded project. Over the course of six months, these interactions with smallholder farmers, within the context of their work, served as scoping field visits that helped to define the research questions and contributed to the final research plan, which was submitted in December 2016 as part of the Confirmation Report. This period also marked the time when the researcher learned to program and digitized the questionnaire (as described in section 3.5.1).

However, the research plan was adjusted in 2017 when the opportunity arose to collect data in additional countries beyond Lesotho. In February 2017, the sample and final questionnaire was prepared and the first enumerator training took place in Kenya. This was followed by a one-day piloting phase and a month-long period of data collection. The same process was applied to each country in the subsequent months and years. Figure 3.2 below presents a timeline of this study.

Figure 3.2: Study timeline



3.3 The data collection tool: The Multidimensional Poverty Assessment Tool (MPAT)

Central to successful rural poverty alleviation at a local level is an enhanced understanding of what constitutes destitution, what challenges exist, and what aspirations look like for the rural poor themselves. The choice of research method for this study was guided by the desire to capture perceptions of the rural poor. Case studies and in-depth interviews are adequate tools to capture detailed knowledge of a situation or the iterative nature of farmer decision-making processes but require significant amounts of time, and therefore collecting information from large numbers of households in each country with this method in the context of part-time study would have been impossible. Instead, this study is based on data collected through a socio-economic survey, the Multidimensional Poverty Assessment Tool (MPAT) that meets two needs: i.) Capturing respondent perceptions and multiple dimensions of rural poverty; and ii.) Capturing large amounts of data from various countries in a time constrained manner.

The Multidimensional Poverty Assessment Tool is the result of a collaborative initiative led by the United Nations International Fund for Agricultural Development (IFAD) to develop, test and pilot a new tool for local-level rural poverty assessment. It was iteratively refined and tested in cooperation with government partners, international NGOs, academic institutions, and local partners. Financial support for MPAT's initial development in China and India (2008-2009) (Cohen, 2009), and refinement in Bangladesh and Mozambique (2012-2013) (IFAD, 2014), was primarily provided by IFAD and the United Kingdom's Department for International Development (DFID). MPAT data are collected primarily via administered household-level surveys, and additional data for some components (education, health, gender) are also collected from village-level administrators, educators, and healthcare staff.

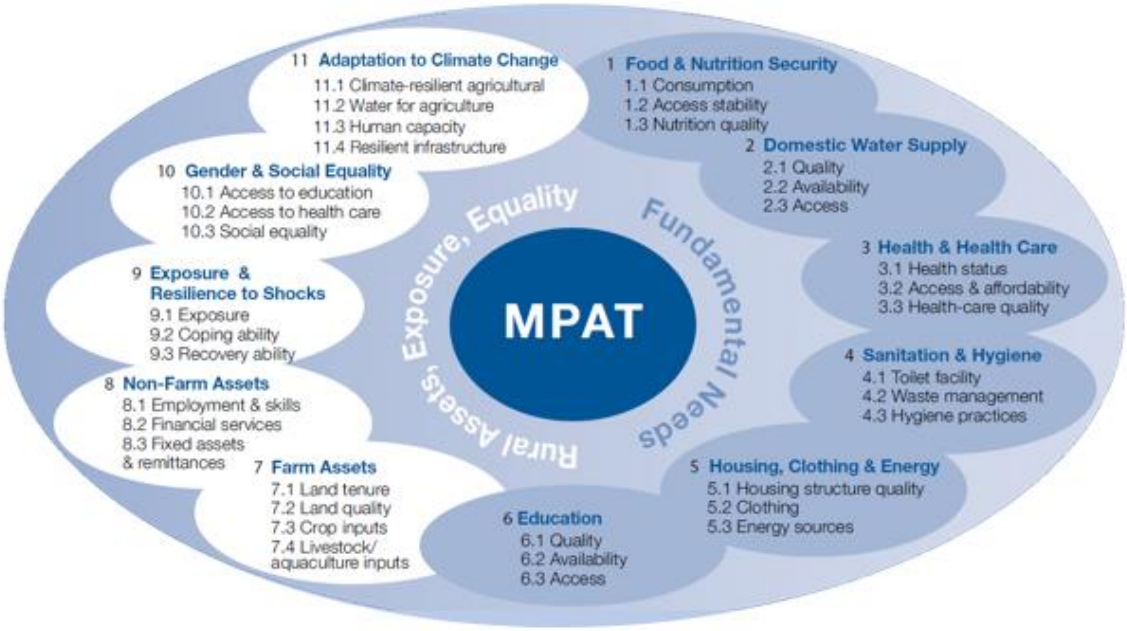
MPAT measures 11 core dimensions of rural poverty by collecting data general enough to be relevant across various contexts, yet specific enough to serve the needs of researchers, beneficiaries, policy makers, and others. Although the design of MPAT started in 2007, Narayan et al.'s (2009) study of poverty on 60,000 people across 15 countries provides a wealth of evidence which supports the theoretical rationale behind its design (Cohen, 2010). The study found that whether people climb from destitution by "growing new crops, using new agricultural techniques or equipment, accessing new markets, starting a business, getting a job, or migrating for employment, […] people take initiatives based on their self-confidence, agency, aspirations, and empowerment" (Narayan et al., 2009, p. 46).

Accordingly, MPAT aims to provide an overview of the key sectors involved in rural poverty alleviation, and considers multidimensional assessment as a superior alternative to the previously predominant measurement of income or economic growth as a proxy measure of poverty (Bourguignon & Chakravarty, 2003; Hicks & Streeten, 1979; Sen, 2000; Streeten, 1984). Instead of defining the quality of life that people should strive to obtain, MPAT assesses the overall environment within which rural people live, in order to consider whether it is sufficient to allow them to seek the quality of life that they desire.

Although the enabling environment is shaped by individual contexts, there are fundamental domains that are generally universally relevant to rural poverty, and MPAT defines a concrete list of dimensions to be assessed, inspired by fundamental, relatively universal, domains of rural poverty (Cohen, 2010). Six of MPAT's components have their roots in Basic Needs theory (Streeten, 1984): i.) Food and Nutrition Security; ii.) Domestic Water Supply; iii.) Health and Health Care; iv.) Sanitation and Hygiene; v.) Housing, Clothing, and Energy; and vi.) Education. Within each of these fundamental needs, MPAT contains an analysis of the level of quality and reliability (or availability) of the dimension, and the respondent's access to it.

In addition to these six fundamental needs, MPAT contains five more dimensions deemed vital to the enabling environment often necessary for contemporary rural poverty reduction: vii.) Farm Assets; viii.) Non-Farm Assets; ix.) Exposure and Resilience to Shocks; x.) Gender and Social Equality; and xi.) Adaptation to Climate Change. The breakdown of the MPAT components and subcomponents is shown in figure 3.3 below.

Figure 3.3: MPAT Components and subcomponents



Source: Adapted from the MPAT User's Guide (IFAD, 2014)

Each of MPAT's 11 components is itself a composite indicator composed of three or four subcomponents. The subcomponents are in turn composed of multiple survey items from the MPAT household survey. Thus, while MPAT components themselves are composite indicators, MPAT is a thematic indicator overall, because all 11 component scores stand alone and are not combined or averaged together.

MPAT is implemented as an interview, although the actual form is structured as a questionnaire which allows enumerators to both engage respondents in a more evocative way and to quickly record respondents' answers (the full questionnaire can be found in Annex 1). Once the data are collected, survey responses are assigned numerical values. These numerical

values fall within absolute scales with a range of 0–100, where 100 is the highest, or most positive. Subcomponent values are first calculated, and then aggregated to yield the component values. Table 3.2 below gives an example of the MPAT results generated (in this case from Lesotho) and the scores in each Component, with the range to the right.

Table 3.2: An example of MPAT results generated with scores for each component

Scores across households	Average	[min, max]
Food & Nutrition Security	77,5	[15, 100]
Domestic Water Supply	71,3	[24, 100]
Health & Health Care	65,8	[24, 99]
Sanitation & Hygiene	62,2	[18, 99]
Housing, Clothing & Energy	70,4	[21, 98]
Education	79,9	[10, 100]
Farm Assets	43,4	[10, 100]
Non-Farm Assets	46,9	[24, 88]
Exposure & Resilience to Shocks	42,3	[10, 100]
Gender & Social Equality	83,0	[26, 100]
Adaptation to climate change	36,6	[10, 76]

3.3.1 Understanding the mechanics of MPAT indicator calculation

Many poverty-related indices are composite indicators, combining various values into a single index. However, the Multidimensional Poverty Assessment Tool (MPAT) was designed as a thematic indicator, keeping its 11 components separate to better capture the multidimensional nature of rural poverty. Instead of merging these values into one index, MPAT presents them together as a ‘dashboard,’ each focusing on different aspects of rural poverty.

Each of MPAT’s 11 components is itself a composite indicator, comprising three or four subcomponents, which are derived from multiple survey items in the MPAT Household and Village Surveys. Thus, while the components are composite indicators, MPAT as a whole remains a thematic indicator because the 11 scores are not combined or averaged. An

independent analysis of MPAT pilot data in 2009 supported this approach, confirming the robustness of MPAT's structure (Saisana & Saltelli, 2010).

Although MPAT indicators can be manually calculated, the MPAT User's Guide (Cohen, 2009), provides an automated Excel Spreadsheet to calculate and review standardized MPAT results. This spreadsheet is pre-coded with values, scores, and weightings, and performs all calculations automatically once data is entered. Once the survey data from the Household Surveys are entered into the spreadsheet these are converted to values on a 1-10 scale. Each subcomponent consists of multiple survey items. The values for each subcomponent are aggregated using a weighted arithmetic average (Equation 1) and then converted to a 10-100 scale for greater resolution.

Equation 1: Weighted arithmetic average formula and explanation

$y_{jk} = \sum_{i=1}^{n} w_{ik} x_{ijk}$

Where:

- y_{jk} is the score for household *j* in subcomponent *k*
- w_{ik} is the weight attached to survey question *i* in subcomponent *k*
- x_{ijk} is the scaled score for household *j* in question *i* in subcomponent *k*.

And:

$\sum_i w_{ik} = 1$ and $0 \leq w_{ik} \leq 1$

The subcomponent values are aggregated using a weighted geometric average (Equation 2) to determine the component values, with the conversion weights detailed in Annex 7. Although the user inputs data for all households simultaneously, this process is executed individually for each household, and thus the necessity of having unique codes for each one.

Equation 2: Weighted geometric average formula and explanation

$\bar{x} = (\prod_{i=1}^{n} xi^{wi})^{1/\sum_{i=1}^{n} wi}$

Where:

- y_{jk} is the score for household *j* in subcomponent *k*
- w_{ik} is the weight attached to survey question *i* in subcomponent *k*
- x_{ijk} is the scaled score for household *j* in question *i* in subcomponent *k*

And:

$\sum_i w_{jk} = 1$ and $0 \leq w_{ik} \leq 1$

Survey questions deemed more significant in determining the subcomponent score are assigned a higher weight, resulting in a weighted arithmetic average. Additionally, MPAT formulas assign weights to each subcomponent based on their relative importance or contribution to the overall component score. In this case, MPAT employs a weighted geometric mean versus the standard weighted average when they are placing mor emphasis on the lower values. When data for certain items are missing due to intentionally skipped survey questions or specific responses, the weights for the remaining items are adjusted by dividing them by their total sum, unless stated otherwise. Thus, if an item is not relevant for a given household, the new weights for the remaining items are calculated by dividing the old weights by their sum and multiplying by 100, so that the ratio of the weights remains the same.

The weights used for each calculation are provided in the MPAT Values and Weights tab of the excel spreadsheet. An example of how to calculate a component score is provided in the section below, and Annex 7 provides the breakdown of the valuations and weightings for each MPAT component and subcomponent.

Example: Calculations to generate a Food & Nutrition Security component score

Food & Nutrition Security

Component	Description	Percentage
Food & Nutrition Security	This component measures the stability and availability of sufficient quantities of adequately nutritious food to the household.	
1.1 Consumption	This subcomponent assesses whether the household has a sufficient quantity of food most of the time.	43%
1.2 Access Stability	This subcomponent assesses the stability of the household's access to food.	32%
1.3 Nutrition Quality	This subcomponent assesses the diversity of the household's diet as a proxy measure for balanced nutrition intake.	25%

1.1 Consumption

Survey Question (Q59): During the last 12 months, did any member of your household eat fewer meals, or smaller portions, than usual because there was not enough food? [If 'Yes', for approximately how long?]

Response	Code	Value
Never	**1**	**10**
Yes, once or twice	**2**	**8**
Yes, for about 1 week	**3**	**6.5**
Yes, for a few weeks	**4**	**5**
Yes, for about 1 month	**5**	**3.5**
Yes, for more than 1 month	**6**	**2**
Yes, most days	**7**	**1**
Don't know	**8**	**MD**

Survey Question (Q60): During the last 12 months, did any member of your household go to sleep at night hungry? [If 'Yes', how often did this occur?]

Response	Answer Code	Value (1-10)
Never	1	10

Yes, once or twice	2	9
Yes, for about 1 week	3	7
Yes, for a few weeks	4	6
Yes, for about 1 month	5	4.5
Yes, for more than 1 month	6	2
Yes, most days	7	1
Don't know	8	MD

Aggregation for Subcomponent 1.1

Question	Weight (%)
Q59	60
Q60	40
Total	**100**

1.2 Access Stability

Survey Question (Q61): During the past 12 months, did your household experience a period of time longer than 2 weeks when there was not enough food? [If 'Yes', how many such periods?]

Response	Answer Code	Value (1-10)
No	1	10
Yes, 1	2	5
Yes, 2	3	3
Yes, 3	4	2
Yes, 4	5	1
Yes, more than 4	6	1
Don't remember	7	MD
Other, specify	8	MD

Survey Question (Q62): During the past 12 months, did your household ever experience 1 full day with no food to eat? [If 'Yes', how often did this occur?]

Response	Answer Code	Value (1-10)
Never	1	10
Once or twice	2	7
Approximately once a month	3	5
Approximately every 2 weeks	4	3
Approximately every week	5	1
Don't know	6	MD

Aggregation for Subcomponent 1.2

Question	Weight (%)
Q61	55
Q62	45
Total	**100**

1.3 Nutrition Quality

Survey Question (Q63): During the last 12 months, how often did the majority of your household eat the following foods?

Food Category	Response	Answer Code	Value (1-10)
Grains (cereals, bread, rice, pasta)	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**4**
	About once a week	**5**	**5**
	A few times a week	**6**	**7**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**

Vegetables/Greens	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**4**
	About once a week	**5**	**6**
	A few times a week	**6**	**9**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**
Fruits	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**4**
	About once a week	**5**	**6**
	A few times a week	**6**	**8**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**
Dairy &/or Eggs	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**4**
	About once a week	**5**	**6**
	A few times a week	**6**	**8**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**
Meat &/or Fish/Seafood	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**4**
	About once a week	**5**	**6**
	A few times a week	**6**	**8**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**

Nuts &/or Legumes (and/or derivatives, tofu, etc.)	**Never**	**1**	**1**
	Almost never	**2**	**2**
	Approximately once a month	**3**	**3**
	A few times a month	**4**	**5**
	About once a week	**5**	**7**
	A few times a week	**6**	**10**
	Every day	**7**	**10**
	Not eaten for religious or cultural reasons	**8**	**MD**

Aggregation for Subcomponent 1.3 – Option 1

Question	Weight (%)
Q63.1	7.5
Q63.2	7.5
Q63.3	20
Q63.4	12.5
Q63.5	20
Q63.6	12.5
Q63.7	20
Total	**100**

Aggregation for Subcomponent 1.3 – Option 2[1]

Question	Weight (%)
Q63.1	7.5
Q63.2	7.5
Q63.3	20
Q63.4	12.5

[1] If household does not consume meat/fish/seafood for religious/cultural reasons

Q63.5	25
Q63.7	27.5
Total	**100**

Aggregation for Subcomponent 1.3 – Option 3[2]

Question	Weight (%)
Q63.1	7.5
Q63.2	7.5
Q63.3	35
Q63.4	12.5
Q63.7	37.5
Total	**100**

Food Security Component Responses and Calculations

Subcomponent	Question	Response	Value	Weight (%)	Weighted Score
1.1 Consumption	Q59	Yes, for about 1 week	6.5	60	3.9
	Q60	Yes, for about 1 month	4.5	40	1.8
Subcomponent 1.1 Score				**100**	**5.7**
1.2 Access Stability	Q61	Yes, 2	3	55	1.65
	Q62	Approximately once a month	5	45	2.25
Subcomponent 1.2 Score				**100**	**3.9**
1.3 Nutrition Quality	Q63.1 Grains	Every day	10	7.5	0.75
	Q63.2 Vegetables/Greens	A few times a week	9	7.5	0.675
	Q63.3 Fruits	About once a week	6	20	1.2

[2] If household does not consume meat/fish/seafood and dairy/eggs for religious/cultural reasons

	Q63.4 Dairy &/or Eggs	A few times a week	8	12.5	1
	Q63.5 Meat &/or Fish/Seafood	About once a week	6	25	1.5
	Q63.6 Nuts &/or Legumes	A few times a week	10	27.5	2.75
Subcomponent 1.3 Score				**100**	**6.675**
Aggregated Component Score	**Subcomponent**	**Score**	**Weight (%)**	**Weighted Score**	
	1.1 Consumption	5.7	43	2.451	
	1.2 Access Stability	3.9	32	1.248	
	1.3 Nutrition Quality	6.075	25	1.51875	
Food & Nutrition Security Score			**100**	**5.21775**	

In this example, the food security component score for a household would be approximately 52.2 when converted to a 10-100 scale (for increased resolution). This process is repeated for all components and subcomponents.

3.4 Empirical contribution to research applications of MPAT

3.4.1 Multidimensional Poverty Assessments for rural poverty reduction efforts

Smallholder farmers (managing farms <2 hectares) account for 84% of all farms worldwide (Lowder et al., 2021) and constitute the majority of the world's poor and hungry (Von Grebmer et al., 2019). Within the context of sustainable development, initiatives that support smallholder production and wellbeing are central and urgent.

Poverty assessments can help inform and develop sustainable development strategies, and the targeting, design, monitoring, and evaluation of development projects, particularly in the face of climate change which negatively impacts rural livelihoods. Indicators and composite indicators are commonly used to inform development initiatives, both for policy making and for communicating performance (Singh et al., 2009). The OECD (OECD, 2003, p. 5) defines an indicator as a "parameter, or value derived from parameters, able to convey

information or description of the state of a given phenomenon (…)" while an index is "a group of parameters which are aggregated or weighed based on indicators". Poverty indicators, although highly useful for standardized assessments and comparisons, often present a significant drawback in that they tend to (over)simplify the complexity of poverty. While there is a general consensus that poverty and well-being are multidimensional, and that deprivations and achievements go beyond income (Alkire, 2007; Barrett, 2005; Bourguignon & Chakravarty, 2003; Sen, 1985), there is a less wide consensus on whether various dimensions of poverty can be, or should be, aggregated into a single, multidimensional index in a meaningful way (Cohen, 2009; Lustig, 2011).

Indicator systems have long been criticized for their poor ability to speak to cause-effect relationships (Pissourios, 2013) and their redundant representation of certain aspects, depending on the indicator selection (Patten, 2006). The value of an indicator depends on the quality of the data used to construct it, its ability to describe a context, and the caution with which it is used to inform programs and policies (Cohen, 2010). Indicator selection and usage in the context of poverty reduction programs and sustainable development assessments requires well-defined criteria, otherwise the analysis can be compromised by the availability of multiple indicators from several sectors (da Silva et al., 2020). Rural poverty assessments tend to either produce 'narrow' data that is useful for sector-specific interventions, or are so in-depth that the surveys become very expensive and time-consuming, and result in datasets that end up being unmanageable (Cohen, 2010). As a result, there is a need to find a balance between standardizing assessments (in order to compare countries and regions) and catering for contextualization so as to adequately measure the dimensions of poverty at a meaningful resolution and to act commensurately.

MPAT was designed in part to try and find this balance (Cohen, 2010). MPAT measures 11 core dimensions of rural poverty by collecting data general enough to be

relevant across various contexts, yet specific enough to serve the needs of researchers, beneficiaries, investors, project managers, policy makers, and others.

3.4.2 MPAT in the context of existing research

Achieving climate adaptation goals and resilience in the rural sector depends on understanding the links between household well-being, livelihood practices, and possible adaptation options (including the provision of climate information). Reliable indicators of household well-being are necessary to model these links and to inform interventions that meet the differing needs of various households. The need for multidimensional tools, their development and their strengths and weaknesses have been extensively studied (D'attoma & Matteycci, 2023; Pomati & Nandy, 2020). While the application of multidimensional poverty indices is common, most research products use poverty assessments to describe rural poverty contexts which has so far been largely the case with the use of MPAT.

The majority of existing research products on MPAT revolve around the theoretical construct of the tool (Cohen, 2009; Cohen & Saisana, 2014) as well as its use for baseline studies of rural development projects (IFAD & World Agroforestry, 2019). This said, MPAT has been applied to several studies in rural development, mainly in terms of household profiling to inform interventions. For example, Cerio et al. (2021) applied MPAT in a study in the Philippines to demonstrate that age, sex, number of children, educational attainment, number of crops planted, and the informal ex-ante social risk mechanisms in place did not have a significant association with multidimensional poverty whilst households employing plant diversification methods were less likely to fall into multidimensional poverty. Similarly, a study by Michael et al. (2019) employed MPAT to identify the determinants of multidimensional poverty in the communities sampled. The study found that household multidimensional poverty levels were influenced by age, marital status and household size

(negatively) as well as educational level, livelihood activities, farm size, livestock ownership, remittance, membership of group, and access to credit (positively).

No study, however, exists on the use of MPAT to inform climate adaptation interventions. Likewise, there appears to be a lack of climate information studies that use standardized multidimensional poverty indicators to describe the linkages between household well-being and climate information use. This gap limits our ability to compare studies and draw general conclusions on the relationships between climate information and household well-being. Most closely linked to this thesis is a study conducted by Sandhu & Sandhu in 2014 to understand the poverty–ecosystem services interactions. The authors first assessed multidimensional poverty to determine the socio-economic status and then secondly, identified the drivers of ecosystem change and linkages between ecosystem services and some of the constituents of human well-being. They argue that such linkages can provide meaningful contributions to simultaneously address poverty and environmental degradation.

Research applications of multidimensional tools to identify the links between poverty and the value of climate information are scarce, and even less so for multi-country applications. This thesis adds to the body of knowledge, not only on the value of climate information, but also on the application of a specific poverty assessment tool. The unique distinction with this thesis compared with other research applications of MPAT is that first, it compares several countries and second, it focuses on climate adaptation which to the author's knowledge has not yet been explored so far.

3.5 The data collection process

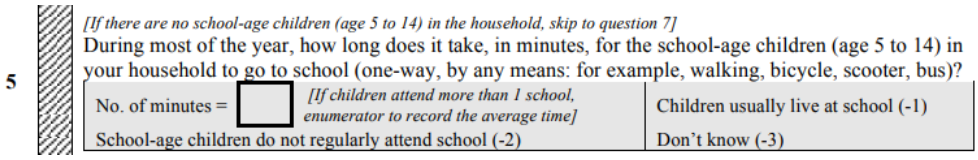
3.5.1 Digitisation of the MPAT survey

The first step in the data collection process was to digitise the MPAT questionnaire which had so far only been conducted on paper. This was first done by creating an Open Data Kit (ODK) form in excel and learning to programme. Open Data Kit (ODK) is an open-

source suite of tools that allows for data collection on Android mobile devices and data submission to an online server. By using ODK, the traditional paper form was replaced with an electronic form that allowed for text, numeric data, and GPS information to be uploaded to an online server. The ability to upload the data collected daily to a server was important for the data quality checking stage, which is further elaborated below.

Once the electronic form was programmed in excel, this gave a better idea of the structure of the survey and the differences between the paper and electronic form. Some questions, for example, needed to be split into two as an electronic form does not allow for both quantitative and qualitative answers to one single question. For example, Q5 below from the paper version is transformed into two questions (5a & 5) for the electronic version.

Paper Version



5	*[If there are no school-age children (age 5 to 14) in the household, skip to question 7]* During most of the year, how long does it take, in minutes, for the school-age children (age 5 to 14) in your household to go to school (one-way, by any means: for example, walking, bicycle, scooter, bus)?	
	No. of minutes = ☐ *[If children attend more than 1 school, enumerator to record the average time]*	Children usually live at school (-1)
	School-age children do not regularly attend school (-2)	Don't know (-3)

Electronic Version

SKIP TO Q7 IF NO CHILDREN BETWEEN 5 AND 14 5a. Do the children in your household (those between 5 and 14) who regularly attend school travel to school from home on a daily basis?	Yes.....1 No, the children usually live at school...-1 **>Q6**
5. During most of the year, how long does it take, in minutes, for the school-age children (age 5 to 14) in your household to go to school (one-way, by any means: for example, walking, bicycle, scooter, bus)? **WRITE ANSWER IN MINUTES. IF CHILDREN ATTEND MORE THAN 1 SCHOOL, ENUMERATOR TO RECORD THE AVERAGE TIME**	MINUTES _____ **IF THE RESPONDENT IS NOT SURE, TRY TO ESTIMATE. IF REALLY NOT SURE, WRITE "-99"**

3.5.2 Translating the questionnaires into local languages

To collect high quality data, it is important to have questionnaires in the corresponding language of each country. For each of the five countries, the survey was translated using a professional translator into the local language. In the case of Kenya, for example, the questionnaire was available in English, Kikuyu and Swahili and respondents were free to select their preference. Survey Solutions, a free software developed in the data

group of The World Bank, allows users to create multilingual questionnaires. As a result, the survey was migrated from ODK to Survey Solutions and this tool was used to collect data instead.

The English questionnaire was downloaded into an excel spreadsheet and shared with professional translators who translated each question and answer into corresponding columns. The questionnaires were then translated back into English to double check the accuracy of the translation.

3.5.3 Enumerator training

Teams of supervisors and enumerators were hired in each country through an official recruitment process overseen by IFAD. Interested parties had to submit their application and candidates were selected based on experience, educational background, and the proposed cost. The number of enumerators varied per country, but usually averaged 12 (3 teams of 4 enumerators with one supervisor per team). Two additional enumerators were trained as reserve data collectors in each country, to allow for a replacement in case of need.

The study lead (author of this thesis) prepared a field manual to help the enumerators during data collection. Instructions were written for each survey question which included the questions' purpose and additional directions as needed. The field manual for enumerators was reviewed with the enumerators during the training sessions and can be found in Annex 2. In addition to the enumerator manual, a manual with MPAT definitions (Annex 3) and a supervisor manual were prepared (Annex 4). The enumerator trainings in each country ran for three days and were followed by one day of piloting. A review session took place at the end of the piloting day to reflect on unexpected challenges, possible solutions and to respond to any questions that enumerators had. The training covered MPAT and its purpose, the role of the enumerator, enumerator professionalism, interview skills, ethics, confidentiality, field

logistics and schedules, and how to gain the trust of respondents as well as overcome obstacles in interviews.

3.5.4 Ethics

Anonymity, confidentiality, and data security of participants was ensured so that the information that they provided could not be traced tracked back to them in any form of dissemination. Before the start of each survey, the respondent was assured of the anonymous nature of the survey and data processing. The participants had the opportunity to withdraw the information provided after being interviewed if they chose to. An informative text before the questionnaire communicated the practices concerning the respondents' data treatment and their voluntary participation in the study (included in the Enumerator Field Manual, Annex 2, p. 197).

This study is based on data collected in accordance with The University of Reading's Research Ethics Guidelines and the official IFAD and United Nations regulations, details of which can be found in Annex 5.

3.5.5 Sampling

The samples of households in each country were defined using a stratified random sampling technique. The first stage involved the selection of villages using systematic random sampling from a list of villages obtained from the Bureau of Statistics (BoS) in each respective country. This proved to be one of the most challenging steps with the reluctance of Government departments to share the census data for a variety of reasons (upcoming elections, request for payment, etc.). To manage this challenge, the latest publicly available census data were used.

To manage enumerator schedules and to cover as many villages as possible, the target was to select 20 households per village. In cases where the total population of a selected

village was less than 20 households, the nearest village was selected to complete the targeted 20 households.

The second stage in the sampling process regarded the selection of the households in each village. Household listings within a village were largely inexistent and therefore this was conducted by employing a random walk method. Each village was divided into 4 clusters (approximately equal in size) with the aim of selecting 5 households from each cluster. The selection of households was done using the following steps:

1. The team supervisor would count the number of households within each cluster or ask the village leader for the number of households

2. Numbers were written on pieces of paper (1-n), mixed together, and a piece of paper was chosen blindly.

3. The supervisors would then walk to the household that corresponded to the number. For example, if the number 5 was chosen, the supervisors would walk past the first four households and stop at the 5^{th} household to assign an enumerator with an interview. This would then be identified as the 1^{st} household in the village.

4. The supervisor would then select another number from the mix, hypothetically the number 3, and walk past the two closest households in order to identify the next household for an interview, now known as household number 2.

5. The process continued until the required number of households had been visited. However, in few cases where the number of households in the village was less than 20, all the households were interviewed without applying the random walk method.

Table 3.3 below presents the number of households that were interviewed in each country, and then the number of households that were used for the analysis after cleaning the data.

Table 3.3: Data collected for this study

Country	Year data collected	No. of Households surveyed	No. of Households used in data analysis	Location of survey
Eswatini	2018	1200	1,198	National
Kenya	2017	1002	996	3 sub-catchments of the upper Tana River in parts of 7 counties (Murang'a, Nyeri, Laikipia, Nyandarua, Kiambu, Kirinyaga, Embu)
Lesotho	2017	1320	1,292	National
Tanzania	2019	850	846	28 villages in 5 districts (Nzega, Magu, Mkalama, Kondoa, Micheweni)
Zimbabwe	2018	1000	990	4 provinces (Manicaland, Midland, Mat South, and Masvingo)
Totals		**5376**	**5,322**	

3.6 Data quality checking

Data collection was obtained through hired enumerators rather than by the study lead (author of this thesis) for three main reasons. First, interviews needed to be conducted in the local languages, which the study lead does not speak, second, due to time constraints, the study lead could not conduct all 5000+ interviews herself, and lastly, it was important to avoid the influence that a foreign researcher might have on the responses. It was of the utmost importance that respondents felt comfortable, and responding to an enumerator from their country was more likely to put them at ease.

During the trainings, the presence of the study lead was discussed and enumerators always expressed their concern that my presence, as a foreigner, might intimidate respondents and influence their answers. I therefore did not conduct any interviews personally, but I was present on the piloting days, and reachable throughout the data collection period by phone.

When a household was selected, the field supervisor, with the help of village elders, made introductions to the household member. Eligible respondents had to be household

members at least 18 years old and spend at least 9 months of the year in the household. Enumerators collected all data for the household survey using Android tablets. The average interview time was 50 minutes.

The field supervisors conducted quality checking surveys for 10% of all interviews done the previous day using an abbreviated version of the survey instrument. Every day, the two field supervisors uploaded the survey data from each enumerator and the quality check surveys. Every evening, the study lead would download the data collected that evening, and would run data quality checks. An example of a standard check was on the negative events portion of the questionnaire. Enumerators could enter up to three events that the respondent was worried about, starting with the one they worried about the most. Later questions asked about likelihood and severity of the events. If entered correctly, the likelihood and severity of an event entered second or third should not both be higher than for an earlier entered event. As an indication of the level of issues that were identified, during the data collection period in Kenya, the research lead found errors in 34 interviews (3.4% of all the interviews conducted).

When answers appeared inconsistent, the research lead would communicate the outliers, errors, and other suspicious data to the field supervisors for corrections. The field supervisors met with the enumerators every day to review field results, communicate my feedback and the next day's activities. A copy of the data quality checking procedures can be found in Annex 6.

3.7 Data analysis

The data collected was downloaded from the Survey Solutions cloud in tabular format and prepared for analysis. As mentioned above, the first step in the data analysis was done by an automated excel spreadsheet which comes with the MPAT tool, and is freely available online (IFAD, 2014). Different data analyses were then used for each Chapter and include i.) Descriptive statistical analyses to examine the frequencies of key variables, such as

household characteristics and levels of resilience to various shocks; ii.) Logistic regressions to evaluate associations between predictor variables (such as socio-economic characteristics) and the likelihood that households access climate information; iii.) Generalized linear regressions (Poisson family); iv.) ANOVA (Analysis of Variance) to compare the MPAT scores across countries and determine significant differences in the mean scores of various components such as food security and resilience; and v.) Bonferroni Post-hoc Analysis (applied after ANOVA) to analyse differences by country while minimizing the chance of false positives. These analyses are described in more detail under the respective methods sections (Section 4.2, Section 5.2 and Section 5.3).

4. Chapter Four: Perceptions of Poverty: Comparing global development indicators and MPAT derived country rankings in East and Southern Africa

4.1 Introduction

Indicators within poverty assessments and measurements play a strong role in informing policy making, ensuring effective resource allocation, and enabling monitoring and evaluation of development initiatives (Singh et al., 2012). They help to highlight inequalities and facilitate global comparisons, but as described in Chapter Three (section 3.4), they often oversimplify poverty's complexity.

Different dimensions of poverty include economic poverty (such as a lack of income and resources for sustainable livelihoods) (D'Attoma, 2023; Ellis, 1984; Zulkifli, 2023) social poverty (limited access to education, healthcare, and social services) (Ferreira et al., 2005; Khan, 2001; Ozmusl, 2013), political poverty (characterized by a lack of participation in decision-making processes and civil rights) (Gilbert, 2015), legal poverty (involving inadequate legal protection and access to justice) (Greene, 2018), psychological poverty (feelings of powerlessness, dependency, and low self-esteem) (Knifton & Inglis, 2020; Macintyre et al., 2018) and environmental poverty (living in areas with poor environmental conditions and exposure to hazards) (Rentschler, 2023).

While poverty and well-being are recognized as multidimensional, there's debate on whether these dimensions should be aggregated into a single index. Indicator systems face criticism for not effectively showing cause-effect relationships and sometimes redundantly representing aspects (Patten, 2006; Pissourios, 2013). Effective indicator selection requires well-defined criteria to avoid compromised analyses. Rural poverty assessments often produce either narrow, sector-specific data or overly detailed, unmanageable datasets. The

MPAT aims to balance standardization and contextualization by measuring 11 core dimensions of rural poverty, providing relevant data for various stakeholders.

Rather than defining and measuring the quality of life that the rural poor may strive to obtain, MPAT assesses the overall environment within which people live, their access to information, support, and services, and their general state of well-being across a number of dimensions. MPAT theoretical rationale is based largely on the Basic Needs framework (Streeten, 1984; Streeten & Burki, 1978), as well Sen's work on the importance of enabling people as both the means and the ends of 'development' (Sen, 2000, 2005), and findings from other poverty-focused researchers (Narayan et al., 2009). Central to MPAT's development is the idea that income (or economic growth), even if accurately measured, does not provide a reliable proxy measure of poverty and that a multidimensional assessment is needed (Bourguignon & Chakravarty, 2003; Cohen, 2010; Hicks & Streeten, 1979; IFAD, 2014; Streeten, 1984). Each of MPAT's subcomponents includes an analysis of the level of quality and reliability (or availability) of the dimension, as well as people's access to it. MPAT's intention is not to rank households, regions or countries but rather to capture the perceptions of respondents and identify which dimensions of poverty are more likely to require attention.

Numerous well-known indicators are currently used to inform needs assessments and policy making in the area of development and poverty reduction. Indicators such as the Human Development Index (HDI), Gross National Income (GNI), Global Hunger Index Scores (GHI) and the UNDP Gender Inequality Index (GII) are also the products of significant conceptualization by experts in respective fields and have been subject to much reflection, revision, criticism and adjustments.

This paper examines trade-offs between the depth of information and the practicality of obtaining it by exploring whether MPAT can be employed as a sufficiently useful complement to existing global indices. We also assess whether participatory and perception-

based data from MPAT offers a means to interpret results and rankings from commonly used global development indices, while at the same time using those global indices to assess the potential generalizability of MPAT data. This research aimed to answer the following five questions:

i.) How do the perceptions of rural households, as captured by MPAT, align with the rankings and results from global development indices like HDI, GNI, GHI, and GII?

ii.) Which thematic combinations of MPAT components and subcomponents are most effective in supplementing the existing global indices?

iii.) Can MPAT be used as a complement to existing global indices to provide a more comprehensive understanding of poverty?

The overarching goal is not to add to the extensive body of literature on the shortcomings of development indicators (e.g. see Kovacevic, 2010 for a compendium of critiques on the HDI), but rather to compare commonly used existing global indicators with values and country rankings derived from MPAT data collected in five countries in East and Southern Africa.

4.2 Methods

4.2.1 Distributions of MPAT scores and variability between and among countries

As a first step, an overview of how rural households in five countries across East and Southern Africa (Eswatini, Kenya, Lesotho, Tanzania, Zimbabwe) report various aspects of their wellbeing and access to services based on MPAT's 11 components is presented. As described in Chapter Three, data was collected from 5322 households and the MPAT automated excel spreadsheet was used to generate scores. To visualize distributions of MPAT components scores, a simple ANOVA one-way was run which allows for the simultaneous comparison of multiple countries and to determine if there are significant differences in the mean scores of various components. By calculating F-values and p-values, the ANOVA test helped to identify which MPAT components show statistically significant differences among

the countries. The ANOVA test also provided insights into the variability within each country and between countries.

This was then followed by a post-hoc analysis using a Bonferroni test to test differences by country and ensure that the likelihood of making type I errors (false positives) was minimized while identifying specific country differences. The Bonferroni correction was applied to control the family-wise error rate by dividing the desired significance level by the number of comparisons. Pairwise comparisons were performed between all possible pairs of countries, calculating the differences in means, confidence intervals, and p-values. These p-values were adjusted using the Bonferroni correction and compared to the new significance level to determine which differences are statistically significant.

4.2.2 Developing comparable indicators

To evaluate how MPAT components align with the rankings and results from global development indices like HDI, GNI, GHI, and GII, comparable indicators from MPAT were developed to facilitate comparisons with global indices. For instance, MPAT's Farm Assets and Non-Farm Assets components were combined to represent a proxy for income, similar to GNI. Below each global indicator is described and how it compares with MPAT, including a note on the advantages and disadvantages. The rankings of countries based on MPAT data were then compared with their rankings based on HDI, GNI, GHI, and GII, assessing the extent to which MPAT subcomponent and component data reflected findings from these global indicators.

The Human Development Index (HDI)

The HDI (UNDP, 2023b) is a widely used tool for quantifying development; the HDI emphasizes that people and their capabilities are the ultimate criteria for assessing development, rather than focusing solely on economic growth. The HDI is composed of normalized indices for each of three dimensions: i.) Health - assessed by life expectancy at

birth; ii.) Education - measured by mean of years of schooling for adults above 25 years and expected years of schooling for children of school entering age; and iii.) Standard of living - measured by GNI per capita. These three indices are then aggregated into a composite index using a geometric mean.

Since its development, innumerable studies exist on the construction of the HDI, it use and its shortcomings (e.g. Herrero et al., 2012; Mazumdar, 2003; Morse, 2003; Ranis et al., 2006). In addition to this, the HDI has also been used in a variety of thematic studies to characterize and measure changes in the quality of life of certain populations. To date, it is the most widely used complex indicator for international comparisons and assessments of the achieved development level of a particular country or region (Boban et al., 2020) in all areas, ranging from health (e.g. Amin, 2020) to energy (Ray et al., 2016), trade (Davies, 2006) and so on.

The HDI differs from MPAT in that it comprises three components, whereas MPAT includes eleven. Additionally, HDI addresses both rural and urban poverty, while MPAT specifically focuses on rural poverty. HDI focuses on overall human development across countries, using life expectancy, education, and GNI per capita. It's simple and widely recognized but doesn't account for inequalities or local disparities. In contrast, MPAT assesses rural poverty at the household and village level, considering health, education, housing, food security, social capital, vulnerability, and empowerment. While MPAT provides a comprehensive and localized picture of poverty, it's more complex and less suitable for international comparisons. Both tools have unique strengths: HDI is ideal for broad comparisons, whereas MPAT offers detailed insights for community-level planning and evaluation.

Reflecting on HDI's three building blocks, a comparable MPAT indicator to HDI was created by aggregating 4 MPAT components: Farm Assets, Non-farm Assets, Education, and

Health & Health Care. Each of the 4 MPAT components are composed of subcomponents. For Farm Assets, this includes i.) Land Tenure, ii.) Land Quality, iii.) Crop Inputs and iv.) Livestock/Aquaculture inputs. For Non-Farm Assets, this includes i.) Employment and Skills, ii.) Financial Services, and iii.) Fixed Assets and Remittances. The Education component is composed of i.) Quality of, ii.) Availability of, and iii.) Access to Education. The Health & Health Care subcomponents include i.) Health Status, ii.) Access & Affordability, and iii.) Healthcare Quality. Within this calculation, the Assets & Non-Farm Assets components were combined into one score to represent a proxy for standard of living, similar to that of the GNI. The choice of these components was inspired by the three dimensions of human development (income, health, and education) presented in the HDI.

The Gross National Income (GNI)

The Gross Domestic Product (GDP) (the monetary value of final goods and services produced in a country in a given period of time) is typically the most commonly accepted measure for a country's economic performance. However, increasing importance is given to the Gross National Income (GNI) as a better measure for the financial resources available to a country's population (Capelli & Vaggi, 2013). A wide range of studies in various research domains (health, economics, etc.) use the GNI as the indicator for income status of a country and its effect on demographic trends (e.g. Jalal, 2016; Savoldi et al., 2019).

It is now more widely recognized that material living standards are more closely associated with national income (GNI) rather than with national production (GDP) (in times of depreciation for example, production can expand while income decreases) (Stiglitz et al., 2009). Moreover, the GNI is considered a better indicator as it captures the incomes related to the mobility of factors of production (e.g. wages earned by cross-border worker) (Capelli & Vaggi, 2013). The Gross National Income (GNI) is calculated by taking a country's GDP, adding net receipts from abroad and subtracting subsidies on production.

The GNI differs from MPAT in that it measures the total income earned by a country's residents, including both domestic and international earnings, making it a key economic indicator for assessing a country's economic strength and facilitating international comparisons. However, it focuses solely on economic income and may not reflect income distribution or local disparities. In contrast, MPAT assesses rural poverty at the household and village level, considering multiple dimensions such as health, education, housing, food security, social capital, vulnerability, and empowerment.

As discussed above, a comparable MPAT indicator to GNI was created by aggregating the Farm Assets and Non-Farm Asset component scores as a proxy to represent income. These two components include the following subcomponents: Farm Assets i.) Land Tenure, ii.) Land Quality, iii.) Crop Inputs and iv.) Livestock/Aquaculture inputs and Non Farm Assets i.) Employment and Skills, ii.) Financial Services and iii.) Fixed Assets and Remittances.

The Global Hunger Index (GHI)

The GHI, developed by International Food Policy Research Institute (IFPRI) is a composite index formed by aggregating three equally weighted indicators: i.) Proportion of population undernourished as a percentage of the population; ii.) Prevalence of underweight children under five years of age, and iii.) Under-five mortality rate (Wiesmann, 2006).

Data for the child mortality and undernourishment components come from the United Nations International Children's Emergency Fund (UNICEF) and the Food and Agriculture Organisation (FAO), respectively. The child underweight component of the index originates from 3 sources: i.) The World Health Organisation (WHO) global database on child growth and malnutrition, ii.) Demographic and health survey data; and iii.) UNICEF's multiple indicator cluster survey reports. Countries are ranked on a 100-point scale, categorized from

'low' to 'extremely alarming' hunger. GHI scores above 10 are considered serious, scores greater than 20 are alarming and scores beyond 30 are extremely alarming (GHI, 2023).

The GHI has been applied widely in studies to determine the impact of an event, a change, a policy, etc. on levels of hunger. For example, Mansoor et al. (2022) investigate the impact of droughts on hunger and how biotechnological interventions could be a solution whilst Rawat et al. (2020) investigate the impact of COVID-19 on hunger levels in the world.

The GHI differs from MPAT in that it specifically targets hunger and malnutrition and measures this component in great detail. In contrast, MPAT relies on a few survey questions rather than detailed health and nutritional data. This means that while MPAT provides a wide-ranging view of poverty with an additional ten dimensions, it does not delve as deeply into the specific aspects of hunger and malnutrition as the GHI does.

The MPAT Food & Nutrition Security component was then used to compare with the Hunger Index Scores. MPAT's Food & Nutrition Security component is composed of three subcomponents; i.) Consumption; ii.) Access Stability; and iii.) Nutrition Quality.

The UNDP Gender Inequality Index (GII)

The Gender Inequality Index (GII), developed by the United Nations Development Programme (UNDP, 2023a) is a composite measure of gender-based disadvantage in three dimensions: i.) Reproductive health; ii.) Female empowerment and iii.) Labour market participation (UNDP, 2023a). GII's purpose is to provide a measure of the human development costs of gender equality. The higher the index value, the greater the disparity between women and men and therefore the greater the losses to human development (Barnat et al., 2019).

The GII is widely used in cross-country studies that examine the correlates of gender inequality (e.g. Democracy (Quaiyyum et al., 2022); economic growth (Altuzarra, 2021); globalization (Naveed et al., 2022)).

The GII differs from MPAT in that it specifically targets gender inequalities and measures these components in great detail. In contrast, MPAT relies on a few survey questions rather than detailed gender-related data. This means that while MPAT provides a wide-ranging view of poverty with an additional ten dimensions, it does not delve as deeply into the specific aspects of gender inequality as the GII does.

In order to compare with UNDP Gender Inequality Index scores, the MPAT Gender & Social Equality component was used, which is composed of three gender-focused subcomponents; i.) Access to education; ii.) Access to health care; and iii.) Social Equality.

Table 4.1: MPAT components used to construct indices for comparison with global indicators

Comparison Indicator	MPAT Components used for Comparison
Human Development Index (HDI)	
Decent standard of living (GNI per capita)	Average of Farm Assets and Non-Farm Assets components
Life expectancy at birth	Health and Health Care Component
Education (Expected years of schooling & mean years of schooling)	Education component
Gross National Income (GNI)	Average of Farm Assets and Non-Farm Assets components
Global Hunger Index (GHI)	Food & Nutrition Security component
Gender Inequality Index (GII)	Gender & Social Equality component

4.2.3 Comparing MPAT with Global Indices

To assess the extent to which MPAT subcomponent and component data reflects findings from indicators such as UNDP's HDI and the World Bank's GDP per capita, the ranking of the countries in this sample were compared. Values for the HDI, GNI, GHI and GII were obtained for the same year/s that MPAT surveys were completed in each country.

Bar plots were also generated to compare subcomponent scores of the MPAT Food and Nutrition Security (i.e., nutrition quality, consumption, and access stability) across

countries with the Global Hunger Index (GHI), after inverting GHI country scores to better facilitate comparison (i.e., 100-GHI), as well as to compare the MPAT Gender and Social Equality subcomponent scores (i.e., access to education, access to health care, and social equality) across countries with the Gender Inequality Index (GII). Mean values were calculated for each subcomponent score by country using R, and missing values were excluded from analysis. Calculated mean values were then exported from R to an Excel file, and the respective indices (i.e., 100-GHI and GII) were added to create the bar plots.

4.3 Results

4.3.1 MPAT scores by component

The distributional characteristics of the MPAT components across all five countries, as well as the range of scores are displayed in Table 4.2. The results demonstrate statistically significant differences in the means among countries for all variables assessed, as indicated by very low p-values (all less than 2×10^{-16}). The F-values, which measure the ratio of variance between the groups to variance within the groups, are notably high across all variables, suggesting substantial variability and significant country-specific influences on each of these components.

The components with the highest MPAT scores (i.e., most optimal) across all five countries, were ‘Food & Nutrition Security’ and ‘Gender & Social Equality’. While both of these components display the highest medians and interquartile ranges out of all 11 components, they also show evidence of high variability over the range of scores. The ‘Food & Nutrition Security’ component shows that Kenya has the highest mean score, indicating better food and nutrition security, while Eswatini has the lowest. This suggests that Kenya’s households perceive their food and nutrition situation more positively compared to those in Eswatini.

The two MPAT components with lower overall scores were the 'Exposure & Resilience to Shocks' and 'Adaptation to Climate Change' (i.e., overall, households in all five countries perceive themselves to be highly exposed to shocks and stresses and to have low resilience and adaptive capacities to adapt to a changing climate). The component on 'Exposure & Resilience Shocks' presents the lowest median score out of all 11 components. 'Adaptation to climate change' showed the highest F-value (1142.298), suggesting extremely strong disparities among countries in their adaptation measures. It is important to note that these indicators are not assessed by any of the four comparison indices in this study: HDI, GNI, GHI, or GII.

Households across all five countries perceive themselves to have low ownership of 'Non-farm Assets' (tv, radio, etc.) This was also the component with the lowest degree of variability and the third lowest median score (after the components on resilience and adaptation).

Table 4.2: Distribution of MPAT scores by component across all five countries

Variable	Kenya 254 Mean (st. dev.)	Lesotho 266 Mean (st. dev.)	Zimbabwe 263 Mean (st. dev.)	Eswatini 268 Mean (st. dev.)	Tanzania 255 Mean (st. dev.)	ANOVA F-value	ANOVA p-value
Food & Nutrition Security	84.28 (18.83)	77.01 (15.37)	83.36 (14.49)	61.43 (21.82)	68.66 (21.42)	302.0942	<2e-16
Domestic Water Supply	67.97 (19.06)	72.89 (15.34)	72.92 (13.81)	55.25 (17.20)	56.86 (16.43)	296.3282	<2e-16
Health & Health Care	58.74 (13.48)	65.83 (14.67)	56.23 (12.24)	62.29 (11.56)	55.08 (13.57)	123.9825	<2e-16
Sanitation & Hygiene	68.19 (7.60)	60.30 (17.27)	54.48 (16.82)	51.59 (15.98)	52.74 (16.69)	204.0293	<2e-16
Housing, Clothing & Energy	62.93 (14.03)	70.94 (16.61)	56.75 (12.84)	55.04 (18.83)	50.29 (15.16)	281.8611	<2e-16
Education	70.34 (16.85)	81.20 (13.98)	54.92 (19.06)	64.72 (10.47)	54.47 (15.08)	595.7454	<2e-16
Farm Assets	70.72 (15.23)	44.76 (31.20)	69.13 (10.43)	51.26 (19.71)	48.30 (20.52)	344.7457	<2e-16
Non-Farm Assets	53.64 (10.83)	46.43 (10.26)	49.28 (10.77)	46.36 (9.68)	50.03 (9.15)	94.8174	<2e-16
Exposure & Resilience to Shocks	45.49 (17.20)	42.74 (12.45)	53.55 (22.04)	36.64 (13.14)	54.71 (28.61)	164.5762	<2e-16

Gender & Social Equality	86.29 (14.70)	83.30 (14.99)	75.53 (11.99)	87.16 (11.70)	74.69 (18.18)	169.5694	<2e-16
Adaptation to climate change	53.74 (11.27)	38.23 (12.77)	51.48 (10.54)	29.97 (7.74)	54.44 (10.16)	1142.298	<2e-16

The ANOVA results indicated significant differences in all components among the countries. The Bonferroni Post-Hoc tests, which compare the scores pairwise between countries, show significant differences for most comparisons. The full Bonferroni Post-Hoc test results can be found in Annex 9 (22 tables). To demonstrate an example, Table 4.3. and Table 4.4. below display the results for the Food & Nutrition Security Component scores between various pairs of countries.

For each comparison with a statistically significant difference (p-value < 0.05), the confidence interval does not include zero, reinforcing the conclusion that the observed differences in scores are unlikely to be due to random variation. For instance, the comparison between Eswatini and Kenya shows a difference of -22.85 with a confidence interval from -25.02 to -20.68, and a very low p-value of 1.348e-12, indicating a highly reliable and significant difference. Similarly, the comparisons between Eswatini and Tanzania, Lesotho and Kenya, and Lesotho and Tanzania also show significant differences with confidence intervals wholly below zero, suggesting Eswatini and Lesotho have notably lower food security scores compared to Kenya and Tanzania.

On the other hand, the comparison between Zimbabwe and Kenya has a p-value of 0.80 and a confidence interval that includes zero (-3.19, 1.35), suggesting no statistically significant difference in food and nutrition security between these two countries. This aligns with the higher p-value, indicating that any observed difference could well be due to random chance.

Table 4.3 ANOVA Results for Food_Nutrition_Security

Variable	F_value	P_value
Food_Nutrition_Security	302.0942	<2e-16

Table 4.4 Bonferroni Post-Hoc Test Results for Food_Nutrition_Security

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-15.6193009	(-17.98,-13.26)	1.348e-12
263-254	Zimbabwe vs Kenya	-0.9191145	(-3.19,1.35)	0.8034
266-254	Lesotho vs Kenya	-7.2660703	(-9.4,-5.14)	1.400e-12
268-254	Eswatini vs Kenya	-22.8483632	(-25.02,-20.68)	1.348e-12
263-255	Zimbabwe vs Tanzania	14.7001864	(12.33,17.07)	1.348e-12
266-255	Lesotho vs Tanzania	8.3532307	(6.12,10.59)	1.396e-12
268-255	Eswatini vs Tanzania	-7.2290623	(-9.5,-4.96)	1.390e-12
266-263	Lesotho vs Zimbabwe	-6.3469557	(-8.48,-4.21)	1.416e-12
268-263	Eswatini vs Zimbabwe	-21.9292487	(-24.1,-19.76)	1.348e-12
268-266	Eswatini vs Lesotho	-15.5822929	(-17.61,-13.56)	1.348e-12

The full results can be found in Annex 9, but for ease of reference, Table 4.5 below summarises the findings. Overall, the Bonferroni post-hoc analysis revealed significant differences across most components when comparing the five countries. In Food & Nutrition Security and Housing, Clothing, and Energy, all country comparisons were significant, indicating no false positives. For Domestic Water Supply, all comparisons were significant except for “Eswatini vs Tanzania” and “Lesotho vs Zimbabwe.” Health & Health Care and Sanitation & Hygiene both had most comparisons significant, with exceptions for “Zimbabwe vs Tanzania” and “Eswatini vs Tanzania.” In the areas of Education, Farm Assets, and Non-Farm Assets, most comparisons were significant, except for a few pairings like “Zimbabwe vs Kenya” and “Eswatini vs Lesotho.” Exposure Resilience to Shocks and Gender Social Equality also showed significant differences, with only “Zimbabwe vs Tanzania” and “Eswatini vs Kenya” comparisons showing no significance. Lastly, Adaptation to Climate Change showed significant differences except for “Tanzania vs Kenya.” These results highlight the varying levels of resource access, resilience, and socio-economic conditions across countries, with significant country-specific disparities.

Table 4.5. General findings of Bonferroni Test

Component	Finding
Food & Nutrition Security	All comparisons have p-values much smaller than the adjusted significance level, indicating no false positives.
Domestic Water Supply	All comparisons except “Eswatini vs Tanzania” (p = 0.1895) and “Lesotho vs Zimbabwe” (p = 1.0000) are significant.
Health & Health Care	All comparisons except “Zimbabwe vs Tanzania” (p = 0.3346029) are significant.
Sanitation & Hygiene	All comparisons except “Zimbabwe vs Tanzania” (p = 0.1107493) and “Eswatini vs Tanzania” (p = 0.4591888) are significant.
Housing, Clothing, and Energy	All comparisons are significant, indicating no false positives.
Education	All comparisons except “Zimbabwe vs Tanzania” (p = 0.9724) are significant.
Farm Assets	All comparisons except “Zimbabwe vs Kenya” (p = 0.461614) are significant.
Non-Farm Assets	All comparisons except “Zimbabwe vs Tanzania” (p = 0.5088) and “Eswatini vs Lesotho” (p = 0.9998) are significant.
Exposure Resilience to Shocks	All comparisons except “Zimbabwe vs Tanzania” (p = 0.718336) are significant.
Gender Social Equality	All comparisons except “Eswatini vs Kenya” (p = 0.6185) and “Zimbabwe vs Tanzania” (p = 0.7204) are significant.
Adaptation to Climate Change	All comparisons except “Tanzania vs Kenya” (p = 0.637) are significant.

4.3.2 MPAT in the context of other data - relative rankings

To assess whether MPAT data reflect findings from the HDI, GNI, GHI and GII, we compared the ranking of the countries in this sample for all indicators, as shown in Table 4.5.

Table 4.6: MPAT scores compared with other data

Rank	HDI	MPAT: Average of Farm Assets, Non-Farm Assets, & Education, Health & Health Care Scores	GNI per capita	MPAT: Average of Farm Assets & Non-Farm Assets Scores	Hunger Index (GHI)	MPAT: Food & Nutrition Security score	UNDP Gender Inequality Index (GII)	MPAT: Gender & Social Equality Score
1st	Eswatini (0.61)	Lesotho [64.21]	Eswatini (7913.63)	Kenya [62.18]	Kenya (21)	Kenya [84.28]	Kenya (0.52)	Eswatini [87.16]
2nd	Zimbabwe (0.60)	Kenya [63.60]	Kenya (4,126.28)	Zimbabwe [59.20]	Eswatini (22.5)	Zimbabwe [83.36]	Zimbabwe (0.54)	Kenya [86.29]
3rd	Kenya (0.57)	Eswatini [58.61]	Zimbabwe (3864.01)	Tanzania [49.17]	Lesotho (24.1)	Lesotho [77.01]	Lesotho (0.56)	Lesotho [83.30]
4th	Tanzania (0.548)	Zimbabwe [56.74]	Lesotho (3031.41)	Eswatini [48.81]	Tanzania (28.6)	Tanzania [68.66]	Tanzania (0.56)	Zimbabwe [75.53]
5th	Lesotho (0.52)	Tanzania [52.93]	Tanzania (2693.54)	Lesotho [45.59]	Zimbabwe (32.9)	Eswatini [61.43]	Eswatini (0.56)	Tanzania [74.69]
Data Source	(UNDP, 2021)	This study	(World Bank, 2017)	This study	(GHI, 2023; Von Grebmer et al., 2017, 2018, 2019)	This study	(UNDP, 2023a)	This study

The results show that perceptions of food security from the households in this sample align well with the GHI assigned to those countries, as well as perceptions of gender equality with the GII (with the exception of Eswatini and Zimbabwe). It was noted that for comparisons of all indices in general, Eswatini and Zimbabwe did not align well. Were these two countries to be separated from the data set, the scores would align almost perfectly for all indices.

Kenya, Lesotho and Tanzania all ranked the same between the GHI and MPAT-based scores (1st, 3rd and 4th). When looking at the GII and the MPAT scores on Gender and Social equality, the scores also align well with Kenya scoring highly for both (1st & 2nd place), Lesotho being placed 3rd in both, and Tanzania in 4th and 5th place respectively. MPAT comparisons with GNI are also reasonably similar but the same cannot be said for HDI, in

which none of the countries ranked comparably. It was also found that poorer countries (in terms of HDI per capita) had high MPAT scores and richer countries (in terms of higher HDI per capita) had lower MPAT scores which could be an indication of relative deprivation in richer countries.

In terms of consistencies amongst countries, Kenya was the most consistent in comparisons (i.e., always scoring first or second place) and for corresponding MPAT scores. Eswatini and Zimbabwe were the countries that almost always displayed inconsistencies between perceptions (i.e., MPAT) and the four global indices. For example, this sample reported low perceptions of asset ownership and food security in Eswatini, when in fact, the country scored highly in the global indices (HDI, GNI and GHI). On the other hand, households in Eswatini perceived themselves to experience high levels of gender equality while the country had the lowest GII score in this sample. Similarly, Lesotho ranked highest in the MPAT asset score but lowest with its HDI.

Figure 4.1: MPAT Food & Nutrition Security Scores compared with GHI by Country

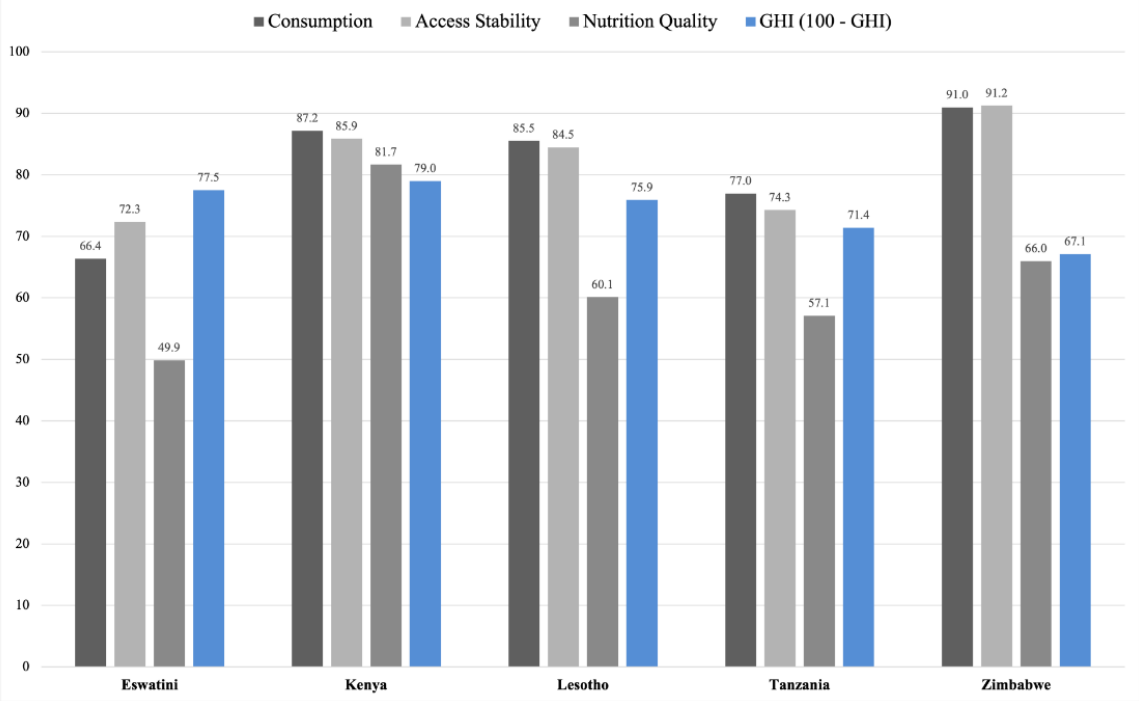
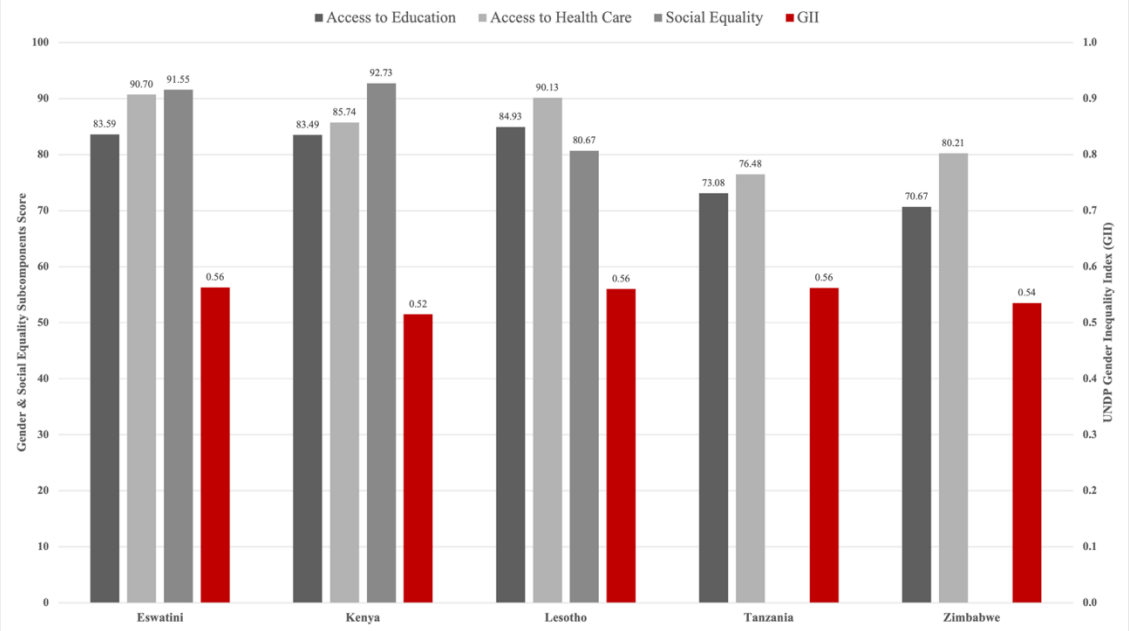


Figure 4.1 shows that MPAT Food and Nutrition Security scores aligned well with the GHI. When this MPAT component was broken down into the three subcomponents (consumption, food access stability, nutrition quality), it was found that nutrition quality systematically lowers the MPAT 'Food & Nutrition Security' score for all countries ('nutrition quality' is not covered by the GHI so this appreciation need not surprise yet adds to the advantages of MPAT). Figure 4.1 also reveals that the subcomponent score with the highest scores for all countries (with the exception of Eswatini) is 'consumption' indicating that households have a good perception of their level of consumption of food.

Figure 4.2: MPAT Gender & Social Equality Subcomponents Scores compared with GII by Country



Note: No data for Social Equality were collected for Zimbabwe and Tanzania given the sensitive nature of the questions and the imminence of governmental elections in the respective countries.

Figure 4.2 shows that households in all five countries perceive that women have better access to health care than to education. Households in Kenya have the highest

perceptions of social equality out of all five countries, which is consistent with the GII ranking.

While the UNDP GII score is the same for Eswatini and Lesotho, households in Eswatini have a better perception of their levels of social equality than households in Lesotho. Table 4.5 had revealed that Eswatini fared the best in terms of MPAT Gender & Social Equality but the worst in terms of ranking for GII within this sample of 5 countries. When breaking down the MPAT subcomponent, it was found that the Social Equality Subcomponent fared particularly well in Eswatini, although this was also the case for the Access to Health Care subcomponent.

4.4 Discussion

When MPAT indicators were compared with global indicators such as the HDI, GHI, GNI and GII, we found there to be reasonable comparisons in the rankings, with the exception of Eswatini. With Eswatini removed, the rankings are far more comparable, as shown in Table 4.6.

Table 4.7: MPAT scores compared with other data after removing Eswatini

Rank	HDI	Average of MPAT Farm Assets, Non-Farm Assets, & Education, Health & Health Care Scores	GNI per capita	Average of MPAT Farm Assets & Non-Farm Assets Scores	Hunger Index (GHI)	MPAT Food & Nutrition Security score	UNDP Gender Inequality Index (GII)	MPAT Gender & Social Equality Score
1st	Zimbabwe (0.60)	Lesotho [64.22]	Kenya (4,126.28)	Kenya [62.18]	Kenya (21)	Kenya [84.28]	Kenya (0.515)	Kenya [86.29]
2nd	Kenya (0.57)	Kenya [63.60]	Zimbabwe (3864.01)	Zimbabwe [59.27]	Lesotho (24.1)	Zimbabwe [83.50]	Zimbabwe (0.54)	Lesotho [83.31]
3rd	Tanzania (0.55)	Zimbabwe [56.85]	Lesotho (3031.41)	Tanzania [49.17]	Tanzania (28.6)	Lesotho [77.00]	Lesotho (0.56)	Zimbabwe [75.45]
4th	Lesotho (0.52)	Tanzania [52.93]	Tanzania (2693.54)	Lesotho [45.62]	Zimbabwe (32.9)	Tanzania [68.66]	Tanzania (0.562)	Tanzania [74.69]
Data Source	(UNDP, 2021)	This study	(World Bank, 2017)	This study	(GHI, 2023; Von Grebmer et al., 2017, 2018, 2019)	This study	(UNDP, 2023a)	This study

Despite the fact that rankings using these indicators appear broadly similar, there are important underlying differences beyond the metrics used for comparison. Perhaps most importantly, MPAT focuses on rural areas while the other indicators are intended to be nationally representative, and include data from both rural and urban areas. With regard to the comparisons, two of the datasets were national (Eswatini and Lesotho), but while Lesotho compared well with most indicators (GHI, GNI and GII), Eswatini almost always ranked the polar opposite.

A related key factor is sample size. Interestingly, of the five countries in this dataset, Kenya tracked best with existing global indices, despite being too small of a sample to be considered representative of the country (3 out of 8 provinces, and only rural households). As the sample of households from Eswatini was national, it would have been expected that those rankings would be more likely to align with other indices. It was assumed that the fact

that the other global indices included urban households could account for such large differences. However, 76% of Eswatini's population is rural (Table 3.31) - the highest proportion in this sample of countries- and hence this may not explain the divergence in rankings. More broadly, the data used to inform MPAT and to inform the HDI, GNI, GHI and GII are very different. In the following sections the results by indicator are discussed and explored further.

The Bonferroni post-hoc test results indicate that for most components, the comparisons show significant differences, with p-values much smaller than the adjusted significance level, suggesting no false positives. However, there are a few exceptions where no significant differences were found, and these were most often between Zimbabwe and Tanzania. In cases where the p-values are much smaller than the adjusted significance level, as seen for Food & Nutrition Security and Housing, Clothing, and Energy, all country comparisons showed very significant differences.

4.4.1 Comparing MPAT and the HDI

The HDI rankings and the rankings for MPAT's equivalent of the HDI compared the least well (along with the GNI). Lesotho for example, ranked worst with HDI, but best with MPAT. This could be explained by the fact that HDI presents averages and, as a result, conceals disparities in distribution of human development in the overall population. In the MPAT sample, on the other hand, the disparities between the households are likely to be smaller (i.e., only rural households) despite also being an average (albeit based on geometric averages). For a better comparison, one approach would be to calculate separate HDIs for urban and rural populations and then compare the rural population results with MPAT scores.

4.4.2 Comparing MPAT and the GNI

Comparing GNI ranking and the ranking of the MPAT equivalent of the GNI, fared the least well, alongside the HDI comparison. The only two countries that were fairly comparable were Kenya and Zimbabwe, ranking amongst the top three for both indicators.

The difference in rankings can be explained in part by the issue of relative wellbeing, when a household perceives itself to be well off when the households that surround it have the same level of income/wealth. Another reason that might explain the disparity in the rankings is that the GNI may be underestimated in lower-income economies that have more informal subsistence activities as well as unilateral transfers (foreign aid and remittances, for example). If data on informal subsistence activities, foreign aid, and movement of people, were to be gathered and we notice that the level of subsistence activities and unilateral transfers are highest in Tanzania or Lesotho (the two countries with the lowest rankings for GNI in Table 4.5); then this might explain why the rankings do not match.

In addition, household income and consumption should also reflect in-kind services provided by governments, such as subsidized health care and educational services, which MPAT does help to capture (by asking how affordable health care and education is) but the GNI does not.

4.4.3 Comparing MPAT & GHI

The results show that perceptions of food security from the households in this sample align well with the GHI assigned to those countries. Kenya, Lesotho and Tanzania all ranked the same between the GHI and MPAT score (1st, 3rd and 4th). Eswatini and Zimbabwe, however, did not compare well. Similarly, to the discussion on GNI above, this discrepancy in rankings between MPAT and GHI might be attributable to the idea of relative poverty where households consider themselves food insecure only if they eat less than their counterparts.

Moreover, the GHI uses equal weightings whereas the (standardized) MPAT is based on expert weightings for its subcomponents on access, stability and nutrition quality. One of the GHI's indicators, the proportion of population undernourished is not a prevalence indicator derived from individuals' food consumption data, but rather a macro-economic indicator derived from *per-capita* food availability. MPAT, on the contrary, separates food consumption and availability. One thing to note is that both the GHI and MPAT fail to capture potential inequitable distributions and access to food within households.

4.4.4 Comparing MPAT & GII

Gender refers to the context specific, socially constructed attributes, opportunities, roles and relationships that are given to women and men, girls and boys (UN Women, 2023). The results show that perceptions of gender equality (MPAT) compare well with the GII (with the exception of Eswatini and Zimbabwe). Table 4.6 had revealed that Eswatini fared the best in terms of MPAT Gender & Social Equality but the worst in terms of ranking for GII within this sample of 5 countries.

The difference may be accounted for by the fact that the two indicators (GII and MPAT) do not measure the same thing. For example, it was found that when breaking down the MPAT subcomponent, the 'Social equality' subcomponent fared particularly well in Eswatini (Figure 4.2). This subcomponent applies to more than gender (e.g., an MPAT survey question for this subcomponent asks whether the respondent feels that all groups have equal opportunities). Moreover, the GII focuses on three domains not directly covered by MPAT: reproductive health, female empowerment, and labour market participation.

4.4.5 Limitations

Table 4.6 shows that MPAT encompasses and aggregates components and subcomponents closely related to all four major global indices covered in these analyses, however these indicators were, of course, not designed with the intention of being directly

compared, and thus this is a broader limitation of this overall analysis. Our analysis was also limited to comparison for score rankings for only these five countries, similar analyses with MPAT data from other countries would help further elucidate the degree to which these MPAT-derived indicators are comparable to the HDI, GHI, GNI and GII. As discussed above, the use of data from rural and urban areas for the HDI, GHI, GNI and GII would be expected to skew comparisons with the rural-focused MPAT indicators. Access to HDI, GHI, GNI and GII data disaggregated by rural and urban areas within these countries was not available, and therefore a more nuanced, rural-focused, comparative analysis could not be conducted.

4.5 Conclusions

Poverty is relative, multidimensional, complex, and deeply embedded in local and broader culture, history, politics, and geography. Measuring multiple dimensions of poverty is important, but even for multidimensional poverty indices it is important to question how much, and what, single, aggregated, values can reveal about poverty or wellbeing in a location. No consensus exists for what constitutes development, let alone how to achieve sufficiently levels of development; it is not surprising then that alternative understandings of concepts and processes in the development discourse lead to different frameworks and indicators for understanding and attempting to measure poverty.

MPAT, as well as the HDI, GHI, GNI and GII, are indicators of course, but more broadly they reflect statements about the means and goals of rural development and poverty reduction and are shaped by the socio-political and other predilections of their creators. Indeed, the framing of development and poverty reduction metrics in certain ways favours different poverty reduction priorities and strategies over others. When our measurements are flawed, and by nature of the complexity of poverty they inevitably are, the decisions that we

make based on resulting data are necessarily distorted. More simply put, our findings add to the evidence that *what we measure affects what we do* (Stiglitz et al., 2009).

Overall, these analyses demonstrate that MPAT has the potential to be used as a complement to existing indices and to render macro data for policy action into locally applicable micro data that can more accurately inform targeting and poverty reduction project management in specific domains. With regard to country-level development and poverty related comparisons, these findings demonstrate how the choice to use a particular tool or indicator can influence our understanding of relative levels of development or poverty.

5. Chapter Five: Climate information access and use among rural smallholder farming households: A multidimensional poverty-based analysis in East & Southern Africa

5.1 Introduction

5.1.1 Climate change risks

Climate variability and change disproportionately affect households across the world, with regions of major exposure often coinciding with a high prevalence of poverty and food insecurity. The adverse impacts of climate change and variability on crop yields, livestock and on fisheries are strongest in areas in which food security is already weak (Vermeulen, 2014). The Intergovernmental Panel on Climate Change (IPCC, 2012) notes that increasing temperatures in Africa impact people's health and livelihoods through several ways: (i) unpredictable precipitation patterns, leading to more extreme and less predictable rainfall; (ii) extreme weather events such as heat waves, tropical cyclones, heavy rainfall, floods, wildfires, and droughts; and (iii) rising sea levels.

Considering the significant influence of weather and climate on agricultural production, extensive research has been conducted to examine the relationship between these factors and African agriculture (Calzadilla et al., 2014; Knox et al., 2012; Kotir, 2011; Schlenker & Lobell, 2010; Ziervogel et al., 2014). The effects of climate change in Sub-Saharan Africa on smallholder farmers (and in particular, Eswatini, Lesotho, Kenya, Tanzania and Zimbabwe for the purpose of this study) have been studied extensively and corroborated. These include prolonged droughts (Ibrahim et al., 2022; Kamara et al., 2023), rising temperatures (Adenuga et al., 2021; Serdeczny et al., 2017), and extreme weather events such as flooding (Muller et al., 2014; Ngoran, 2015). In turn, these events have led to numerous negative consequences such as crop failures in Kenya and Eswatini, locust outbreaks due to heavy rains creating conducive conditions in Tanzania and decreases in

production due to extreme heat in Zimbabwe and Lesotho (WMO, 2020). The challenges and risks associated with climate change are largely similar across all five countries, as are the adaptive strategies employed. Common adaptive practices are observed in the five countries, reflecting shared vulnerabilities such as drought, water scarcity, and reliance on rain-fed agriculture. The following paragraphs provide specific examples of the challenges faced by each country, along with the corresponding adaptive measures employed to mitigate these impacts.

Kenya faces significant climate change impacts, notably in the form of increasing droughts, floods, and rising temperatures. Prolonged droughts, especially in arid and semi-arid regions, have severely affected agriculture, livestock, and water resources. For instance, the 2008-2011 drought caused extensive damage to livelihoods, affecting millions and leading to massive food insecurity (World Bank, 2023). In response to these challenges, mainstreaming climate adaptation into County Integrated Development Plans (CIDPs), has been promoted, focusing on improving water access, conservation, and enhancing livelihoods (World Bank, 2023).

Lesotho is facing pronounced climate change impacts, primarily through increased droughts, heavy rainfall, and other extreme weather events. The country is experiencing hotter, drier conditions, particularly in the lowlands and northern regions, which are exacerbating issues like food insecurity and water scarcity. In response to these challenges, several adaptive strategies are being implemented. Notably, Early Warning Systems (EWS) have been established to help communities anticipate and prepare for climate-related disasters, improving their resilience (UNEP, 2021).

Zimbabwe is experiencing significant climate change impacts, with rising temperatures and increasing variability in rainfall patterns. These changes are contributing to frequent droughts and occasional floods, especially affecting rural areas reliant on rain-fed

agriculture (Dube, 2023). For instance, recent droughts have severely reduced crop yields, leading to food insecurity, while floods have displaced communities and damaged infrastructure. In response, the government has promoted climate-smart agriculture, including the cultivation of drought-tolerant crops like small grains. Investments in water harvesting and irrigation infrastructure are also key strategies to mitigate water scarcity (Dube, 2023).

Eswatini is facing significant climate change challenges, including rising temperatures, unpredictable rainfall, and more frequent extreme weather events like droughts and floods. These changes are particularly affecting agriculture, which is heavily dependent on rain-fed systems, and water resources, leading to water scarcity and food insecurity. Droughts, for example, have left about 25% of the population vulnerable to food and water shortages (World Bank, 2021). To adapt to these changes, Eswatini has implemented several strategies. These include enhancing water resource management through improved irrigation infrastructure and water harvesting techniques to mitigate the effects of droughts (World Bank, 2024).

Tanzania is experiencing notable climate change impacts, including rising temperatures, shifting rainfall patterns, and an increase in extreme weather events such as droughts and floods. These changes are particularly affecting the agricultural sector, which is largely rain-fed and employs the majority of the workforce. To address these challenges, Tanzania is implementing adaptive strategies. The country has embraced ecosystem-based adaptation (EbA), which includes the restoration of ecosystems to strengthen resilience against climate impacts (UNEP, 2023).

5.1.2 Climate information as a tool to manage climate risks

Climate information on temperature and precipitation (historical, monitored and predicted) offers great potential to enable farmers to make informed decisions, manage risk more efficiently, and adapt to climate change. Yet the availability of climate information and

climate information services alone does not guarantee household access and use, nor does it automatically result in an increase in the adoption of adaptive practices (Vaughan et al., 2019).

Rural farm households are faced with multiple concurrent risks (Ansah et al., 2019; Tongruksawattana & Wainaina, 2019) and often make farm management decisions without information on the weather (historical and future scenarios). For example, a study led by Tongruksawattana and Wainaina (2019) Kenyan maize-legume farmers face multiple risks due to climate shocks including drought, crop pests and excessive rainfall. The authors found that these risks influence farmers' decisions to adapt and the specific strategies they employ, such as using improved crop varieties, replanting, selling assets, borrowing, and reducing consumption (Tongruksawattana & Wainaina, 2019).

Research shows that climate information and climate services can support farmers to manage risks, improve their productivity, profitability, and welfare through climate-sensitive agricultural and livelihood decisions (Born et al., 2021; Clarkson et al., 2020, 2021; Coulibaly et al., n.d., 2017; Dessai et al., 2009; Giraldo et al., 2021; Hansen et al., 2022; Tall, Davis, et al., 2014). Seasonal and short-term forecasts, for example, can inform seasonal decisions such as input timing and use, the sowing period, and marketing decisions (Hammer et al., 2001; Hansen et al., 2011; Phillips et al., 2002). In spite of the considerable advances in the provision of timely, accurate, and reliable information and the evidence on the utility of climate information (Hammer et al., 2001; Patt & Gwata, 2002; Phillips et al., 2002), evidence on the value added of climate information in the hands of users remains low (Ouedraogo et al., 2018; Partey et al., 2020; Tall et al., 2018). Climate services have rarely achieved the desired impacts on farmers' resilience to climate variability and change (Clarkson et al., 2022). To increase the potential of climate information generating positive impacts, emphasis is placed on saliency and timeliness (Hansen et al., 2011; Ingram et al.,

2002; O'Brien et al., 2000), the need to understand what the users of the information perceive to be useful (Carr & Onzere, 2018; Carr et al., 2016; Tall, Davis, et al., 2014) and adequately considering farmers' context-specific requirements (Clarkson et al., 2022; Staub & Clarkson, 2021). Climate services also require appropriate two way engagement with users in order to be salient to their needs (Tall et al., 2018). Understanding smallholder farmer needs and priorities is central to understanding why climate information does or does not encourage the uptake of adaptive measures (Hansen, Vaughan, et al., 2019) and forms the purpose of this paper.

Socio-economic characteristics can help understand these needs and priorities. Household and household head characteristics, such as personal experience, access to resources, age (Carr & Owusu-Daaku, 2016; Muema et al., 2018; Oluwatayo, 2019; Partey et al., 2020), gender (Carr & Owusu-Daaku, 2016; Carr et al., 2016; Partey et al., 2020; Tschakert et al., 2010), and education (Waiswa et al., 2007) all have the potential to influence the perceived value of climate information as well as its uptake. Socio-economic characteristics also play a role in the decision-making processes related to climate change. Owusu et al. (2021) found that household heads' likelihood of adopting adaptation measures is significantly affected by household size, perceptions on climate variability, marital status, access to extension services, and TV ownership (Owusu et al., 2021). Similarly, the gender of the household head plays a part, as shown by Bird and Shepherd (2003) who found that livelihood coping strategies for female-headed households (FHH) and male-headed households (MHH) differed in semi-arid Zimbabwe. Moreover, context, such as farm characteristics (Ouedraogo et al., 2018; Partey et al., 2020; Singh et al., 2018), institutional characteristics (Singh et al., 2018; Vaughan & Dessai, 2014), and location-specific factors (Diouf et al., 2019; Roncoli, 2006) shape household decision-making and the likelihood of climate information use.

Some approaches, rather than using the premise that the generators and providers of information know what practices and actions farmers should do, have sought to develop simple decision-making tools and methods that farmers can use to plan and decide what they consider most appropriate for their own individual (and very varied) farms, resources and objectives. Dorward, Clarkson, & Stern (Dorward et al., 2015) have demonstrated that the use of participatory decision-making and planning tools coupled with climate information (historical and predictive) and farmers' own expertise and knowledge, through the PICSA approach (Participatory Integrated Climate Services for Agriculture), has been compellingly effective in supporting farmers to make changes to their practices (Clarkson et al., 2022; Staub & Clarkson, 2021).

5.1.3 Research Objectives

This chapter is concerned primarily with rural livelihoods and the related agricultural practices that they undertake. The core objective of this chapter is to explore the association between socio-economic household characteristics and access to (and use of) climate information. Specifically, it aimed to answer three research questions: (1) What are the sources of climate information that rural households have access to across five East & Southern African countries; (2) What are the socio-economic characteristics of households that have access to climate information; and (3) What are the socio-economic characteristics of households that *use* climate information?

The remainder of this chapter is organized as follows: Section 5.2 details the methods used in this study, including the survey data collection process, the variables considered, and the statistical models employed for analysis. Section 5.3 presents the results, providing an overview of the socio-economic indicators and key household characteristics, followed by a detailed examination of the sources and number of climate information sources accessed by households, and the differences between households with varying food security and health

levels. Section 5.4 discusses the findings in the context of existing literature, highlighting the implications for policy and practice. Finally, Section 5.5 concludes the chapter, summarizing the key insights and suggesting directions for future research.

5.2 Methods

Survey data were collected from 5,322 households across five East & Southern African countries: Eswatini, Lesotho, Kenya, Tanzania, and Zimbabwe from 2017 to 2019 (please see Chapter 3 for the detailed breakdown) and then entered into MPAT's automated excel spreadsheet to obtain MPAT values for each component. R (version 4.1.2) was used to conduct regressions with country dummies, estimated coefficients, z value, LR tests and Pseudo R. to attempt to i.) Identify which types of households access climate information, and ii.) Identify which types of households, of the ones that access climate information, actually use one or more sources of available climate information.

The logistic regression (Table 5.5) was used to evaluate associations between would-be predictor variables and other covariates and the odds (odds ratio) of whether households had access to at least one source of climate information. Logistic regression is particularly suited for modelling scenarios where the dependent variable has two possible outcomes, such as whether a household has access to climate information (yes/no). Unlike linear models, logistic regression is designed for binary outcomes and ensures that the predicted probabilities are constrained between 0 and 1. This is crucial because linear regression can predict values outside this range, leading to non-sensible probabilities, especially near the boundaries at 0 and 1.

Consider a logistic regression model where $P(y_i = 1|x_i) = p_i$ represents the probability of 'access' (yes), and $P(y_i = 0|x_i) = 1 - p_i$ the probability of 'no access.' The logistic model can be expressed as:

$$\text{logit}\,(p_i) = \log\left(\frac{pi}{1-pi}\right) = \beta_0 + \beta_1 x_i$$

Where logit (p_i) is the log-odds of access, and x_i are the predictor variables. The logistic function transforms the linear combination of predictors to ensure the output remains between 0 and 1.

The odds of 'access' are defined as $\frac{pi}{1-pi}$, and the odds ratio for a one-unit increase in x_i is $e^{\beta 1}$, which quantifies the multiplicative change in odds due to the predictor. This model thus offers a non-linear but interpretable way to estimate and understand the impact of predictors on the probability of binary outcomes.

Logistic regression provides results in terms of log odds. To translate these log odds into more interpretable values, they were converted into probabilities using the logistic function $p = \frac{1}{1+ e^{-log\,odds}}$ in Table 5.5. This approach directly shows the likelihood of the outcome occurring for given values of the predictors, offering a more intuitive grasp of the model's implications. The dependent variable is whether a household has access to at least one source of climate information. Presented numbers are the change in the likelihood of the outcome with a one-unit change in the variable.

In order to evaluate variables in an iterative fashion (Cohen et al., 2017), models were built up such that those variables hypothesized to be most important were selected for model 1, and then other variables known or suspected to be associated with the outcomes of interest were added and evaluated in models 2 and 3. With regard to covariate selection, considering access to credit, asset ownership, better levels of health and high levels of food security as proxies for wellbeing, we wanted to see if there was a difference in access and use of climate information between households that are considered better off and those that are not. The following variables were therefore focused on in particular: i.) Ability to afford school fees and school supplies; ii.) Access to credit; iii.) Overall household health; iv.) Food security levels; v.) Source through which climate-related information is accessed; and vi.) Total

number of sources of climate information households have access to. Table 5.1 below describes each variable used in the analysis.

Table 5.1. Description of variables

Variable	Description
Food Consumption	The variable 'food consumption' quantifies household food consumption on a scale from 0 to 100. It integrates responses to two questions: "During the last 12 months, did any member of your household eat fewer meals or smaller portions than usual due to insufficient food?" and "During the last 12 months, did any member of your household go to sleep at night hungry?" This metric provides a measure of a household's food consumption status, reflecting the extent of food adequacy or scarcity experienced.
Food Nutrition Quality	The variable 'food nutrition quality' quantifies household food nutrition quality on a scale from 0 to 100. It integrates responses to seven questions related to food nutrition. This metric provides a measure of the nutritional quality of food consumed within a household.
Exposure Degree	The variable 'exposure degree' quantifies a household's exposure to negative natural or socio-economic events on a scale from 0 to 100. It integrates responses to five questions related to the frequency and effect of negative events.
Coping Ability	The variable 'coping ability' quantifies a household's coping strategies to negative natural or socio-economic events on a scale from 0 to 100. It measures the ways in which a household would like to cope with negative events.
Recovery Ability	The variable 'recovery ability' quantifies a household's ability to recover from negative natural or socio-economic events on a scale from 0 to 100. It integrates responses to three questions related to the time and social network needed for recovery.
Water Availability	The variable 'water availability' quantifies household's water availability status on a scale from 0 to 100. It integrates responses to two questions: "During the last 12 months, for how many months was your household's main source of water sufficient to meet your household's drinking and cooking needs?" and "How often do you worry there will not be enough water from your household's main water source to satisfy your household's drinking and cooking needs?" This metric assesses the reliability and adequacy of water resources for essential household uses.
Water Access	The variable 'water access' quantifies household's access to water on a scale from 0 to 100. It integrates responses to two questions: "During most of the year, approximately how much time (in minutes) does it take your household to collect enough water for your household's drinking and cooking needs for a normal (average) day?" and "Can your household usually afford to pay the fees (direct payments only, not maintenance fees) for using water from your household's main water source?" This metric evaluates both the physical accessibility and economic affordability of water.
Water Quality	The variable 'water quality' quantifies the quality of water used by households on a scale from 0 to 100. It is derived from responses to three questions concerning the sources of water, methods of water treatment, and the perceived quality of water used for household purposes.
Health Affordability	The variable 'health affordability' quantifies the accessibility and affordability of the nearest health centre to a household on a scale from 0 to 100. It integrates responses to three questions that assess the time required to reach the nearest health centre and the associated healthcare fees.

Health Status	The variable 'health status' quantifies the overall health status of household members on a scale from 0 to 100. It is derived from responses to three questions focused on the incidence of illness among household members over the last 12 months.
Health Quality	The variable 'health quality' quantifies the quality of healthcare provided for a household on a scale from 0 to 100. It integrates responses to five questions related to the medical supplies provided by a health centre.
Head of HH's age	The variable "head of HH's age" is a numeric variable for households that indicated the age of the household head.
Head of HH is female	The variable "head of HH is female" is a variable for households that indicated that the head of the household is male (=1) as opposed to the head is female (=2).
Observed historic weather changes (Q81)	The variable "observed historic weather changes" is a binary for households that indicated that they have observed changes in the weather over the last 15 years (=1) as opposed to households that say they haven't noticed any changes (=0).
Can afford school (Q6)	The variable "can afford school" is a binary for households that indicated that they can afford children's school fees and school supplies (=1) as opposed to households that say they can't afford school fees or school supplies (=0).
Long term Land Ownership (Q51)	The variable "long term land ownership" is a binary for households that indicated that they have long term ownership of their land (=1) as opposed to households that don't (=0).
Access to credit (Q66)	The variable "access to credit" is a binary for households that indicated that they are able to borrow money from a bank or other financial service provider (not including friends or relatives) (=1) as opposed to households that are unable to borrow (=0).
Lease out land (Q39b)	The variable "lease out land" is a binary for households that indicated that their land is leased out to other households (=1) as opposed to households that don't (=0).
Has another income source (Q65)	The variable "has another income source" is a binary for households that indicated that someone in their household provided others a skilled service (for example, equipment repair, tailoring, construction work) for money or barter (=1) as opposed to households that say no one in their household has provided such service (=0).
In debt (Q67)	The variable "in debt" is a binary for households that indicated that they're currently in debt from any lender including family and friends (=1) as opposed to households that say they're not in debt (=0).

For those households with access to at least one source of climate information, a generalized linear regression model was used (Table 5.6) with a log link (Poisson family) and the same model covariates where the outcome variable was a count variable for the number of accessible climate information sources households reported to actually use, if any. In the regression analysis, country dummies were used to examine differences across five countries (Table 5.6). Dummy variables were used to capture country effects when analysing the access and use of climate information among smallholder farmers across different countries rather than conducting a separate regression analysis per country. This is because separate

regressions would provide insights only at the individual country level. However, using country dummies within a single regression model allowed for a comparison across the five countries while controlling for country-specific effects. Compared with a regression per country, the dummy approach is more efficient for three reasons: i.) it combines all the data into one model, increasing statistical power; ii.) it enables the identification of country-specific influences while also comparing these effects across countries; and iii.) it avoids the risk of model overfitting or inefficiency that could arise when analysing smaller, country-specific datasets individually.

Only four country dummies appear in the model instead of five. This is because including a dummy variable for each country would lead to multicollinearity, a statistical issue where one variable can be perfectly predicted from the others. To avoid this and ensure the model remains statistically valid, one country is omitted as the baseline or reference group. The coefficients of the included country dummies then reflect the difference in the outcome variable for those countries compared to the baseline country (in this case, Kenya).

5.3 Results

5.3.1 Overview, socio-economic indicators, and key household characteristics

General socio-economic characteristics of rural households across East & Southern Africa are presented in Table 5.2. Across this sample, men are predominantly the head of households, with only 32.8% of households being female headed. The proportion of female-headed households ranges from 23.9% (Tanzania) to 40.6% (Lesotho) and the average age of the household head ranges between 50 and 56 years across the five countries.

In terms of food security, Zimbabwe has the highest percentage of households with high food security (75.2%), while Eswatini has the lowest (22.2%). Zimbabwe also has the highest percentage of households able to afford school fees (26.1%), while Eswatini has the lowest (5.5%). Female-headed households also show lower percentages in this category.

Access to credit remains low, with only 32.9% of households across the sample believing they could borrow money if needed. The question asked is not about whether there is a direct possibility to borrow money, but if the respondent perceives themselves as being able to borrow money. Although the existence of financial institutions may affect this response, the answers do not reflect the availability of these institutions, but rather the perceived freedom to acquire credit if a household member wanted to. This perception varies widely, with Kenya having the highest confidence (61.8%) and Eswatini the lowest (17.4%) (Table 5.2). Female-headed households are less likely to perceive themselves as able to borrow money (23.0%) compared to male-headed households (Table 5.2).

Table 5.2: Socio-economic characteristics of rural households in five East & Southern Africa countries

	Eswatini	Kenya	Lesotho	Tanzania	Zimbabwe	All
Sample size	1198	996	1292	846	990	5322
% Female HoHH	39.0%	24.7%	40.6%	23.9%	30.6%	32.8%
Average HoHH Age (SD)	54.7 (14.5)	56.4 (15.7)	55.1 (16.7)	50.1 (15.4)	55.6 (15.2)	54.5 (15.7)
% of HHs with high levels of Food Security (Score above median (80.4))	22.2%	70.7%	48.2%	39%	75.2%	50%
% of HHs with ability to borrow money (if desired)	18.5%	61.8%	17.4%	31.2%	43.0%	32.9%
% of F HoHH with ability to borrow money (if desired)	16.7%	45.1%	10.5%	27.2%	33.7%	23.0%
% of HHs able to afford school	5.5%	23.6%	15.3%	17.6%	26.1%	17.0%
% of F HoHH able to afford school	4.7%	15.9%	13.7%	13.9%	17.8%	12.3%

Notes: HoHH = Head of household; F = Female; SD = Standard Deviation

Table 5.3: Comparing characteristics of high food security households with low food security households: Data is presented by top and bottom food security score quartiles

		Eswatini (268)	Kenya (254)	Lesotho (266)	Tanzania (255)	Zimbabwe (263)	All
Total	t-value	80.56	46.03	60.20	54.78	36.97	132.36
	p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
% of female headed HHs	t-value	0.48	-3.83	-3.53	-0.56	-1.74	-5.35
	p-value	0.63	0.00***	0.00***	0.58	0.08	0.00***
Average age of HoHH	t-value	0.14	-3.78	1.64	0.57	-0.54	1.30
	p-value	0.89	0.00***	0.10	0.57	0.59	0.19
% of HHs with ability to borrow money (Q66)	t-value	9.19	8.42	6.78	1.21	5.99	22.31
	p-value	0.00***	0.00***	0.00***	0.23	0.00***	0.00***
% of HHs able to afford school (Q6)	t-value	0.81	4.64	0.29	1.39	0.62	0.31
	p-value	0.42	0.00***	0.77	0.16	0.54	0.75
Average number of sources of climate information (Q78)	t-value	3.68	3.24	4.68	1.76	-0.13	18.85
	p-value	0.00***	0.00**	0.00***	0.08	0.90	0.00***
% of HHs indicating that they use climate information (Q77a)	t-value	-5.53	4.94	-0.83	-1.72	0.87	4.24
	p-value	0.00***	0.00***	0.41	0.09	0.39	0.00***

Notes: Variables with a *, **, and *** are significant at $p < 0.05$, $p< 0.01$, and $p< 0.001$, respectively.

The t-values in Table 5.3 above and Table 5.4 below are the result of the t-test statistic used to determine whether there is a significant difference between the means of the top and bottom quartiles of food security scores and health scores. A larger absolute value of the t-value indicates a greater difference between the means. On the other hand, the p-values indicate the probability of observing the data if the null hypothesis (no difference) were true. As such, smaller p-values suggest stronger evidence against the null hypothesis. The high t-values and very small p-values (0.00***) for total food security scores across all countries indicate significant differences between the means of the top and bottom quartiles.

In Kenya, the results for "% of HHs able to afford school" are statistically significant (t-value = 4.64, p-value = 0.00***), indicating a significant difference in the capacity to afford school fees between the top and bottom quartile food security groups, although the t-test itself does not specify which group is more or less able to afford the fees. Additionally, significant differences in the ability to borrow money are noted in all countries except for Tanzania, highlighting the perceived financial constraints faced by those with lower food security scores across these regions (Table 5.3).

The significant p-values of "Average number of sources of climate information" in Eswatini, Kenya, and Lesotho show that the number of climate information sources used varies significantly between quartiles.

Zimbabwe stands out with 75.2% of households scoring above the median on the food security component while Eswatini has only 22.2% of households scoring above this median (Table 5.2). It is important to note that these results express the household perception of food security and not the anthropometric value used in food security situation analyses.

Table 5.4: Comparing characteristics of households in the top and bottom quartiles of health levels

		Eswatini (268)	Kenya (254)	Lesotho (266)	Tanzania (255)	Zimbabwe (263)	All
Total	t-value	61.19	60.39	67.25	55.03	54.66	137.53
	p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
% of female headed HHs	t-value	-0.17	-3.62	-2.21	-1.26	-2.77	-1.96
	p-value	0.87	0.00***	0.03*	0.21	0.01**	0.05
Average age of HoHH	t-value	-0.07	-2.22	-3.79	-0.82	-4.90	-3.63
	p-value	0.95	0.03*	0.00***	0.41	0.00***	0.00***
% of HHs with ability to borrow money (Q66)	t-value	4.11	4.00	2.30	2.05	3.74***	1.88
	p-value	0.00***	0.00***	0.02*	0.04*	0.00	0.06
% of HHs able to afford school (Q6)	t-value	3.40	4.16	1.06	1.14	0.41	4.46
	p-value	0.00***	0.00***	0.29	0.26	0.68	0.00***
Average number of sources of climate information (Q78)	t-value	1.57	-0.10	1.80	0.89	0.63	-3.73
	p-value	0.12	0.92	0.07	0.37	0.53	0.00***
% of HHs indicating that they use climate information (Q77a)	t-value	-3.12	-0.17	0.71	2.24	-0.29	0.56
	p-value	0.00**	0.87	0.48	0.03*	0.77	0.58

Notes: Variables with a *, **, and *** are significant at p < 0.05, p< 0.01, and p< 0.001, respectively.

Similar to Table 5.3, the high absolute t-values and a very small p-values (0.00***) for “Total” indicate significant differences in health levels between the top and bottom quartiles across all countries in Table 5.4.

There are notable differences in the ability to afford school fees, as evidenced by statistical findings in Kenya (t-value = 4.16, p-value = 0.00***) and overall (t-value = 4.46, p-value = 0.00***). Additionally, significant differences in the ability to borrow money are observed in multiple countries, including Kenya (t-value = 4.00, p-value = 0.00***), Lesotho (t-value = 2.30, p-value = 0.02*), and Tanzania (t-value = 2.05, p-value = 0.04*). The result reveals statistical significance of “Average age of HoHH” in Kenya (t-value = -2.22, p-value = 0.03*), Lesotho (t-value = -3.79, p-value = 0.00***), and Zimbabwe (t-value = -4.90, p-value = 0.00***), indicating variations in age demographics associated with different health statuses of households.

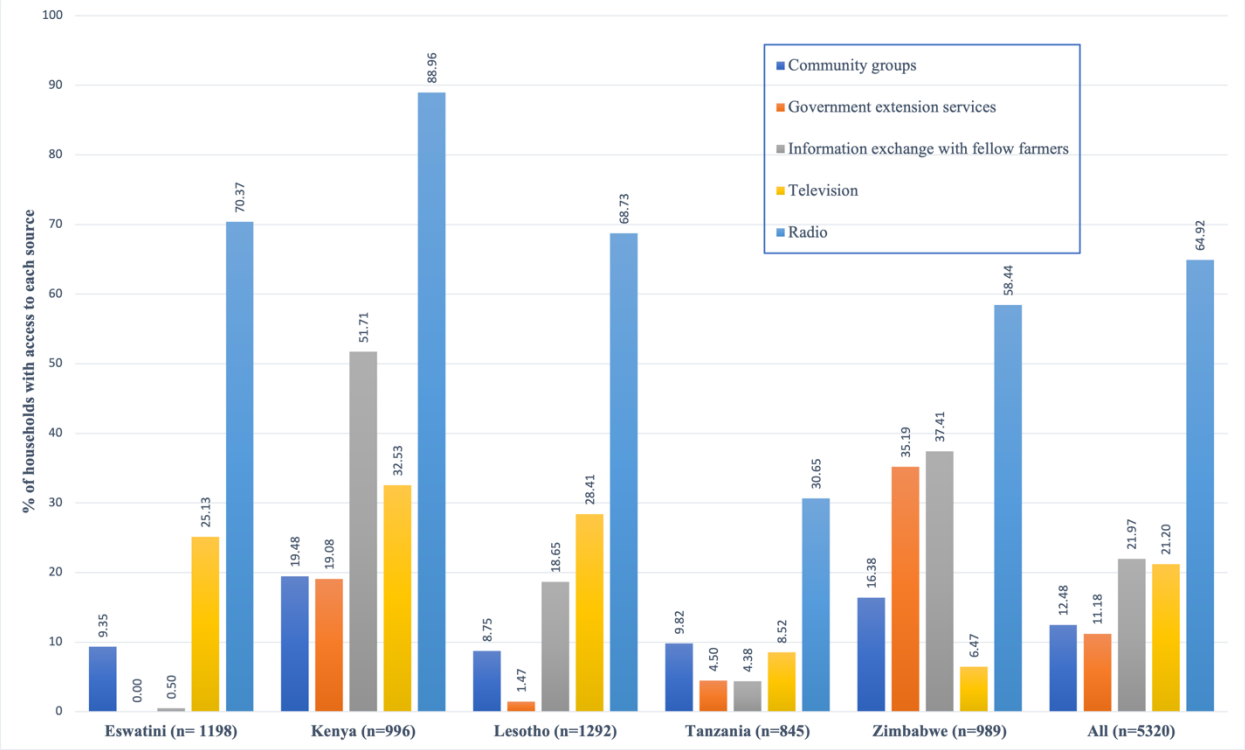
There are statistically significant disparities in using climate information across top and bottom health status households in Eswatini, as shown by a t-value of -3.12 and a p-value less than 0.001, although this trend is not universal across all countries (Table 5.4).

5.3.2 Number and sources of climate information

Figure 5.1 presents the sources of information accessed by households in each country. Overall, 78.5% (4,177) of households reported access to at least one source of climate information; of those with access to information, 85.9% (3,587) reported using the climate information they received in some fashion. Results varied significantly across countries in terms of access and sources of climate information. The average number of climate information sources varied by country between 1 and 3, with households in Kenya accessing the highest number of sources. The most common source of climate information across the region was the radio (64.9%) followed by information exchange with fellow

farmers (22%), television (21.2%) and from community groups (12.5%). It is important to note that high variation for access to climate information via the radio across countries ws observed (e.g., 89% in Kenya compared with 30.7% in Tanzania). 12.6% of households had access to information through extension delivery services (11.2% Government extension and 1.4% private extension).

Figure 5.1: Main sources of information accessed by households in each country



Notes: Survey responses 'Don't Know' and 'None' were excluded. Most households reported having more than one source of information, which is why percentages do not sum to 100% by country.

Table 5.5: Households with and without access to information by country

Country	Access to Climate Information	No Access to Climate Information	Proportion of HHs with access
Kenya	365	20	94.81%
Lesotho	127	27	82.47%
Zimbabwe	603	118	83.63%
Eswatini	314	39	88.95%
Tanzania	166	153	52.04%
All	4177	1144	78.50%

Table 5.6. Characteristics of households with access to climate information

Variables	Model 1	Model 2	Model 3
MPAT Related			
Food Access Stability	0.498** (-2.455)	0.498** (-2.471)	0.497** (-2.445)
Food Consumption	0.502*** (3.131)	0.503*** (3.212)	0.501 (0.853)
Food Nutrition Quality	0.504*** (4.389)	0.505*** (4.447)	0.503* (1.837)
Exposure Degree	0.500 (0.128)	0.500 (-0.105)	0.500 (-0.176)
Coping Ability	0.502*** (2.967)	0.502*** (2.775)	0.502 (1.217)
Recovery Ability	0.502** (2.319)	0.502** (2.495)	0.499 (-0.847)
Water Availability		0.500 (-0.211)	0.499 (-1.275)
Water Access		0.499 (-1.076)	0.500 (-0.161)
Water Quality		0.498*** (-3.243)	0.498** (-2.046)
Health Affordability		0.502** (2.092)	0.503* (1.926)
Health Status		0.501 (1.058)	0.502 (1.410)
Health Quality		0.499* (-1.866)	0.498** (-1.966)
Demographic Indicators			
Head of HH's age		0.499 (-1.062)	0.501 (0.513)
Head of HH is female		0.453* (-1.655)	0.421 (-1.620)
Observed historic weather changes (Q81)	0.614*** (3.590)	0.625*** (3.888)	0.667*** (3.054)
Economic Indicators			
Can afford school (Q6)			0.542 (0.804)
Long term Land Ownership (Q51)	0.694*** (4.713)	0.698*** (4.670)	0.641* (1.649)
Access to credit (Q66)	0.649*** (4.819)	0.643*** (4.481)	0.628*** (2.612)
Lease out land (Q39b)			0.558 (0.510)
Has another income source (Q65)			0.700** (2.055)
In debt (Q67)			0.550 (1.026)
Tanzania	0.204*** (-6.352)	0.197*** (-6.235)	0.183*** (-3.761)
Zimbabwe	0.482 (-0.378)	0.501 (0.016)	0.452 (-0.561)
Lesotho	0.462 (-0.758)	0.492 (-0.150)	0.425 (-0.694)
Eswatini	0.704*** (3.891)	0.718*** (4.002)	0.637 (1.370)
(Intercept)	0.147***	0.223**	0.650

	(-4.232)	(-2.302)	(0.610)
Model Indicator			
AIC	2,552.03	2,500.371	967.804
n	3,316	3,268	1,421
Log Likelihood	-1,262.016	-1,228.186	-457.902
Pseudo R-squared	0.123	0.132	0.158

The coefficients in Table 5.6 represent the change in the probability of the dependent variable (the likelihood that a household has access to at least one source of climate information) associated with a one-unit increase in the predictor variable, holding all other variables constant. t-values are used to determine if a coefficient significantly differs from zero. A larger absolute value of the t-value generally indicates stronger evidence against the null hypothesis (that the coefficient is zero).

The significant positive probabilities across Models 1 and 2, and some in Model 3, suggest that improvements in these variables are associated with a higher probability of households having access to climate information. A coefficient of 0.498** in Model 1 for *Food Access Stability* indicates a roughly 49.8% increase in the probability of having climate information access with each unit increase in food access stability, significant at $p < 0.01$. Similarly, *Food Consumption* shows a positive and significant relationship in Models 1 and 2, with coefficients of 0.502*** and 0.503*** respectively, indicating that better food consumption is associated with higher access to climate information ($p < 0.001$). *Food Nutrition Quality* also has a significant positive impact in Models 1 and 2, with coefficients of 0.504*** and 0.505*** respectively ($p < 0.001$).

Other significant variables include *Coping Ability* and *Recovery Ability*, both showing positive associations with access to climate information. *Coping Ability* has coefficients of 0.502*** in Models 1 and 2 ($p < 0.001$), while *Recovery Ability* has coefficients of 0.502** in Models 1 and 2 ($p < 0.01$). *Water Quality* is another significant factor, with coefficients of 0.498*** in Model 1 and 0.498** in Model 2 ($p < 0.01$).

Health-related variables also play a crucial role. *Health Affordability* shows positive and significant coefficients of 0.502** in Model 1 and 0.503* in Model 2 ($p < 0.05$). *Health Quality* is significant in both Models 1 and 2, with coefficients of 0.499* and 0.498** respectively ($p < 0.05$).

Demographic indicators reveal that households where the head has observed historic weather changes are more likely to access climate information, with significant coefficients of 0.614*** in Model 1, 0.625*** in Model 2, and 0.667*** in Model 3 ($p < 0.001$). Female-headed households show a positive association in Model 1 with a coefficient of 0.453* ($p < 0.05$).

Economic indicators further highlight the importance of financial stability. *Long-term land ownership* is positively associated with access to climate information, with significant coefficients of 0.694*** in Model 1 and 0.698*** in Model 2 ($p < 0.001$). *Access to credit* is also significant, with coefficients of 0.649*** in Model 1 and 0.643*** in Model 2 ($p < 0.001$).

Table 5.7: Access to information. Logistic Regression Statistical Test

	# Df	LogLik	Df	Chisq	Pr (>Chisq)
Model 1	14	-1262.0			
	1	-1438.6	-13	353.22	< 2.2e-16 ***
Model 2	22	-1228.2			
	1	-1415.3	-21	374.22	< 2.2e-16 ***
Model 3	26	-457.90			
	1	-543.84	-25	171.88	< 2.2e-16 ***

Table 5.7 presents the results of logistic regression statistical tests used to evaluate the goodness-of-fit for different models predicting access to climate information by households. The table confirms that as the models become more complex (with more parameters), they fit the data better, as indicated by higher log likelihood values and significant chi-square statistics. For instance, Model 1 has a log likelihood of -1262.0 and a chi-square value of 353.22, Model 2 has -1228.2 and 374.22, and Model 3 has -457.9 and 171.88. The p-values

for all models are less than 0.05, confirming that the improvements in model fit are statistically significant. This suggests that the additional parameters included in the more complex models provide valuable information for predicting access to climate information by households.

5.3.3 Characteristics of households using climate information

Table 5.8: Coefficients for households using climate information sources (Generalized Linear Regression Models)

Variables	Model 1	Model 2	Model 3
MPAT Related			
Food Access Stability	-0.002 (-0.839)	-0.001 (-0.397)	-0.001 (-0.533)
Food Consumption	0.002 (0.935)	0.002 (0.985)	0.003 (1.381)
Food Nutrition Quality	-0.007*** (-2.839)	-0.007*** (-2.791)	-0.007*** (-2.610)
Exposure Degree	0.004** (2.423)	0.004** (2.166)	0.004** (2.091)
Coping Ability	-0.004* (-1.743)	-0.003 (-1.640)	-0.003 (-1.599)
Recovery Ability	0.003* (1.922)	0.003* (1.884)	0.003** (1.991)
Water Availability		0.002 (1.406)	0.002 (1.322)
Water Access		-0.006*** (-4.257)	-0.005*** (-3.836)
Water Quality		0.0001 (0.090)	0.000 (0.014)
Health Affordability		0.004* (1.650)	0.005* (1.913)
Health Status		0.002 (0.911)	0.002 (1.052)
Health Quality		-0.004*** (-2.784)	-0.004*** (-2.829)
Demographic Indicators			
Head of HH's age		-0.000 (-0.040)	-0.000 (-0.158)
Head of HH is female		-0.104 (-1.420)	-0.123* (-1.670)
Observed historic weather changes (Q81)	0.328*** (2.789)	0.349*** (2.959)	0.342*** (2.906)
Economic Indicators			
Can afford school (Q6)			-0.207** (-2.535)
Long term Land Ownership (Q51)	0.384* (1.683)	0.348 (1.534)	0.300 (1.318)
Access to credit (Q66)	0.073 (1.047)	0.043 (0.610)	0.057 (0.798)
Lease out land (Q39b)			0.043 (0.278)

Has another income source (Q65)			0.124 (1.231)
In debt (Q67)			-0.078 (-1.196)
Tanzania	-0.450** (-2.316)	-0.520*** (-2.645)	-0.592*** (-2.990)
Zimbabwe	0.368*** (3.731)	0.213** (1.997)	0.204* (1.899)
Lesotho	0.451*** (3.135)	0.466*** (3.066)	0.471*** (3.074)
Eswatini	-0.346*** (-2.931)	-0.368*** (-3.063)	-0.437*** (-3.569)
(Intercept)	1.729*** (5.027)	1.871*** (4.616)	1.960*** (4.771)
Model Indicator			
n	1,114	1,097	1,097
R2	0.109	0.134	0.141
Adjusted R2	0.098	0.177	0.121
Pseudo R-squared	0.038	0.048	0.051

Across all models, the coefficient of *Food Nutrition Quality* is negative and significant (-0.007*** in Model 1, -0.007*** in Model 2, and -0.007*** in Model 3), indicating that an increase in food nutrition quality is associated with a decrease in the likelihood of using climate information sources (Table 5.8). The consistent significance across models suggests a robust relationship. The significantly negative coefficients of *Water Access* across all models (-0.006*** in Model 2 and -0.005*** in Model 3) indicate that better access to water is associated with a decrease in the use of climate information (Table 5.8). Of the households with access to climate information, households who reported observing past climate-related changes were more likely to actually use climate information, with significant coefficients of 0.328*** in Model 1, 0.349*** in Model 2, and 0.342*** in Model 3 ($p < 0.001$) (Table 5.8).

Other significant variables include *Exposure Degree*, which shows a positive association with the use of climate information, with coefficients of 0.004** in Model 1, 0.004** in Model 2, and 0.004** in Model 3 ($p < 0.01$) (Table 5.6). *Recovery Ability* also has a positive and significant impact, with coefficients of 0.003* in Model 1, 0.003* in Model 2, and 0.003** in Model 3 ($p < 0.05$) (Table 5.6).

Health-related variables play a crucial role as well. *Health Affordability* shows positive and significant coefficients of 0.004* in Model 1 and 0.005* in Model 2 ($p < 0.05$) (Table 5.6). *Health Quality* is significant in both Models 1 and 2, with coefficients of -0.004*** and -0.004*** respectively ($p < 0.001$) (Table 5.7).

Demographic indicators reveal that female-headed households are less likely to use climate information, with a significant negative coefficient of -0.123* in Model 3 ($p < 0.05$) (Table 5.8). The age of the household head does not show significant effects across the models.

Economic indicators highlight the importance of financial stability. The *ability to afford school fees* is negatively associated with the use of climate information, with a significant coefficient of -0.207** in Model 1 ($p < 0.05$) (Table 5.7). *Long-term land ownership* shows a positive association in Model 1 with a coefficient of 0.384* ($p < 0.05$) (Table 5.8).

Table 5.9 below presents the results of logistic regression statistical tests used to evaluate the goodness-of-fit for different models predicting the use of climate information by households. It confirms that as the models become more complex (with more parameters), they fit the data better, as indicated by higher log likelihood values and significant chi-square statistics. The p-values confirm that the improvements in model fit are statistically significant. This suggests that the additional parameters included in the more complex models provide valuable information for predicting the use of climate information by households.

Table 5.9: Use of information. Logistic Regression Statistical Test

	# Df	LogLik	Df	Chisq	Pr (>Chisq)
Model 1	15	-1612.0			
	2	-1676.3	-13	128.54	< 2.2e-16 ***
Model 2	23	-1569.1			
	2	-1647.9	-21	157.7	< 2.2e-16 ***
Model 3	27	-1564.5			
	2	-1647.9	-25	166.93	< 2.2e-16 ***

5.3.4 The country-specific effects

Country-specific effects show that households in Tanzania are more likely to access climate information than households in Kenya, with significant negative coefficients across all models (e.g., 0.204*** in Model 1, $p < 0.001$). Additionally, households in Eswatini are more likely to access climate information than households in Kenya, with a significant positive coefficient of 0.704*** in Model 1 ($p < 0.001$).

In terms of using of climate information, country-specific effects show that households in Tanzania are less likely to use climate information than households in Kenya, with significant negative coefficients across all models (-0.450** in Model 1, -0.520*** in Model 2, and -0.592*** in Model 3) ($p < 0.01$) (Table 5.8). Conversely, households in Zimbabwe are more likely to use climate information than households in Kenya, with significant positive coefficients of 0.368*** in Model 1, 0.213** in Model 2, and 0.204* in Model 3 ($p < 0.05$) (Table 5.7). Households in Lesotho also show a positive association with the use of climate information, with significant coefficients of 0.451*** in Model 1, 0.466*** in Model 2, and 0.471*** in Model 3 ($p < 0.001$) (Table 5.6). This differs for households in Eswatini who are less likely to use climate information than households in Kenya, with significant negative coefficients of -0.346*** in Model 1, -0.368*** in Model 2, and -0.437*** in Model 3 ($p < 0.001$) (Table 5.8).

The results of the country dummy variables reflect how different countries influence the outcome variable relative to a baseline country (in this case, Kenya). The coefficients of the dummy variables show the magnitude and direction of the difference between the baseline country and the other countries. The results of using the country dummy variables revealed significant country-specific differences in access to climate information.

When looking at Lesotho and Zimbabwe, these countries had mixed results. In Zimbabwe, for instance, access was similar to Kenya, but use of information was still lower.

Households in Zimbabwe had a lower likelihood of using climate information compared to Kenya, despite having similar access rates to information. Overall, these results show that the differences in access and use of climate information across countries were largely attributed to country-specific factors rather than other variables.

5.4 Discussion

5.4.1 Access to Climate Information

Significant progress has been made in providing timely and salient climate information to rural communities and in developing adaptation strategies to assist farmers in becoming more resilient to the negative effects of climate change. Despite this progress, climate information has typically been delivered with little attention to how it relates to farmers' experiences (Staub & Clarkson, 2021) with a top-down and technology transfer approach (Brooks, 2013; Carr et al., 2016; Clarkson et al., 2022; Lemos et al., 2012).

At the start of this study, it was predicted that better-off households (higher levels of food security, credit, land ownership, water quality, education, and health) would have greater access to climate information (in part because of their ability to access sources like the radio or the TV). The results showed that households were more likely to have access to climate information if they had high levels of food nutrition quality, food access and consumption, access to credit, long-term land ownership, and experienced high levels of health affordability and quality (Table 5.7).

In general, households with higher food security levels have access to a greater number of climate information sources, with the exception of households in Zimbabwe. This implies that there still exists inequity in exposure to climate information, with households that are generally better off having greater access. This leaves open the possibility that there is a causality between food security and access to climate information that can go both ways.

Households that have access to climate information have a greater possibility to increase their income (e.g., through agricultural decision-making) and/or households that are better off have greater access to climate information because of their increased ability to access information sources (e.g., radio ownership or an ability to move to information hotspots, such as markets).

5.4.2 Use of Climate Information

The idea that climate information can simplify decision-making in agriculture is straightforward in principle but problematic in practice. A myriad of factors influence a household's desire and ability to implement changes. This is demonstrated by the findings where female headed households are more likely to access climate information but less likely to use it. Understanding motives and priorities can help climate information providers meet user needs. Take, for example, a household that is severely preoccupied with the health of one or more of its members. The decisions surrounding the limited resources that rural households have are likely to respond directly to a need to improve individual health (e.g., acquiring medication) rather than act on climate information to, say, invest in a new variety of drought-resistant crops.

Hypothesizing over the characteristics of households that would use climate information is contentious, given the complexities in distinguishing between cause and effect. Would households with high food security levels be more likely to use climate information because they have the means to act on the information? Or are they more food secure because they had used climate information in the past to adopt adaptive strategies? Our analyses did not reveal clear indicators of the causal factors underlying such observations. For example, the results showed that households with higher health affordability (i.e., able to pay medical fees and costs) and quality (i.e., the health services available are better) are more likely to both access and use climate information. Further studies would help shed light on whether increased access to resources (after using climate information to increase production) allowed

households to be able to afford health care, or whether it is because of other underlying factors.

The results showed that households that were more likely to use climate information were those had had observed weather changes in the past, that had land ownership, and had high levels of exposure to shocks and stresses. These findings can help inform the design of climate services and policy so that user groups can be more effectively targeted and supported. For example, if households with long term land ownership are more likely to use climate information, then perhaps climate services need to be coupled with action on land tenure to encourage the adoption of adaptive practices.

5.4.3 Limited capacity to use climate information

The dummy analysis helped to isolate the effects of broader country-specific factors across the different countries, rather than just relying on individual household characteristics. Some household characteristics did have similar effects across all countries, meaning their influence on resilience is consistent regardless of the country. This included land ownership, access to credit, food security and education. This said, our results showed that the baseline probability of resilience is indeed shifted by unobserved, country-specific factors, meaning that even if households share similar characteristics, their resilience may vary depending on the country due to these structural differences.

The results regarding access to credit challenged the researcher's assumptions. One of the key reasons for climate information not being used by some smallholders is the limited capacity to respond to the information (Ncoyini et al., 2022). This limited capacity may come in many forms, for example, lack of workable or effective options, limited access to technologies, and limited access to credit. Access to credit typically means that households have an ability to invest and to explore opportunities to improve agricultural production, yet there was no significant association between households with access to credit in this sample

and their likelihood of using climate information. This could imply that the method of delivery of climate information may be more important than the capacity of the respondents to act on it. On the other hand, the results could be explained by the fact that access to credit is not limited to *access to credit for agricultural purposes in response to climate information*. Households may be utilising credit access for other purposes (such as health, for example). Moreover, credit may be linked to specific agricultural programmes in the regions which may remove the link with climate information.

When a household is highly exposed to climatic shocks and stresses and has long term land ownership (therefore allowing for long-term investments) it is unsurprising that climate information is more likely to be used. This finding supports the IPCC's statement in *Climate Change and Land* that land tenure is a key part land-climate interactions has important implications for policy makers and development practitioners. In 2018, at the time these data were collected, 43.1 billion USD was invested by multi-lateral development banks in climate change mitigation and adaptation, but only a fraction was aimed at increasing land tenure security. Paying increasing attention to factors such as land tenure could have significant impacts on resilience and livelihoods if it encourages the adoption of adaptive practices. For this, however, climate information providers need to work together with National Governments in efforts to improve land tenure security.

In terms of sources of information, it was found that households accessed climate information from between 1 and 3 sources, and that the most common source of climate information across the region is the radio, followed by information exchange with fellow farmers and then by television. There is extensive evidence that extension delivery facilitates information delivery on new technologies and farming practices (Nettle et al., 2017) and on the use of climate information in the adoption of climate change adaptation measures (Antwi-Agyei et al., 2013; Fuhrer et al., 2014; Owusu & Yiridomoh, 2021). Our dataset suggests that

only 11.2% of households have access to information through government extension services, therefore limiting the uptake of information through what is considered one of the most effective sources.

Extension services, however, are not simply a solution in themselves. Attention to the approach that extension services adopt is crucial. Traditionally, extension services have adopted knowledge-based transfer of technology models, where farmers are trained on specific practices (Klerkx et al., 2012) . These, however, have shown to not be as effective (Andersson & D'Souza, 2014) as anticipated. Alternative approaches that consider the complex processes involved in decision-making, innovation and change have proven to be more successful (Klerkx et al., 2012). The Participatory Integrated Climate Services for Agriculture approach (PICSA) is an example of such a method where farmers are considered more as decision-makers rather than beneficiaries of solution providers. PICSA is farmer-centric and engages participants to think about their future livelihood options within the context of seasonal forecasts, historical climate information, and their socio-economic conditions. Farmers who were trained to use individual PICSA tools have reported that they understood them and perceived them to be useful in their planning and decision making. In Haiti for example, farmers shared the tools and/or the information and advice from the PICSA training to an average of eight fellow farmers, a testament to the fact that they understood and valued the approach (Staub & Clarkson, 2021). In this study, respondents were asked whether they used the information or not, but why farmers used or did not use information and what the information was used for was not investigated. Future research would help shed light on the decisions that climate information supports.

5.5 Conclusions

Our study provides evidence that the majority of households regularly accessed at least one source of climate information, primarily via radio. Results from the statistical

models indicate that households with relatively better access to credit and land tenure were more likely to *receive* climate information. Household heads that indicated that they have observed changes in the climate over the past few years are more likely to have access to climate information and to use climate information. Understanding the context in which smallholder farmers live, their needs, their perceptions and *why* certain characteristics (such as access to credit) play a role in the uptake of climate information, is key to climate adaptation policy formulation. By successfully engaging rural communities in the provision, access and use of climate information, smallholder farmers will be empowered to manage their livelihood activities accordingly. If climate information development, dissemination and services are informed by users' characteristics, the likelihood of its uptake and adoption of adaptive practices will be improved, and ultimately serve pathways of sustainable development. Overall, findings from this study offer guidance for improving the targeting and delivery of climate information programmes and policies and indicate that the assumed benefits of climate information provision should be more rigorously evaluated.

6. Chapter Six: Coping and adaptive strategies to climate change related shocks among low-income smallholder households in five East and Southern African countries

6.1 Introduction

East and Southern Africa is a region of the world facing chronic, recurrent food insecurity and is classified as one of the most vulnerable regions to climate change (Field & Barros, 2014). The capacity, or lack thereof, of agricultural systems and smallholder farming households to become resilient and adapt to increasing climate change will determine the global state of their poverty in the future. Climate information includes historical observations, short-term forecasts, and medium- to long-term projections and can improve resilience to climatic shocks when it appropriately informs agricultural and livelihood decision making (Coulibaly et al., 2017; Vaughan et al., 2019). The utility of climate information for smallholder farmers, however, is far from homogenous. Different users (men vs. women, crop vs. livestock farmers), in different contexts, will find climate information to be useful at different times and for different reasons. If the generation, provision, and use of climate information is a means to strengthening smallholder household resilience, it is important to first understand how rural households currently cope with shocks in the context of their respective livelihoods, and more importantly determine their future needs to be able to use climate information more effectively.

Natural resource-dependent smallholder households not only face a disproportionate burden of the negative impacts of climate change (droughts, heat waves, floods, etc.) but they also face a variety of additional shocks, depending on their geographic location (natural resource induced conflict, political instability, etc.). Recurring shocks can have disastrous consequences for the poor (Adger et al., 2003; Linkov & Trump, 2019), leaving households in a constant state of coping with shocks, rather than engaging in proactive adaptive strategies

to build their resilience to future shocks. By resilience, we refer to the idea of maintaining or enhancing existing capabilities and assets in the face of an external shock (Agrawal & Perrin, 2009). Households can only become more resilient when their choice of strategy shifts from coping (i.e. short term responses to survive) to adaption (i.e. the capacity for renewal, reorganization and learning in response to change (Burnham & Ma, 2016; Folke et al., 2010; Folke, 2006; Gbegbelegbe et al., 2018; Thornton & Herrero, 2015).

At the household level, a variety of factors shape the degree of people's resilience to shocks and their levels of adaptive capacity. Household ownership of assets, saved capital and access to credit (e.g. Nelson et al., 2007; Tschakert et al., 2010) as well as previous experiences and perceived capability (Elrick-Barr et al., 2017) have been found to be determinants of capacity. Smallholder farmers use a range of options to cope with and adapt to climate variability and change. Common coping measures include – but are not limited to - selling livestock, migrating, receiving aid, reducing consumption & spending, and selling assets (Kidane et al., 2022). On the other hand, common adaptive strategies include – but are also not limited to- soil & water conservation (Gebrehiwot & van der Veen, 2013; Workalemahu & Dawid, 2021), crop diversification, diversifying income sources, livestock management practices (e.g. culling unproductive animals), etc.

Given their experience with coping with shocks, it is important to identify and to strengthen the existing strategies that smallholder households (households relying primarily on agriculture for subsistence and income and working on less than 2 hectares of land) already use. Exploring the shocks and stresses (hereafter referred to as shocks) that rural households have historically and currently face, as well as the existing strategies they use to deal with such shocks, can serve to inform policy and ensuing action/interventions on how to support rural households and strengthen their capacity to respond in the way that they deem most appropriate for their situation.

A systematic review of farmers' adaptation strategies to climate risks in Africa highlights a wide range of coping and adaptive practices, such as diverse crop varieties and management techniques, water and soil management, financial schemes, migration, and weather services (Magesa et al., 2023). Smallholder households in the countries covered by this study—Kenya, Lesotho, Eswatini, Zimbabwe, and Tanzania—exemplify these strategies, already implementing various coping and adaptive measures. In Kenya, for example, some smallholder farmers cope with climate shocks by selling livestock and migrating to urban areas, while adaptive strategies include climate-smart agriculture and water harvesting (Giliba, 2012; Nguimalet, 2018). In Lesotho, food aid and casual labour are common coping mechanisms, whereas the use of indigenous technology for treating pest and disease, conservation agriculture,, rain water harvest storage for use in dry seasons and soil conservation (Dick Sagoe, 2023). Zimbabwean households cope by reducing meal frequency and borrowing, while also implementing soil water-harvesting techniques, using improved varieties, mulching and planting drought-tolerant crops to help build resilience (Dzvimbo, 2022; Madamobe, 2024). In Tanzania, adaptation methods include the cultivation of early maturing crops, early planting, growing drought-tolerant maize varieties, using precautionary savings, practicing income diversification, and selling assets (Gebre, 2023). Eswatini households implement rainwater harvesting and conservation farming techniques and plant drought tolerant crops (Magesa et al., 2023).

This chapter seeks to answer three research questions: (1) What are the shocks that smallholder households across five East and Southern African countries are most concerned with, and what are their perceived levels of resilience to these shocks? (2) What are the strategies that smallholder households use to recover from shocks? and (3) Is there a meaningful association between household resilience and access to, and use of, climate information? The study objectives are to analyse: (i) associations between household socio-

economic characteristics and their resilience, (ii) the shocks that smallholder households across five East and Southern African countries are most concerned with and their perceived levels of resilience to these shocks, (iii) the strategies that smallholder households use to recover from shocks, and (iv) associations between household coping and adaptive strategies and increases in levels of resilience.

6.2 Methods

Survey data were collected from 5,322 smallholder households across five East & Southern African countries: Eswatini, Lesotho, Kenya, Tanzania, and Zimbabwe using the Multidimensional Poverty Assessment Tool (full explanation of the data collection process is described in Chapter Three). Given that rural households face a variety of challenges which aren't limited to climatic shocks, and that this research aimed to capture perceptions of household vulnerabilities and capabilities, respondents were encouraged to speak about the negative event of their choice and were not limited to climatic events.

The MPAT component on Exposure & Resilience to Shocks measures the household's exposure to natural and socio-economic shocks and its ability to cope and recover from such shocks. This component is a direct response to potential climate change impacts and natural disasters, as well as the impacts of domestic and national conflicts. This said, the assessment is based on an open-ended question, since the goal is to let respondent's convey what they are most worried about (whether it be natural disasters, violence or something else). This component allows them to voice their concerns and fears, and clarifies the degree to which they might cope and recover were such an event or shock to pass.

Table 6.1 below provides a breakdown of the component calculations. Detailed information on the values given to each answer as well as the percentage weight each subcomponent contributes to the overall component (i.e. the expert weighting scheme) can be found in the second part of Annex 7.

Table 6.1: Breakdown of MPAT Component 9

Component 9: Exposure & Resilience to Shocks		
9.1 Degree of Exposure [33%]	**9.2 Coping Ability [34%]**	**Recovery Ability [33%]**
Assesses the severity and likelihood of exposure the household faces from natural and/or socio-economic shocks/hazards.	Assesses the household's ability to cope with natural and/or socio-economic shocks/hazards.	Assesses the household's ability to recover from natural and/or socio-economic shocks/hazards
Question 52. **Of all the possible negative events (natural or socio-economic) that could occur in the next 12 months, and that would have a bad or damaging impact on your household, which 3 are you most worried about? (as far as negative impacts on household members, livelihoods, agriculture, livestock, aquaculture …).**	Question 55. If the worst of the negative events you just mentioned [in question 52] were to occur in the next 12 months, what are the 3 main ways your household would likely react (cope)?	Question 56. If the worst of the negative events you just mentioned [in question 52] were to occur in the next 12 months, how long do you think it would take for your household to return to a satisfactory situation?
Question 53. **For these events, how damaging would each be for your household?**		Question 57. If in an extreme disaster (of any sort) your household's home was completely destroyed, but your family members were not injured, how long would it take for your household to rebuild your home? [35%]
Question 54. **For these events, how likely is it that the event will occur in the next 12 months?**		Question 58. If the worst of the negative events you just mentioned [in question 52] were to occur in the next 12 months, who do you think would be most likely to assist your household?

Data were entered into separate MPAT excel spreadsheets, one per country, and the MPAT tool then automatically assigned numerical values to the survey responses, using MPAT's standardized item valuation and weightings (IFAD, 2014). Once the MPAT scores were generated, descriptive statistical analyses were conducted in R (version 4.0.2) to examine frequencies of each key variable within each country dataset. Linear models were then employed to evaluate the impact of selected variables on the level of resilience. The resilience variable was dichotomized, with resilience scores above the median (43.40) taking

1 (i.e., more resilient) and those below the median (43.40) taking 0 (i.e., less resilient). The median is a measure of central tendency that is less sensitive to outliers compared to the mean. In the context of resilience scores, where there might be extreme values due to specific household circumstances, using the median helps to create a more robust threshold that better represents the "typical" resilience level. By using the median resilience score, households are classified as having either relatively high or relatively low resilience, which can be straightforward for policy makers to interpret and understand.

With regard to covariate selection, we wanted to assess if there was a difference in resilience levels when households had particular socio-economic characteristics. The following variables were focused on in particular: i.) Presence of diversified income sources; ii.) Access to credit; iii.) Asset ownership; iv.) Access to healthcare and v.) Access and use of climate information. Linear regression models were used to evaluate associations between socio-economic characteristics of households and their level of resilience. The resilience score was used as the dependent variable (Exposure & Resilience to Shocks score of above 43.40 meant relatively resilient, and the scores below 43.40 were considered relatively less resilient).

The source of support refers to the person/group/institutions that the respondent identified as the most likely to assist if a shock would occur. These sources were split into three groups: i) Formal (i.e., an insurance company, financial institution, local government, national government, aid organization); ii) Informal (friends, family, relatives, religious institution); iii) Don't Know and No one.

In alignment with the nature of the dependent variable 'resilience,' which was dichotomized, logistic regressions were conducted to suit the binary nature of the variable and avoid the issue of predicted values falling outside the 0-1 range. Probabilities were

calculated from odds ratios of the logistic regressions to provide a straightforward interpretation of how socio-economic characteristics influence household resilience.

6.3 Results

6.3.1 Exposure to shocks and associated indicators

A very small minority of the households in the sample perceive themselves to have high levels of resilience. A wide variability in perceptions of household resilience between countries was noted. 20.1% of households in Tanzania expressed a high-level resilience, while only 1.3% of households in Eswatini felt that they were highly resilient to shocks. In this sample, Kenya had the highest percentage of households indicating that they had high asset ownership (78.7%) as well as the highest proportion of households indicating that they had access to credit (61.8%).

In terms of households perceiving themselves to have high levels of health, this varied significantly across the sample of countries (Table 6.2). A large variability was noted in the percentage of households indicating that they have high levels of health between countries, ranging from 66.9% in Lesotho to 35.2% in Tanzania. Despite the low scores for health in Zimbabwe (36.5%) (i.e., households do not perceive their levels of health and access to health care to be high), it is the country in this sample with the most positive perception of food security levels (75.2% of households consider themselves food secure).

In an open-ended question, households were asked what type of possible negative event (shock or stress) they were most worried about. As mentioned above, the majority of households in this sample indicated that this was a climatic shock (drought, floods, hails, etc.). This was not the case in the sample in Kenya, however, where the majority of households were preoccupied with a health-related shock (42.2%). Households were then asked to list the three main strategies they would adopt in response (in order) and categorized these responses as either ‘coping’ or ‘adaptive’ using Berman et al’s (Berman et al., 2012, p.

91) definition of coping as an ‘immediate response to climate variability, and adaptation as preparation for expected future climate change’.

Irrespective of the type of shock that households faced, the majority adopted coping (60.7%) rather than adaptive strategies as their primary strategy. The most common form of coping strategy was to rely on an aid organisation (Eswatini, 40%) or the National Government (Lesotho, 27.9%) or to sell livestock (Zimbabwe, 30.3% and Tanzania, 17.4%). The most common form of adaptive strategy was income diversification and off farm work demonstrating that households tended to move away from the agricultural sector, rather than investing in different strategies within the sector (planting different crop varieties for example).

In the event of a shock, households were asked who they thought would be most likely to assist. With the exception of Tanzania, where the majority of households responded ‘No one’, the majority of households indicated that the most common source of support they had in the event of a shock was family/relatives (40.25%). When asked about the second most likely source of support, all countries responded ‘no one’, with the exception of households in Tanzania who responded ‘Government’.

Table 6.2: Socio-economic characteristics of rural households in five East & Southern Africa countries

	Eswatini	Kenya	Lesotho	Tanzania	Zimbabwe	All
Sample size (n)	1,198	996	1,292	846	990	5,322
% Female HoHH	39%	24.7%	40.7%	23.9%	30.8%	32.8%
Average HoHH Age (SD)	54.7 (14.5)	56.4 (15.7)	55.1 (16.6)	50.1 (15.4)	55.6 (15.2)	54.5 (15.7)
% of HHs with high levels of resilience	1.3%	10.4%	4.3%	20.1%	4.6%	7.3%
% of households with high levels of asset ownership (Score above median (62.49))	31.1%	78.7%	39.2%	29.8%	75.3%	50%
% of households with high levels access to credit (i.e indicated 'yes' to Q66)	18.5%	61.8%	17.4%	31.2%	43.1%	32.9%
% of households with high levels of health (Score above median (59.82))	59.9%	42.3%	66.9%	35.2%	36.5%	50%
% of households with high levels of food security (Score above median (80.4))	22.2%	70.7%	48.2%	39%	75.2%	50%
% of households that have access to climate information	86.8%	89.9%	77.8%	33.5%	83.1%	76%
Use of climate information	99.1%	78.7%	87.2%	69.9%	91.7%	87.6%
Most common type of shock that households are preoccupied by	Climatic (85.6%)	Health (42.2%)	Climatic (73.6%)	Climatic (42.1%)	Climatic (40.2%)	Climatic (53.1%)
% of households that adopt a coping mechanism in response to a climatic shock (%)	75.3%	62.5%	58.5%	46%	43.7%	60.7%
Most common form of coping mechanism	Rely on aid organizations (40.1%)	Seek medical treatment (34.4%)	Rely on national government (27.9%)	Sell livestock (17.4%)	Sell livestock (30.3%)	Rely on national government (16.4%)
% of households that adopt an adaptive strategy in response to a shock (%)	24.5%	11.6%	43.8%	47.2%	47.8%	33.8%
Most common form of adaptive strategy	Lease out farm (34.1%)	Seek off-farm work (51.6%)	Seek off-farm work (55.2%)	Seek off-farm work (80.7%)	Seek off-farm work (78%)	Seek off-farm work (57.8%)
Most common source of support in the event of a shock	Family/relatives (36.1%)	Family/relatives (41.6%)	Family/relatives (53.2%)	No one (40.5%)	Family/relatives (36.5%)	Family/relatives (40.3%)
Second most common source of support in the event of a shock	No one (32.5%)	No one (23.9%)	No one (27%)	Government (24.7%)	No one (26.6%)	No one (29.2%)

6.3.2 Socio-economic characteristics of households in the sample and their association with levels of household resilience

The results of the linear probability model present the likelihood of a household being classified as highly resilient based on various socio-economic and demographic factors. This classification is grounded in whether a household's resilience score is above or below the median. The occurrence of health-related shocks is associated with a 39.7% probability of increasing household resilience, and this effect is statistically significant with a p-value of 0.027. In contrast, security-related shocks show a higher probability of 55.8% for enhancing resilience, but this association is not statistically significant, with a p-value of 0.537, indicating the effect may not be reliably determined from this data. On the other hand, being preoccupied by security-related shocks does not show a significant association with household resilience (p=0.537).

When comparing households that employ a coping mechanism or an adaptive strategy in response to a shock, it was noted that the use of a coping mechanism in response to a shock is associated with a 43.8% probability of being considered a high resilience household (p=0.047).

The source of support refers to the person/group/institutions that the respondent identified as the most likely to assist if a shock would occur. Our results showed that reliance on social support systems like friends or religious institutions shows a marked increase in resilience. Specifically, relying on friends and religious institutions increases the likelihood of being classified as highly resilient by 25.8% (p=0.000) and 18.6% (p=0.000), respectively. On the other hand, relying on a private institution as the main source of support after a shock does not show a significant association with household resilience (p=0.117) nor does relying on the government (p=0.689).

When looking at households in debt, it was noted that household debt owed to an informal source shows a marginal association with increased resilience (56.2%, p=0.094) whereas household debt owed to a formal source does not show a significant association with household resilience (p=0.330).

Contrary to initial expectations, households having another source of income does not show a significant association with household resilience (p=0.448). This was also the case for households in possession of non-farm assets (p=0.910). Access to healthcare, on the other hand, significantly boosts the probability of a household being classified as highly resilient by 62.2% (p=0.026). Similarly, financial access through formal sources of credit is also a positive contributor, enhancing resilience by 62.9% (p=0.000).

Table 6.3: Model results: Socio-economic characteristics of households in the sample and their association with levels of household resilience

Variables	Coefficients	p-value
Demographic Variables		
Younger HoHH (<30)	0.458	0.608
Older HoHH (>50)	0.462	0.225
Male HoHH	0.539	0.231
Female HoHH	0.000	0.907
Reported Types of Shocks		
Health-related shocks	0.397*	0.027
Security related shocks	0.558	0.537
Climate related shocks	0.393**	0.004
Coping and Adaptation		
Access to healthcare services	0.622*	0.026
Use of a coping mechanism in response to shock	0.438*	0.047
Use of an adaptive strategy in response to shock	NA	NA
Relying on friends as the main source of support after a shock	0.258***	0.000
Relying on a private institution as the main source of support after a shock	0.650	0.117
Relying on the Government as the main source of support after a shock	0.481	0.689
Relying on a religious institution as the main source of support after a shock	0.186***	0.000
Relying on 'other' sources of support	0.307***	0.000
Household has debt (owed to informal source)	0.562	0.094
Household has debt (owed to formal source)	0.419	0.330
Household has another source of income	0.523	0.448
Household has access to formal source of credit	0.629***	0.000
Household possesses non-farm assets	0.488	0.910

(Intercept)	0.582	0.468
Model Indicator		
n	1,315	
Log Likelihood	-843.915	
Pseudo R-squared	0.072	

Notes: Variables with a *, **, and *** are significant at $p < 0.05$, $p< 0.01$, and $p< 0.001$, respectively.

6.3.3 Use of climate information and the association with levels of household resilience

The logistic regression model depicted in Table 6.4 offers analyses on how demographic characteristics, specific climate-related information, and sources of this information influence household resilience, defined as the ability to remain above the median resilience score.

Our results show that older heads of household (>50 years) are slightly more likely to be resilient, with a coefficient of 0.469, although this is marginally significant (p=0.063). In contrast, younger heads of household do not show a statistically significant change in resilience (p=0.662).

In terms of accessing information, the source associated with the greatest increase in resilience was private extension providers, followed by cell phone SMS and community groups (with coefficients of 0.824, 0.739, and 0.660, respectively). Accessing climate information through development NGOs and government extension services and information exchange with fellow farmers was also associated with higher levels of resilience. Information exchange with fellow farmers and broadcasts via television further contribute positively to resilience. Conversely, other sources like the internet, village information centres, the radio, and newspapers do not show a significant impact on resilience.

The use of climate information (forecasts of daily and weekly rainfall, hydrology advisories, extreme event advisories, and advice on crop calendars) showed a significant association with household resilience (p-values of 0.544, 0.958, 0.092, and 0.958, respectively). In addition to that, it was found that households who indicated that they used

forecasts of daily and weekly temperatures were significantly more likely to have high levels of resilience, with a coefficient of 0.374 (p<0.001). The use of climate change projections was also associated with increased resilience, with a coefficient of 0.356 (p=0.001).

Table 6.4: Use of climate information and the association with levels of household resilience

Variables	Coefficients	p-value
Demographic Variables		
Older HoHH (>50)	0.469	0.063
Younger HoHH (18-x yrs)	0.518	0.662
Climate Related Information		
Forecast of daily and weekly rainfall	0.515	0.544
Forecast of daily and weekly temperatures	0.374***	0.000
Hydrology advisory (rise and fall of water level)	0.506	0.958
Extreme event advisories (drought, floods, etc.)	0.429	0.092
Climate change projections	0.356***	0.001
Advice on crop calendar	0.503	0.958
Sources of Climate Related Information		
Private extension providers	0.824***	0.000
Cell phone SMS	0.739***	0.000
Community groups (women, religious, youth...) or farmer associations	0.660**	0.004
Development NGOs	0.715*	0.028
Government extension services	0.716***	0.000
Information exchange with fellow farmers	0.629*	0.023
Village information centres	0.418	0.645
Internet	0.659	0.056
Newspaper/Press	0.609	0.259
Television	0.640*	0.011
Radio	0.577	0.151
(Intercept)	0.378*	0.028
Model Indicator		
n	4,152	
Log Likelihood	-2,792.213	
Pseudo R-squared	0.028	

Notes: Variables with a *, **, and *** are significant at p < 0.05, p< 0.01, and p< 0.001, respectively.

6.4 Discussion

6.4.1 Primary shocks and levels of resilience

Overall, households in this sample were most concerned about climatic shocks, with the exception of households in Kenya where the majority of households indicated that they were worried about health-related shocks. Households in this sample also perceived themselves as having very low levels of resilience. This was defined by how damaging the household perceived the event to be, how likely they perceived the event that they named to occur, and how long it would take for them to recover and return to the situation they were in

prior to the event. Illness, due to its unpredictability and high accompanying direct and indirect costs is known to have major consequence on the stability of consumption of households in rural areas (Asfaw & von Braun, 2004) and poorer (and by extension less resilient, although this could be debated) rural households tend to be more exposed to health shocks than wealthier households (Heltberg & Lund, 2009; Tongruksawattana et al., 2010). It was therefore expected that households with the lowest levels of resilience to be most worried about health-related shocks.

Contrary to initial expectations, households most worried about health-related shocks had the highest levels of resilience compared to households that were more preoccupied by climatic shocks. This leads us to understand that households perceive themselves as able to recover from health-related shocks better than climate shocks. One possible explanation is that responses to climatic shocks might be more multidimensional than responses to health-related shocks which rely primarily on medical expertise. Could this be why a household perceives itself as more resilient to a health-related shock?

Given that income diversification can help to spread risks (Asfaw et al., 2018; Davis et al., 2013), we expected to see from the results that households with diversified sources of income were more likely to have higher levels of resilience. Surprisingly, no significant link could be established in this sample. This could be explained by the fact that decision making processes around income diversification at the household level vary according to a variety of characteristics such as family size, education, asset ownership, existence of markets, access to credit, etc. (Alobo Loison & Bignebat, 2017; Edwards-Jones, 2006; Memon et al., 2020) and the heterogeneity of this sample.

When specific characteristics were looked into, such as access to credit, the results did show that households with access to credit and healthcare were significantly more likely to have higher levels of resilience. This was limited, however, by the extent of the analysis into

all other variables (proximity to a market, asset ownership, etc.). Explanatory variables such as access to credit and location for example have complementarity and could explain why a household chooses to, or not to, engage in income diversification activities. Further research at the individual household level could help understand the simultaneous choice decisions made by farm households and which explanatory variables, such as access to credit, are most likely to have the greatest effect on levels of resilience when they interact with other variables.

6.4.2 Strategies in response to shocks

Regardless of the type of shock that households in this sample faced, the majority adopted coping strategies (relying on external actors and selling assets) rather than adaptive strategies (e.g., seeking other forms of income) as their primary strategy. Those households who did adopt adaptive strategies indicated that they were most likely to move away from the agricultural sector, rather than investing in different strategies within the sector (planting different crop varieties for example). This concurs with the large body of literature (Asfaw et al., 2019; Danso-Abbeam et al., 2020; Thornton et al., 2019; Davis et al., 2009) that already exists on the importance of rural non-farm income in the global south and the determinants of households' choice in engaging in income diversification.

Our results also support existing literature that the adoption of a coping mechanism rather than an adaptive strategy in response to a shock was significantly associated with decreased levels of resilience.

When asked who the households would rely on for support in the event of a shock, the majority of the households in the sample responded family/relatives followed by 'no one'. This is a fundamental finding that needs to be addressed in national plans for development and that demonstrates the role of community in rural settings. Existing literature shows the direct link between shocks and poverty, with shocks leading to persistent poverty of the

already poor (Hallegatte et al., 2020) and their [limited] availability of strategies to respond to shocks. Studies shows that households typically sell assets in order to maintain stable levels of consumption in the event of a shock. Inadequate or missing public safety nets leave households to sacrifice consumption and assets, as shown by these results. To remain resilient, households would need to be able to protect their assets and consumption levels (Asfaw & von Braun, 2004; Cervantes-Godoy et al., 2013; Hansen, Hellin, et al., 2019; Zimmerman & Carter, 2003) and have the ability to rely on formal sources of support. Our results revealed that the households who relied on friends or religious institutions showed a marked decrease in the likelihood of being classified as highly resilient whilst relying on a private institution or the government did not show a significant association with resilience.

6.4.3 The links between household resilience and access and use of climate information

Across the sample of households who had access to climate information, the great majority of households indicated that they used the information. In support of initial expectations, the use of climate information (forecasts of daily and weekly rainfall, hydrology advisories, extreme event advisories and advice on crop calendars) showed a significant association with household resilience.

The source of information associated with the highest levels of resilience was private extension providers, followed by cell phone SMS, and then community groups. Information exchange with fellow farmers and broadcasts via television also contributed positively to resilience. The sources of information that are least associated with high levels of resilience are village information centres and radio, as they do not show a significant impact on resilience. Development NGOs and government extension services, on the other hand, are associated with higher levels of resilience. This supports the wide evidence that extension delivery facilitates information delivery and the use of climate information in the adoption of

climate change adaptation measures (Antwi-Agyei et al., 2013; Fuhrer et al., 2014; Owusu & Yiridomoh, 2021). This said, extension services are not simply a solution in themselves and alternative approaches that consider the complex processes involved in smallholder decision-making and change have proven to be more successful (Klerkx et al., 2012; Singh & Dorward, 2015; Staub & Clarkson, 2021). For example, the Participatory Integrated Climate Services for Agriculture (PICSA) considers farmers as the decision-makers rather than beneficiaries of solution providers (Dorward et al., 2015). The farmer-centric method that PICSA is built on engages participants to think about their future livelihood options within the context of seasonal forecasts, historical climate information, and their socio-economic conditions and has proven to be highly successful in generating positive effects on income, food security, wellbeing, and confidence in smallholders' ability to address climate change and variability (Clarkson et al., 2019, 2021; Giraldo et al., 2021; Staub & Clarkson, 2021).

It is therefore clear that the access to climate information in itself is not simply the key to increasing household resilience, but rather a potential decision-making support tool which is only made effective when it meets farmers' respective needs and options to actually apply desirable changes informed by climate information.

6.4.4 Limitations

Our analyses and interpretation of our findings are subject to a number of limitations. First, whether a household had recently experienced a negative event that they were worried about was not taken into account. Experiencing a recent shock, for example, would have an impact on the respondent's answers in numerous ways. Their memory might be more vivid, for example, and depending on the nature of the shock, the answers could be affected by the emotions attached to the experience. The study also did not capture how many negative events each household might have been faced with in, say, the last 15 years, nor how many of these households face concurrent negative events. Second, the data used in this chapter

derives from a questionnaire that captures respondent perceptions. Although perception-based data is beneficial in various ways, it also makes it difficult to compare households. Lastly, it is important to note that our samples are not representative of these countries and when it comes to climatic shocks, since much depends on the location, exposure, vulnerability and adaptive capacity of each household, which goes beyond the scope of this study.

6.5 Overall findings and significance

Our study showed that the majority of households in our sample were primarily concerned with climatic shocks and have very low levels of resilience. In the event of a shock, households tend to adopt coping strategies rather than adaptive strategies and in general households do not have a formal source of support on which to rely on. Households that adopted adaptive strategies were more likely to more resilient that those who adopted coping strategies.

Although farmers have dealt with the risks to their livelihoods for decades, the lack of support that households perceive to have can result in strategies that sacrifice consumption and assets, ultimately making it more difficult for households to escape poverty. Poverty cannot be strictly equated with vulnerability to shocks, but it strongly limits the ability to respond and recover from them. Even if climate change variability and change are likely to be very similar to village and regional environments, shocks were not the same for all households; context, agency, location, and a variety of factors would still influence a household's ability to respond and recover from it.

Policies that seek to alleviate rural poverty and increase household resilience could be more effective if they understood and recognized both farmers' individual and collective capacity for adjustment and work towards facilitating this constructively. Achieving this necessitates a detailed comprehension of smallholder goals, barriers, decision-making

processes and their interactions and dependencies on their locally operating service institutions (such as religious institutions) towards a better understanding of why households respond to adverse shocks in the way that they currently do. Although it was found that some factors, such as access to credit and climate information are linked to higher levels of resilience, building resilience is a complex process that requires a combination of different variables (financial, technical, social) in order for it to be effective and impactful.

7. Chapter Seven: Key research findings and conclusion

7.1 Introduction

The main objective of this thesis is to contribute to the body of knowledge on ways to improve resilience, food security and well-being of smallholder agricultural communities in Sub-Saharan Africa. Climate information is one of numerous interventions but there remains uncertainty on what more can be done (and how) to enhance its role in supporting smallholder farmers in their decisions around adaptive strategies. Each of the previous chapters focused on related aspects of this research topic and this chapter brings them together to inform the overall research aim. First, the value of the tool on which this research is based, MPAT, was reflected on to verify whether the findings of this research, and in particular the characterization of households, could be comparable to more established tools for policy design (Chapter 4). Second, the socio-economic characteristics of smallholder farmers in East and Southern Africa were explored as well as their current access and use of climate information (chapter 5). This was followed by an exploration of the levels of resilience and shocks that these households face, as well as the types of responses that they currently employ in the aftermath of a shock (chapter 6). The latter two chapters connected to form a discussion on the links between household access and use of climate information and the associations with their levels of resilience. Altogether, Chapter 4, 5 and 6 presented a unique way of furthering our understanding on the links between the contexts in which smallholder farmers live, their characteristics and concerns, and their current coping and adaptive strategies. A better understanding of these links can help strengthen the knowledge base on which policy decisions are made in the development sector.

7.2 Main findings and research contributions

7.2.1 Socio-economic characteristics of smallholder households in the sample

The sample of smallholder households in this study were predominantly headed by men, aged between 50-56 years old. Households with a high food security score were more likely to be able to afford school fees, more likely to be able to access credit if desired, and had access to a larger amount of sources of climate information on average (chapter 5).

Not only did households with higher levels of food security access a larger number of sources of climate information, but they were also associated with higher levels of resilience (chapter 6). In chapter 4 it was found that the data on perceptions of food security from the households in this study's sample align well with the Global Hunger Index (GHI) for each of the respective five countries.

Access to credit typically means that households have an ability to invest and to explore opportunities to improve agricultural production. This study found that access to credit across the region remains low and that households with access to credit were less likely to use climate information (chapter 5) but more likely to have a higher level of resilience (chapter 6).

Contrary to initial expectations, no significant link was found between households with diversified sources of income and high levels of resilience, which goes against the evidence in the literature on the value of income diversification in increasing resilience. A deeper exploration on the specific types of income diversification activities employed by the households in the sample and their sensitivity to a variety of shocks would help establish why this is the case.

7.2.2 Sources of climate information

Chapter 5 revealed that the majority of households had access to at least one source of climate information, and that the average number of sources accessed varied between 1 and

3. In terms of the method of delivery/access to climate information, there is considerable evidence that extension delivery facilitates the use of climate information in the adoption of climate change adaptation measures (Antwi-Agyei et al., 2013; Fuhrer et al., 2014; Owusu & Yiridomoh, 2021) but that a relatively small proportion of farmers actually have access to extension staff, which this study confirms. The most common source of climate information across the region was the radio followed by information exchange with fellow farmers, television, and from community groups. A very small percentage (11.2%) of households had access to information through Government extension delivery services. This said, Chapter 6 revealed that households reporting access to climate information through government extension services were associated with higher levels of resilience.

7.2.3 Access to climate information

The findings in Chapter Five underscore significant inequities in access to climate information, both within and across the surveyed countries. Households that are wealthier and more secure in terms of food, nutrition, credit access, land ownership, and healthcare tend to have better access to climate information. This disparity highlights a critical gap in reaching the most vulnerable populations—poorer households, who are likely to be less resilient to the impacts of climate change due to their limited access to timely and relevant climate information.

Targeting adaptation strategies and interventions based on these findings can significantly enhance their effectiveness. By focusing efforts on improving climate information dissemination among poorer households, policymakers can ensure that the most vulnerable are better equipped to make informed decisions regarding agricultural practices, resource management, and livelihood strategies in the face of climate variability.

The fact that access to climate information correlates with food security also indicates that households with lower food security are doubly disadvantaged. Targeting poorer

households with not just information but integrated support—such as access to credit, training on climate-smart agriculture, and resource-sharing initiatives—can strengthen their resilience.

Lastly, the absence of gender disparity in access to climate information, particularly for female-headed households, suggests that gender-targeted interventions may not be necessary in this context. However, attention should still be given to ensuring that the specific needs of female-headed households are met in other areas of climate adaptation. Overall, these findings emphasize the need for equitable climate information dissemination, particularly for poorer households that are most vulnerable to the impacts of climate change.

7.2.4 Use of climate information

This study found that households that accessed *and used* forecasts of daily and weekly rainfall showed a significant association with household resilience (Chapter 6). Of the households with access to climate information, households who reported observing past climate-related changes were more likely to actually use climate information. This was also true for households with higher food consumption scores. This suggests a potential causality between food security and access to climate information that can go both ways. Households that have access to climate information have a greater possibility to increase their income (e.g. through agricultural decision making) and/or households that are better off have greater access to climate information because of their increased ability to access information sources (e.g. radio ownership or an ability to move to information hot spots such as markets).

Through a combination of the analyses in the various chapters, this study aimed to understand the motives and priorities of climate information 'users' in order to evaluate whether climate information would meet these needs. For example, if a household were to be severely preoccupied with the health of one or more of its members, climate information

might not be considered relevant in that moment. Results in Chapter 5 reveal that households with high health affordability were more likely to both access and use climate information. Given that illness can have severe impacts on household consumption stability in rural areas (Asfaw & von Braun, 2004), it was expected that households with the lowest levels of resilience would be most worried about health related shocks. Contrary to this expectation, chapter 6 revealed that households most worried about health-related shocks had the highest levels of resilience compared to households that were more preoccupied by climatic or security related shocks. Further studies would help shed light on whether increased access to resources (after using climate information to increase production) allowed households to be able to afford health care, or whether it is because households have better health levels that they have the resources and capacity to invest.

7.2.5 Smallholder resilience and responses to shocks

The results in chapter 6 showed that households in this study were most preoccupied by climatic shocks (drought, hail, floods, storms, etc.) followed by health-related shocks. Although there is a wide variability in perceptions of resilience, only a very small minority of smallholder households perceived themselves as having high levels of resilience. Irrespective of the type of shock that households faced, the majority indicated that they adopted coping rather than adaptive strategies as their primary response to a shock. The most common forms of coping strategies were to rely on aid organisations, National Governments, or to sell assets (livestock) and the most common form of adaptive strategies were to diversify income sources and to seek off farm work.

In response to a shock, most smallholder households in the sample relied on informal sources of support such as family or relatives. The results showed that reliance on social support systems like friends or religious institutions shows a marked decrease in resilience as opposed to those who relied on Government assistance. Given that most households in our

sample relied on other sources of support than the Government, this suggests an absence of adequate public safety nets, resulting in households sacrificing consumption and assets (chapter 6). These results support the existing literature on the direct links between shocks and poverty, with shocks leading to persistent poverty of the already poor (Hallegatte et al., 2020) and their [limited] availability of strategies to respond to shocks. To remain resilient, households would need to be able to protect their assets and consumption levels (Asfaw & von Braun, 2004; Cervantes-Godoy et al., 2013; Hansen, Hellin, et al., 2019; Zimmerman & Carter, 2003) and have the ability to rely on formal sources of support. Information like this on the limited existence of formal sources of support is fundamental for national plans for development that need to revise or establish public safety nets to support household resilience.

The dummy analysis helped to isolate the effects of broader country-specific factors across the five countries, rather than just relying on individual household characteristics. The results showed that regardless of the country, land ownership, access to credit, food security and education did have similar effects on resilience. However, it was also found that the baseline probability of resilience was shifted by unobserved, country-specific factors, and therefore even if households share similar characteristics, their resilience may vary depending on the country in which they are located. Therefore, climate information can only be helpful if the specific context of each country, as well as intra-country variations, are taken into account. Broad climate information and adaptation solutions might miss these nuances. To be effective, climate adaptation strategies must be tailored to the local socio-political, economic, and environmental conditions of each country and consider the unique interplay of both household characteristics and country-specific factors, allowing for more precise and practical resilience-building efforts.

7.3 Limitations

The vast majority of studies on climate information access and use are (appropriately) very context and site specific. This makes sense due to the evidence that climate information is more valuable when it appropriately meets a user's context specific needs, but it also limits the ability to identify any trends and patterns across a region. The unique aspect of this study is that the same research questions were applied to five different countries. This said, there is a deep recognition of the limitations posed by the methodological assumptions involved in multi-country comparisons and, therefore, applying a cross-country analysis to factor for differences across each country would have strengthened the study but was not possible due to time and financial constraints.

The analysis and interpretation of the cross-country findings in this study are subject to a number of limitations. First, the samples from each country varied. In Lesotho and Eswatini, the sample was national. In Kenya, Zimbabwe and Tanzania, the samples were specifically linked to particular watersheds/provinces/districts. Moreover, the difference between countries could not be attributed to a certain factor given the different political, socio-economic context in each. Likewise, the timing of the surveys was not the same in each country. As the questionnaire captures respondent perceptions, these views may be affected by the timing of the survey (difference in time since last harvest for example).

Moreover, the research findings are limited because they do not fully account for the nuanced differences within each individual country. While the dummy analysis effectively isolated broader country-specific factors across the five countries studied, the overall research did not dive into the distinct, unobserved characteristics that vary within each country. As a result, the multi country analysis did not identify potential detailed insights into resilience-building at a local level.

The data for this study were collected once in each country which limited the possibility of doing a longitudinal analysis as well as an in-depth analysis of the effect of seasonality. To provide further insights into temporal dynamics of resilience and use of climate information, data collection over several seasonal cycles would be informative. The given timeframe of the fieldwork for a PhD and the financial resources that would be required, however, did not allow for a longitudinal study.

This study was also limited by the extent of the analysis into all variables that are interconnected. Smallholder households do not exist in isolation and their decision-making is enabled and constrained by the environment in which they are situated. Further research on which explanatory variables, such as access to credit, are most likely to have the greatest effect on levels of resilience when they interact with other variables is needed.

The use of the Multidimensional Poverty Assessment Tool offered many advantages but may also have led to some compromise in capturing the complex challenges in climate information use and value. For example, MPAT captures the perceptions of the respondent and not of the household members in general which limits the ability to study any varying intra household perceptions. In-depth interviews and ethnographic studies would have strengthened the study but were not possible due to time and resource constraints.

7.4 Policy implications

7.4.1 Increasing outreach and strengthening extension services to be more farmer-oriented, consultative, inclusive and collaborative

There is extensive evidence that extension delivery facilitates information delivery on new technologies and farming practices (Nettle et al., 2017) and on the use of climate information in the adoption of climate change adaptation measures (Antwi-Agyei et al., 2013; Fuhrer et al., 2014; Owusu & Yiridomoh, 2021). This study found, however, that only a small percentage (11.2%) of households have access to information through government extension

services, thus limiting the uptake of information through what is considered one of the most effective sources. This information could help National Governments revise the outreach of extension services across rural areas.

The existing literature confirms that extension systems which adopt a more farmer-oriented approach and emphasise the importance of mutual learning between different knowledge systems (Dayamba et al., 2018; Wesley & Faminow, 2014) are more effective than traditional top-down approaches. Despite this, evidence indicates that (with the exception of a few approaches such as PICSA) extension systems are still tied to an approach whereby 'scientists' 'deliver' and attempt to embed climate information into the daily lives of smallholder farmers (Vogel et al., 2019).

This study did not analyse in depth the methods adopted by extension services but found (as described in section 7.2.2) that relying on the Government as the main source of support after a shock does not show a significant association with household resilience, suggesting that information might still be 'delivered' by means of a 'transfer of technology' approach. These findings confirm existing evidence that extension services are not simply a solution in themselves and that approaches that consider the complex processes involved in smallholder decision-making are essential to their success (Klerkx et al., 2012; Singh & Dorward, 2015; Staub & Clarkson, 2021). This study endorses the argument that climate information in itself is not the key to increasing household resilience, but rather a potential decision-making support tool which is only made effective when it meets farmers' respective needs and options to actually apply desirable changes informed by climate information.

Such evidence can help to encourage policy makers to revise current extension service approaches and encourage the application of farmer-centric methods, such as PICSA (Dorward et al., 2015) in order to more effectively support rural households.

7.4.2 Improved targeting of climate adaptation interventions

As demonstrated in the literature, the provision of climate information does not systematically lead to its use. Understanding the context in which smallholder farmers live, their needs, perceptions and *why* certain characteristics (such as access to credit) play a role in the use of climate information, is key to climate adaptation policy formulation. If climate information development, dissemination and services are informed by users' characteristics, the likelihood of its uptake and adoption of adaptive practices will be improved, and ultimately serve pathways of sustainable development.

This research found that households who reported observing past climate-related changes were more likely to actually use climate information, as well as households with higher food consumption scores. Climate adaptation strategies can benefit from knowing that farmer perceptions of the changing climate as well as their food security levels will impact the likelihood of the use of climate information. The targeting and the interventions could then be tailored accordingly to meet varying profiles. For example, climate information services could be coupled with approaches that directly support food security.

This study found that female heads of households were significantly less likely to use climate information but more likely to access it. While any cause and effect was not established within this study, it is important that development policies and plans take into account gender considerations when formulating the targeting strategies of climate information and adaptation plans.

Lastly, this study revealed that those who are not traditionally thought of as users of climate information (persons not engaged in agricultural production but who still operate in a rural context for example) should also be engaged in the generation of knowledge about coping, adaptation, and climate resilience. The role of community in rural settings in this study was made clear – the majority of households relied on family or relatives for support

and those households who relied on the wider non-family peer group were more likely to have higher levels of resilience. This suggests that climate information services and approaches should go beyond the smallholder farmer and involve those whom they turn to for support. It also suggests that an appreciation of collective change might be just as important as individual context-specific factors when determining the likelihood of climate information use. Policies that seek to alleviate rural poverty and increase household resilience could be more effective if they understood and recognized both farmer's own and their collective institutional environment's current capacity for adjustment and work towards facilitating this constructively.

7.4.3 Caution when choosing indicators to inform targeting

Poverty is relative, multidimensional and complex, embedded in context, history, politics and geography. Measuring multiple dimensions of poverty is important but we also know how imperative it is to question just how much any one simplified number can reveal about poverty or wellbeing in a location. Despite the fact that MPAT results appeared comparable with some existing indices, there were also conflicting results with other indices, suggesting that the choice in indicator used can influence the status attributed to a country, an individual, a community, etc. Caution is therefore encouraged when choosing the indicators to inform targeting. This study proposes an innovative combination of more rigorous and generalizable assessments (e.g. GHI) with quicker, cheaper and more participatory methods (e.g. MPAT) to better inform targeting and project management in a specific area.

7.5 Concluding remarks

The findings in this study are sobering. There exists inequitable access to climate information, smallholder households do not perceive themselves to have high levels of resilience, coping strategies are employed instead of adaptive strategies and there are no formal sources of support on which smallholder households feel they can rely on in the event

of a shock. By taking a multidimensional approach to research, this study concludes that mainstreaming climate change adaptation in the development discourse is critical, but it should not obscure the other non-climatic stressors (such as health shocks) that smallholder households face.

To successfully support smallholder farmers in becoming more resilient to climate change, a combination of factors need to be considered that are both intrinsic and extrinsic to a household. First, climate information access and use can contribute to building resilience, but this is most successfully achieved through approaches that are participatory, consultative and farmer centric. Second, enabling factors are necessary to capacitate smallholders to adapt, such as asset ownership and access to credit. Lastly, a dependable support network is essential for smallholder farmers to get out of the negative poverty loop of coping with shocks.

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Annex 1: Household Questionnaire

HOUSEHOLD INFORMATION									
Please help me to make a complete list of the people who normally sleep and eat their meals together in this household, starting with the household head, then the immediate family and then the extended family and other household members. Please also include household members who live and work elsewhere during part of the year, but help the household with money.									
I D C O D E	H.1 **START WITH THE HOUSEHOLD HEAD** NAME	H.2 What is the relationship of %rostertitle% to the head of the household? **USE RELATIONSHIP CODING FROM BOX 1 BELOW.**	H.3 What is %rostertitle%'s sex? Male.....1 Female...2	H.4 How old is %rostertitle% in complete years? **IF NOT SURE TRY TO ESTIMATE. IF REALLY NOT SURE ENTER CODE -99**	H.5 AGE BETWEEN 5 AND 14 Is %rostertitle% regularly (almost all days) attending school? No....1 Yes...2	H.6 AGE 15 OR OLDER What is the main activity of %rostertitle%? **USE CODING FROM BOX 2 BELOW**	H.7 In the last 12 months, did %rostertitle% live and sleep in your home for at least 9 months? No.....1 Yes.....2 Don't know...3	H.8 ONLY FOR HEAD What is %rostertitle%'s present marital status? Married....1 Single.....2 Divorced...3 Widowed....4	H.9 ONLY FOR HEAD Can %rostertitle% read a newspaper? No.....1 Yes, with difficulty....2 Yes, without difficulty.3 Don't know.....4
1		1							
2									
3									
4									

5								
6								
7								
8								
9								
10								

BOX 1: RELATIONSHIP CODES	**BOX 2: MAIN ACTIVITY**	H.10	**SELECT THE RESPONDENT FROM THE HOUSEHOLD MEMBER LIST**	**MEMBER ID CODE** _____
Head of the household...1 Wife or husband.....2 Son or daughter.....3 Parent.....4 Other relative.....5 Other non-relative.....6	Farmer/livestock keeper...1 Employee.....2 Household business.....3 Day labourer.....4 Housewife.....5 Student.....6 Other.....99			

EDUCATION	
SKIP TO Q7 IF NO CHILDREN BETWEEN 5 AND 14 5a. Do the children in your household (those between 5 and 14) who regularly attend school travel to school from home on a daily basis?	Yes.....1 No, the children usually live at school..-1 >**Q6**
5. During most of the year, how long does it take, in minutes, for the school-age children (age 5 to 14) in your household to go to school (one-way, by any means: for example, walking, bicycle, scooter, bus)? **WRITE ANSWER IN MINUTES. IF CHILDREN ATTEND MORE THAN 1 SCHOOL, ENUMERATOR TO RECORD THE AVERAGE TIME**	MINUTES _____ **IF THE RESPONDENT IS NOT SURE, TRY TO ESTIMATE. IF REALLY NOT SURE, WRITE "-99"**
6. Can your household afford your children's school fees and school supplies?	No.....1 Rarely.....2 Sometimes.....3 Usually.....4 Yes.....5 Household does not need to pay fees and cannot afford supplies.....6 Household does not need to pay fees, but can afford supplies.....7 Household does not need to pay fees or supply costs.....8 Other (specify).....99
SKIP TO Q8 IF NO GIRLS IN THE HOUSEHOLD 7. What is the highest level of schooling the female children (0 to 14) in your household will likely complete?	No formal education or pre-primary school.....1 Primary school (age 6 or 7 until age 14 or 15).....3 Secondary school (age 14 or 15 until age 18 or 19).4 Technical or vocational school (post primary or secondary school, usually 2 years).....5 College or university (post high school, 3 to 5 years).....6 Advanced degree (Master's, MBA, PhD, etc.).....7 Don't know.....-2
SKIP TO Q9 IF NO BOYS IN THE HOUSEHOLD 8. What is the highest level of schooling the male children (0 to 14) in your household will likely complete?	No formal education or pre-primary.....1 Primary school (age 6 or 7 until age 14 or 15).....3 Secondary school (age 14 or 15 until age 18 or 19).4 Technical or vocational school (post primary or secondary school, usually 2 years).....5 College or university (post high school, 3 to 5 years).....6 Advanced degree (Master's, MBA, PhD, etc.).....7 Don't know.....-2

HEALTH	
9. In the last 12 months, how often have members of your household had a non-serious illness (meaning they were sick, but not so sick they had to rest in bed a full day or more)?	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6
10. In the last 12 months, how often have members of your household been seriously ill (meaning they were so ill that they stayed in bed, or lying down, for 2 or more days)?	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6
11. How much time does it take members of your household to reach the nearest health centre that can diagnose simple illnesses, or treat simple injuries and prescribe basic medicines? **ENTER ANSWER IN MINUTES; IF RESPONDENT IS NOT SURE ENTER "-99"**	MINUTES

11a. Why can't you answer how long it takes to reach the nearest health centre?	No health centre in the area, or centre is too far to travel to.....-2 **>Q14** We don't go because we self-diagnose and self-medicate for simple illnesses..-1 Other (specify).....99
12. How often does this health centre have enough medical supplies to provide adequate health care?	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6
13. How much time does it take for members of your household to reach the nearest health centre that can diagnose and treat complicated or serious illnesses or injuries (can perform surgery)? **ENTER ANSWER IN MINUTES; IF RESPONDENT IS NOT SURE ENTER -99**	MINUTES
13a. Why can't you answer how long it takes to reach the nearest health centre?	No health centre for serious illnesses, or centre too far to reach easily.....-1 Don't know.....-2 Other (specify).....99
14. Can your household afford professional treatment for serious illness or injury?	No.....1 Yes, if money is borrowed.....2 Yes, with much difficulty.....3 Yes, with some difficulty.....4 Yes, because government or employer helps pay for the treatment.....5 Yes, household can afford it.....6
15. For the majority of the households in your village/area, do you think there is a better chance for women or men to receive health care when needed?	Women.....1 Men.....2 About the same...3 Don't know.....4
16. Are the health-care centres in your village/area (within 2 hours distance from your home) usually able to provide women with adequate health care if they seek it?	There are no health-care centres in our village/area.....1 No.....2 Rarely.....3 Sometimes.....4 Often.....5 Always.....6 Yes, but women prefer not to go (for whatever reason).....7 Don't know.....8

HOUSING & FACILITIES	
17. RECORD THE PRIMARY CONSTRUCTION MATERIAL OF THE HOUSING UNIT'S EXTERIOR WALLS **DO NOT ASK THIS QUESTION, ONLY OBSERVE WHILE IN THE HOUSEHOLD. IF NOT POSSIBLE TO SEE OR YOU ARE INTERVIEWING AWAY FROM THE HOUSE, CHOOSE OPTION** "Not possible to observe"	Thin wood.....7 Metal sheeting.....5 Brick (fired/burned).....4 Mud & straw.....10 Stone & mortar.....2 Brick (mud or earth).....9 Cement blocks.....3 Bamboo.....8 Logs or thick wood.....6 Reinforced concrete.....1 Not possible to observe...88 Other (specify).....99
18. RECORD THE PRIMARY CONSTRUCTION MATERIAL OF THE HOUSING UNIT'S MAIN ROOF **DO NOT ASK THIS QUESTION, ONLY OBSERVE WHILE IN THE HOUSEHOLD. IF NOT POSSIBLE TO SEE OR YOU ARE INTERVIEWING AWAY FROM THE HOUSE, CHOOSE OPTION** "Not possible to observe"	Metal sheeting.....4 Straw or reeds.....11 Roofing shingles.....1 Cement or concrete.....5 Thin plastic or fabric....10 Bamboo.....8 Not possible to observe...88 Other (specify).....99

19. Can your home withstand strong winds, severe rain, snow or hail without significant damage?	No.....1 Yes.....2 Yes, with minor damage.....3 Perhaps, but with significant damage likely...4 Little to no extreme weather in this region...5 Don't know.....6
20. What is the primary source of light your home uses when it is dark?	Liquid fuel [petrol, kerosene].....8 Stable voltage electricity from grid [legal or illegal connection].....3 Unstable voltage electricity from grid [legal or illegal connection].....4 Electricity from solar cells, wind turbine or small dam.....6 Electricity from a generator.....5 Gas fuel [from tank or biogas].....7 Candle, paraffin wax or battery-powered source.11 None.....1 Other (specify).....99 Don't know.....13
21. What is the primary fuel source your household uses for cooking?	Wood, sawdust, grass or other natural material.12 Coal or charcoal.....9 Liquid fuel [petrol, kerosene].....8 Gas fuel [from tank or biogas].....7 Stable voltage electricity from grid [legal or illegal connection].....3 Unstable voltage electricity from grid [legal or illegal connection].....4 Electricity from solar cells, wind turbine or small dam.....6 Electricity from a generator.....5 Other (specify).....99 Don't know.....13
22. What is the primary fuel source your household uses for heat?	Coal or charcoal.....9 Wood, sawdust, grass or other natural material.12 Stable voltage electricity from grid [legal or illegal connection].....3 Unstable voltage electricity from grid [legal or illegal connection].....4 Electricity from solar cells, wind turbine or small dam.....6 Electricity from a generator.....5 Heat not needed in region.....2 Gas fuel [from tank or biogas].....7 Liquid fuel [petrol, kerosene].....8 None.....1 Other (specify).....99 Don't know.....13
23a. What type of toilet facility does your household usually use? **ASK PERMISSION TO OBSERVE THE FACILITIES!** **'OPEN' MEANS THERE IS NO STRUCTURE, OR A STRUCTURE WITH NO ROOF. 'ENCLOSED' MEANS THERE IS A STRUCTURE WITH ANY SORT OF ROOF.**	None, open defecation.....1 **>Q25** Open pit.....2 Enclosed pit.....3 Enclosed improved-ventilation pit...4 Enclosed pour-flush.....5 Enclosed flush.....6 Compost or biogas.....7 Other (specify).....99
23b. DID YOU OBSERVE THE FACILITIES?	No....1 Yes...2
23c. Do you share these facilities with other households? If so, with how many other households?	No.....1 Yes, shared with just one other household.....2 Yes, shared with two or more other households...3
24. Over the last 12 months, how often was the toilet usable? (meaning it was working properly or was available to use)	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6

25. What does your household usually do with non-edible food waste/remains (e.g. orange peels, corn cobs, bones, etc.)? **ENUMERATOR TO REMIND RESPONDENT "ALL RESPONSES ARE TREATED CONFIDENTIALLY"**	Feed to pets or guard dogs.....5 Feed to livestock.....4 Compost it.....11 Discard close to a house [within 25 metres].....1 Discard near a house [25 to 75 metres from the house].....2 Discard far from a house [75 metres or more]....3 It is collected regularly within 75 metres of a house [organized garbage collection].....7 It is collected regularly further than 75 metres from a house [organized garbage collection]....13 Other (specify).....99
26. What does your household usually do with non-food waste/garbage?	Burn it.....10 Compost it.....11 Feed to livestock.....4 Discard close to a house [within 25 metres].....1 Discard near a house [25 to 75 metres from the house].....2 Discard far from a house [75 metres or more]....3 It is collected regularly within 75 metres of a house [organized garbage collection].....7 It is collected regularly further than 75 metres from a house [organized garbage collection]....13 Other (specify).....99
27. What does your household usually do with wastewater (for example, from bathing, cleaning, the toilet)?	Discard close to a house [within 25 metres].....1 Discard near a house [25 to 75 metres from the house].....2 Discard far from a house [75 metres or more]....3 Use to water vegetable garden.....9 Put down the drain [piped sewage network].....8 Use to water crops grown for livestock fodder..14 Discard into local waterway or irrigation canal.....15 Other (specify).....99

WASH AND WATER	
28. How many times a week do most members (the majority) of your household clean their teeth? **INCLUDES CHILDREN**	Never.....1 Rarely (less than once a week)...2 1 or 2 days a week.....3 3-5 days a week.....4 Usually once a day.....5 Usually 2 or 3 times a day.....6 Don't know.....7
29. How often do the adults in your household clean their hands before eating a meal? **DOES NOT INCLUDE CHILDREN**	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6
30. How often do the adults in your household clean their hands after defecating? **DOES NOT INCLUDE CHILDREN**	Never.....1 Rarely.....2 Sometimes....3 Often.....4 Always.....5 Don't know...6
31. Do the adults in your household use soap (any kind of soap) when they clean their hands? **DOES NOT INCLUDE CHILDREN**	No.....1 Yes, but very rarely.....2 Yes, but only when guests visit.....3 Yes, after defecating.....4 Yes, before meals.....5 Yes, after defecating and before meals...6 Don't know.....7 Other (specify).....99

32.1 **During the rainy season**, what is the primary source (meaning the source that water comes from immediately before being used) of the water your household uses for drinking and cooking inside the home? **IF THE HOUSEHOLD USES DIFFERENT WATER SOURCES FOR DRINKING AND COOKING, ONLY RECORD THE DRINKING WATER SOURCE**	USE CODES FROM BOX BELOW _____ **A PRIVATE WELL IS USED PRIMARILY BY THE HOUSEHOLD, BUT MAY ALSO BE SHARED WITH 2-4 OTHER HOUSEHOLDS, AND IS LOCATED WITHIN 100 METRES OF THE HOUSEHOLD. A COMMUNAL WELL IT IS SHARED BY 5 OR MORE HOUSEHOLDS.**
32.2 **During the dry season**, what is the primary source of the water your household uses for drinking and cooking inside the home?	USE CODES FROM BOX BELOW _____
ONLY ASK IF 32.1 AND 32.2 ARE DIFFERENT 32.3 You mentioned different sources in the rainy and dry seasons. During most of the year, what is the primary source of the water your household uses for drinking and cooking inside the home?	USE CODES FROM BOX BELOW _____

Piped from water treatment plant (not chlorinated).2 Piped from water treatment plant (chlorinated).....1 Rainwater harvesting container (closed).....11 Rainwater harvesting container (open).....12 Stream.....17 River.....18 Private well (<20m deep).....6 Private well (>20m deep).....5 Unprotected spring.....10 Protected ('box') spring.....9 Borehole (>20m deep).....3 Borehole (<20m deep).....4 Water vender with cart or small tank.....14	Water vender with tanker truck.....13 Pond, lake (or other still water body).....19 Small dam (built & managed by households, village or collective).....16 Large dam (built & managed by government, company or collective).....15 Irrigation canal.....20 Communal well (>20m deep).....7 Communal well(<20m deep).....8 Bottled water (collected by household).....22 Bottled water (delivered by vender).....21 Other (specify).....99 Don't know.....-3

33.1 **During the rainy season**, approximately how much time (in minutes) does it take your household to collect enough water for your household's drinking and cooking needs for a normal (average) day? **TOTAL TIME = THERE AND BACK FOR EACH PERSON AND TRIP COMBINED. IF WATER IS COLLECTED FROM INSIDE THE HOUSEHOLD OR IN THE HOUSEHOLD'S YARD/COMPOUND, WRITE '1' MINUTE**	MINUTES _____ **IF RESPONDENT DOES NOT KNOW, PROBE, IF REALLY UNSURE, WRITE -99**
33.2 **During the dry season**, approximately how much time (in minutes) does it take your household to collect enough water for your household's drinking and cooking needs for a normal (average) day ?	MINUTES
ONLY ASK IF 33.1 AND 33.2 ARE DIFFERENT 33.3 **During most of the year**, approximately how much time (in minutes) does it take your household to collect enough water for your household's drinking and cooking needs for a normal (average) day?	MINUTES
34. Does your household treat water before drinking it (any treatment method: boiling, allowing to settle, filter, chemical treatment, etc.)?	No, household does not believe treatment is necessary.....1 Never.....2 Rarely.....3 Sometimes.....4 Often.....5 Always.....6
35. During the last 12 months, for how many months was your household's main source of water sufficient to meet your household's drinking and cooking needs?	MONTHS _____

IF RESPONDENT DOES NOT KNOW OR REMEMBER, PROBE. IF REALLY UNSURE, WRITE -99	
36. How often do you worry there will not be enough water from your household's main water source to satisfy your household's drinking and cooking needs?	Never.....1 Rarely.....2 Sometimes...3 Often.....4 Always.....5
37. Can your household usually afford to pay the fees (direct payments only, not maintenance fees) for using water from your household's main water source?	No.....1 Rarely.....2 Sometimes.....3 Often.....4 Always.....5 Household does not need to pay for water...6
38. Generally, what do you think the quality of your household's drinking water is (before any treatment)?	Very bad.....2 Poor.....3 Satisfactory...4 Good.....5 Very good.....6 Don't know.....1

FARMING/LIVESTOCK/AQUACULTURE	
39a. Does your household have access to land for agriculture, orchards, livestock or aquaculture (meaning fish-farming), including land that is owned, leased or otherwise available to the household?	No....1 >**Q46a** Yes...2
39b. How much of this land is used by the household and how much is leased out to other households?	All of it is used by the household.....1 Part of it is used and part is leased out to other households.....2 All of it is leased out to other households.3 >**Q46a**
40. How much land in acres does your household have for agriculture (for crops, grasses, trees, orchards, etc.)? **IF THE HOUSEHOLD ONLY HAS ACCESS FOR LIVESTOCK OR AQUACULTURE, WRITE 0.**	ACRES _____ **IF THE HOUSEHOLD HAS NO LAND FOR AGRICULTURE, SKIP TO Q46a**
41a. Is the majority of your household's land flat, gently sloping or steep?	Flat.....4 Gently sloping....3 Steep.....2 Mixed (specify)..99 Don't know.....1
41b. Is any part of your land terraced? **IF YES ASK** "How much of it is terraced?"	Not terraced.....1 Less than half terraced.....2 More than half terraced.....3 Fully terraced.....4
42. What kind of soil covers the majority of your household's land?	Stony-gravely.....2 Clay.....3 Loamy [mixed clay, sand &/or silt]...4 Sandy-droughty.....5 Wet [wetland/marsh].....6 Mixed (specify).....7 Other (specify).....99 Don't know.....1
43. During the last 2 years, was your household able to make, or buy, enough compost/manure or artificial fertilizer for each growing season?	Household does not think they need to use compost/manure or fertilizer.....1 No.....2 Rarely.....3 Sometimes.....4 Often.....5 Always.....6
44. During the last 2 years, was your household able to afford enough seed for each growing season?	Not necessary because household saved seed...1 No.....2 Rarely.....3 Sometimes.....4 Often.....5 Always.....6 Other (specify).....99

45.1 Is there generally enough water for your household's crops **during the dry season**?	Never.....1 Rarely.....2 Sometimes.....3 Often.....4 Always.....5 Few or no crops grown...7
45.2 Is there generally enough water for your household's crops **during the rest of the year**?	Never.....1 Rarely.....2 Sometimes.....3 Often.....4 Always.....5 Few or no crops grown...7
46a. Does the household have livestock?	No....1 >**Q48a** Yes...2
46.1 Is there generally enough water for your household's livestock during the dry season?	Never.....2 Rarely.....3 Sometimes...4 Often.....5 Always.....6
46.2 Is there generally enough water for your household's livestock during the rest of the year?	Never.....2 Rarely.....3 Sometimes...4 Often.....5 Always.....6
47. During the last 2 years, how often was your household able to grow, collect or buy enough fodder?	Never.....1 Rarely.....2 Sometimes...3 Often.....4 Always.....5
48a. Does the household engage in fish farming (aquaculture)?	No....1 >**Q50** Yes...2
48.1 Is there generally enough water for your household's aquaculture during the dry season?	Never.....2 Rarely.....3 Sometimes...4 Often.....5 Always.....6
48.2 Is there generally enough water for your household's aquaculture during the rest of the year?	Never.....2 Rarely.....3 Sometimes...4 Often.....5 Always.....6
49. During the last 2 years, how often was your household able to make or buy enough fish feed?	Never.....1 Rarely.....2 Sometimes...3 Often.....4 Always.....5
SKIP TO Q52 IF HOUSEHOLD HAS NO LAND, LIVESTOCK, OR FISH FARM 50. Does your household usually have enough people to work/manage your farm? (crops, orchards, forestry, livestock and/or aquaculture)	Never.....1 Rarely.....2 Sometimes...3 Often.....4 Always.....5
SKIP TO Q52 IF HOUSEHOLD HAS NO LAND 51. What kind of ownership of your land does your household have?	Illegal access, squatting.....1 Share-cropping arrangement.....2 Rented for less than 12 months...3 Common-law ownership.....4 Leasehold less than 5 years.....5 Leasehold 5-10 years.....6 Leasehold 11-20 years.....7 Leasehold 21-30 years.....8 Leasehold 31-40 years.....9 Leasehold for >40 years.....10 Freehold (legally owned).....11 Other (specify).....99

NEGATIVE EVENTS

52. Of all the possible negative events (natural or socio-economic) that could occur in the next 12 months, and that would have a bad or damaging impact on your household, which 3 are you most worried about? (as far as negative impacts on household members, livelihoods, agriculture, livestock, aquaculture …)

ENUMERATOR TO WRITE DOWN UP TO 3 EVENTS IN THE SPACES PROVIDED BELOW, FROM MOST WORRIED ABOUT (52.1) TO LESS WORRIED ABOUT (52.3). IF THE RESPONDENT IS NOT VERY WORRIED ABOUT ANY NEGATIVE EVENT, WRITE -88 (AND SKIP TO Q59); IF THE RESPONDENT DOES NOT KNOW, WRITE -99

53. For these events, how damaging would each be for your household? **WRITE CODE FOR LIKELY SEVERITY IN BOX BELOW**

Low-minor severity.....1
Medium-moderate severity...2
High-major severity.....3
Don't know.....-1

54. For these events, how likely is it that the event will occur in the next 12 months? **WRITE CODE FOR LIKELY FREQUENCY IN BOX BELOW**

Unlikely.....1
Likely.....2
Very likely...3
Don't know...-1

	LIKELY SEVERITY	LIKELY FREQUENCY
52.1 WRITE FIRST NEGATIVE EVENT (MOST WORRIED)_____	53.1_____	54.1_____
52.2 WRITE SECOND NEGATIVE EVENT (SECOND MOST WORRIED)_____	53.2_____	54.2_____
52.2 WRITE THIRD EVENT NEGATIVE (THIRD MOST WORRIED)_____	53.3_____	54.3_____

55. If a **%Q52_1%** were to occur in the next 12 months, what are the 3 main ways your household would likely react (cope)?

USE CODES FROM BOX BELOW

PRIMARY STRATEGY: _____
SECONDARY STRATEGY:_____
TERTIARY STRATEGY: _____

Seek off-farm work.....1
Work more hours or take on other jobs.....2
Start a business.....3
Reduce health-care spending.....4
Reduce alcohol consumption.....5
Reduce meat consumption.....6
Reduce fuel consumption.....7
Plant fewer crops next growing season.....8
Lease out farmland.....9
Children help more than usual with household work.....10
Ask friends to help with farm labour or business.....11
Ask family to help with farm labour or business.....12
Rely on local government.....13
Rely on national government.....14
Rely on aid organizations.....15
Rely on group insurance.....16
Rely on private insurance.....17
Seek technical assistance.....18
Sell stored grain.....19
Sell livestock.....20
Use savings or sell jewellery.....21
Sell durable goods.....22
Sell farmland.....23
Sell business.....24
Sell/leave home (live with relatives in area)....25
Sell/leave home (move to another area).....26
Seek medical treatment.....27
Postpone payment of debts.....28
Borrow money from relatives.....29
Borrow money from friends.....30
Borrow money from cooperative or village fund (community source).....31
Borrow money from bank or other financial service provider.....32
Borrow money from private lend.....33
Send children to work outside the household.....34
Take children out of school so they can work.....35
Beg for money/food.....36
Other (1) (specify).....99
Other (2) (specify).....999
Don't know.....-1

56. If a **%Q52_1%** were to occur in the next 12 months, how long do you think it would take for your household to return to at least the situation before it happened?

MONTHS

_____

IF NOT POSSIBLE TO ANSWER IN MONTHS, USE CODES:
DON'T KNOW.....-99
LESS THAN 1 MONTH..... -88

	HOUSEHOLD WOULD NOT BE ABLE TO RECOVER.. -77
57. If in an extreme disaster (of any sort) your household's home was completely destroyed, but your family members were not injured, how long would it take for your household to rebuild your home?	MONTHS _____ IF NOT POSSIBLE TO ANSWER IN MONTHS, USE CODES: DON'T KNOW.....-99 LESS THAN 1 MONTH..... -88 WE WOULD MOVE..... -77 HOUSEHOLD WOULD NOT BE ABLE TO REBUILD.. -66
58. If a **%Q52_1%** were to occur in the next 12 months, who do you think would be most likely to assist your household?	No one.....1 Family/relatives.....2 Friends.....3 Insurance company.....4 Financial institution.....5 Local government.....6 National government.....7 Government (general).....8 Aid organizations.....9 Church/mosque/other religious group.11 Don't know.....10 Other (specify).....99

FOOD AND NUTRITION SECURITY	
59. During the last 12 months, did any member of your household eat fewer meals, or smaller portions, than usual because there was not enough food? **IF YES, ASK** "For approximately how long/how often did this happen?"	Never.....1 Yes, once or twice.....2 Yes, for about 1 week.....3 Yes, for a few weeks.....4 Yes, for about 1 month.....5 Yes, for more than 1 month...6 Yes, most days.....7 Don't know.....8
60. During the last 12 months, did any member of your household go to sleep at night hungry? **IF YES, ASK** "For approximately how long/how often did this happen?"	Never.....1 Yes, once or twice.....2 Yes, for about 1 week.....3 Yes, for a few weeks.....4 Yes, for about 1 month.....5 Yes, for more than 1 month...6 Yes, most days.....7 Don't know.....8
61. During the past 12 months, did your household experience a period of time longer than 2 weeks when there was not enough food? **IF YES, ASK** "How many periods like this were there in the last 12 months?"	No.....1 Yes, 1 period of time.....2 Yes, 2 periods of time.....3 Yes, 3 periods of time.....4 Yes, 4 periods of time.....5 Yes, more than 4 periods of time...6 Don't remember.....7 Other (specify).....99
62. During the past 12 months, did your household ever experience 1 full day with no food to eat? **IF YES, ASK**: "How often did this occur?"	Never.....1 Once or twice.....2 Approximately once a month....3 Approximately every 2 weeks...4 Approximately every week.....5 Don't know.....6
63.1 During the last 12 months, how often did the majority of your household eat grains (cereals, bread, rice, pasta)?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8
63.2 During the last 12 months, how often did the majority of your household eat roots &/or tubers (potatoes, cassava, etc.)?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8

63.3 During the last 12 months, how often did the majority of your household eat vegetables or greens?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8
63.4 During the last 12 months, how often did the majority of your household eat fruits?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8
63.5 During the last 12 months, how often did the majority of your household eat dairy products and/or eggs?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8
63.6 During the last 12 months, how often did the majority of your household eat meat and/or fish/seafood?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8
63.7 During the last 12 months, how often did the majority of your household eat nuts and/or legumes (including derivatives, tofu, etc.)?	Never.....1 Almost never.....2 Approximately once a month.....3 A few times a month.....4 About once a week.....5 A few times a week.....6 Every day.....7 Not eaten for religious or cultural reasons...8

EMPLOYMENT, CREDIT, ASSETS AND EQUALITY	
64. During the last 12 months, has anyone in your household managed/run their own business (other than selling agricultural products)? **IF YES, ASK**: "For how many months out of the last 12 months?"	No.....1 Yes, 1-2 months...2 Yes, 3-4 months...3 Yes, 5-6 months...4 Yes, 7+ months....5
65. During the last 12 months, has anyone in your household provided others a skilled service (for example, equipment repair, tailoring, construction work) for money or barter? **IF YES, ASK**: "How often?"	Never.....1 Rarely.....2 Sometimes...3 Often.....4 Always.....5
66. If your household wanted to borrow money from a bank or other financial service provider (not including friends or relatives), would your household be able to borrow money?	No.....1 Probably not.....2 Probably yes.....3 Definitely yes...4 Don't know.....5
67. Is your household currently in debt from any lender including family and friends? **REMIND RESPONDENT THAT ALL INFORMATION WILL BE TREATED CONFIDENTIALLY**	No.....1 >**Q69** Yes, a little.....2 Yes, a moderate amount.....3 Yes, a lot.....4 Don't know, or don't want to discuss...5 >**Q69**
68. To whom is the majority of this debt owed?	Relatives.....1

	Friends.....2 Village fund.....3 Village government.....4 Rural credit cooperative.....5 Private money lender.....6 Microfinance institution.....7 Government bank.....8 Private bank.....9 Joint village & bank fund.....10 Joint development project & bank fund...11 Other (specify).....99
69. How many of the people (adults and children) in your household usually have adequate footwear?	None.....1 Less than half the household...2 About half the household.....3 Most of the household.....4 All household members do.....5 Don't know.....6
70. How many of the people (adults and children) in your household have sufficient clothing for severe weather (for example, very hot and sunny, very cold or very wet weather, depending on the area)?	None.....1 Less than half the household...2 About half the household.....3 Most of the household.....4 All household members do.....5 Don't know.....6
71. Does your household have a television? **IF YES, ASK** "How many?". **IF NO, WRITE "0"**	# TELEVISIONS _____
72. Do some households in your village/area have fewer economic or political opportunities than others because of their religion or ethnic/minority group?	No.....1 >**Q74** Yes, a few households.....2 Yes, less than half of the households..3 Yes, about half the households.....4 Yes, more than half the households.....5 Don't know.....6
73. In the last 2 years, how has this situation of inequality changed?	Improved slightly.....1 Improved moderately.....2 Improved a lot.....3 Worsened slightly.....4 Worsened moderately.....5 Worsened a lot.....6 No significant change...7 Don't know.....8 Other (specify).....99

FARMING CONTINUED	
SKIP TO Q83 IF THE HOUSEHOLD HAS NO FARMING LAND 74. We already asked you some questions about your land, but would like to ask a few more. Among the following agricultural practices, which are those that your household is doing? **READ OUT ALL OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY**	Not ploughing (zero tillage).....1 Reduced ploughing (low tillage).....2 Rotating crops between seasons (e.g. alternating cereals and legumes).....3 Mulching to retain soil moisture and regulate soil temperature.....4 Reducing erosion by wind and water (i.e. hedging, ditching, stone lines..).....5 Dosing fertilizer.....6 Terracing and/or land reclamation.....7 Manure application (to restore soil organic content).....8 Agroforestry/planting trees in fields.....9 Intercropping with nitrogen fixing legumes (like cowpeas, beans or pigeon peas).....10 Fertilizing practices leaving crop residues in the field.....11 Other (specify).....99 Don't know.....-1 None.....12
75. Among the following problems, which are those that your household is facing with its land?	Drought.....1 Soil erosion.....2 Floods (from river/sea).....3

READ OUT ALL OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY	Landslides.....4 Wild fires.....5 Pest infestations.....6 Frost.....7 Hail.....8 Heavy rains.....9 Heat waves (temperature extremes)...10 Soil salinity.....11 Loss of soil fertility.....12 Storms/strong winds.....13 Plant diseases.....14 Other (specify).....99 Don't know.....-1 None.....15
76. What are the 3 main sources of freshwater for crops and livestock for most of the year? **CAN BE LESS THAN 3 SOURCES** **A PRIVATE WELL IS USED PRIMARILY BY THE HOUSEHOLD, BUT MAY ALSO BE SHARED WITH 2-4 OTHER HOUSEHOLDS, AND IS LOCATED WITHIN 100 METRES OF THE HOUSEHOLD. A COMMUNAL WELL IS SHARED BY 5 OR MORE HOUSEHOLDS.**	USE CODES FROM BOX BELOW PRIMARY SOURCE: _____ SECONDARY SOURCE:_____ TERTIARY SOURCE: _____
Piped water.....1 Borehole.....2 Private well.....3 Communal well.....4 Spring.....5 Rainwater harvesting container.....6 Water vender.....7 Stream.....8	Lake.....9 Pond, lake (or other still water body)...10 River.....11 Household wastewater.....12 Dam.....13 Rainfall.....14 Don't Know.....-1
RECORD THE CURRENT TIME	USE 24 HOUR FORMAT, FOR EXAMPLE 13:15 __:__

***The following questions (Q77-Q3) were added to the standard MPAT questionnaire**

CLIMATE	
77. Among the following types of weather information, which are those that your household receives? **READ OUT ALL OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY. DAILY AND WEEKLY RAINFALL AND TEMPERATURE SHOULD ONLY BE TICKED IF THE HOUSEHOLDS RECEIVES THESE REGULARLY.**	Forecast of daily and weekly rainfall.....1 Forecast of daily and weekly temperatures.....2 Hydrology advisory (rise and fall of water level).....3 Extreme event advisories (drought, flood, etc)..4 Climate change projections.....5 Advice on crop calendar.....6 Don't know.....-1 None.....7
77a. Which of the types of weather information you said your household receives have you used in the past to help you make agricultural decisions? **READ OUT ALL OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY.**	Forecast of daily and weekly rainfall.....1 Forecast of daily and weekly temperatures.....2 Hydrology advisory (rise and fall of water level).....3 Extreme event advisories (drought, flood, etc)..4 Climate change projections.....5 Advice on crop calendar.....6 Don't know.....-1 None.....7
78. Among the following information sources about weather issues, which are those that your household has access to? **READ OUT ALL OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY**	Private extension providers.....1 Cell phone SMS.....2 Community groups (women, religious, youth..) or farmer associations.....3 Development NGOs.....4 Government extension services.....5 Information exchange with fellow farmers.....6 Village information centres.....7 Internet.....8 Newspaper/Press.....9 Television.....10 Radio.....11 Don't know.....-1

	None.....12
79. Have you heard of the term "climate change"?	No....1 >**Q92** Yes...2
80. How or where did you hear about climate change? **MORE THAN ONE ANSWER POSSIBLE** **PROBE:** "Did you hear in any other way?"	Community groups (women, religious, youth..) or farmer associations.....1 Development NGOs.....2 Government extension services.....3 Information exchange with fellow farmers.....4 Village information centres.....5 Internet.....6 Newspaper/Press.....7 Television.....8 Radio.....9 Other (specify).....99
Specify	
81. Have you observed changes in weather patterns since you were young?	No.....1 >**Q95** Yes.....2 Don't know...3
82. Did these changes in weather patterns make you change any agricultural practices?	No.....1 Yes.....2 Don't know...3
83. What have you changed?	OPEN

Annex 2: Enumerator field manual

MPAT Enumerator Manual

Introduction

The role of the interviewer is extremely important. The success of the study depends on the quality of the work of each interviewer.

The job of the interviewer includes the following:

- Ask for the cooperation of the selected households and persons for the interview.
- Ask the questions in the questionnaire, and probe when incomplete or contradictory answers are given.
- Check after the interview that it is complete.

General points to keep in mind while conducting the interview:

Doing an interview is more of an art than a mechanical process. Every interview is a new source of information. To keep the respondent interested, it is important to make the interview pleasant and interesting. For this there are some general interview tips.

Conduct of the Interviewer

Be courteous towards everyone. Your behaviour can have a big influence on the quality of the responses provided by the respondent.

Exercise patience and tact in conducting the interview to avoid annoying the respondent or leading him to give answers that are not true.

The way to ask questions:

- Read the questions clearly according to the descriptions and don't be too fast.
- Read questions without adding, reducing or changing them. If the respondent doesn't understand, repeat the question slowly, don't explain in your own words.
- Don't change the order of the questions (changes can alter the answer).
- Don't skip a question due to previous answers or because you know the answer. Don't show your respondent that you are in hurry or tired. Give them time to think about his or her response.

Objectivity of the Interviewer

It is extremely important that you should remain absolutely **NEUTRAL** about the subject of the interview. Most people are naturally polite, particularly with visitors, and they tend to give answers and adopt attitudes that they think will please the visitor. You must not show any surprise, approval or disapproval about the answers given by the respondent, and you must not tell him what you think

about these things yourself. If he asks you for your opinion, wait until the end of the interview to discuss the matter with him. You must also avoid any preconceived idea about the respondent's ability to answer certain questions or about the kind of answer he is likely to give.

If necessary emphasise the confidentiality of the interview

If the respondent is hesitant to answer a question or asks what will be done with this information, explain that the information will be confidential, that no names will be used, and that only averages for the area will be used. It is therefore also vital not to talk to the respondent about what was said in previous interviews. Also never openly – in view of the respondent or other villagers – discuss other interviews with colleague interviewers or a supervisor.

In principle, all of the questions should be asked to the respondent in complete privacy to ensure that his/her answers remain confidential. The presence of other people during the interview may cause him/her embarrassment and influence some of his/her answers. Therefore always try to find a quiet spot where you can be private. However, sometimes a respondent might ask the help of another household member or want another member present. In these cases, this is allowed, but no non-members should be present and in most cases a private setting will produce the best interview.

Incomplete answers or 'I don't know' replies

It is very natural to be a little nervous during interviews, and especially at the beginning you might be happy to get any answer to a question so that you can move on to the next one. But it is vital for the quality of the study that you think about each answer you get and are comfortable that it actually answers the question you asked.

You also have to be alert whether something the respondent says in is conflict with something they said before or with the context of the household or the local environment. If that is the case, you have to ask a clarifying or probing question. This may sound a little difficult, but once you are familiar with the questionnaire and understand the purpose of each question, it will become easier. We will also practice in the group with this, so you become comfortable asking these kinds of probing questions.

Probing should be done without pushing the respondent to select a certain answer. Asking follow-up questions such as 'What exactly do you mean?', 'Anything else?', `Tell me more about...' or simply repeating the question could be useful in probing. When probing, you must be both "mpole na mkali", that is, you must be fully polite, but also firm in your desire to get a good and truthful answer.

Do your utmost to avoid the reply 'I don't know' by helping the respondent to consider his or her answer. The respondent should rarely use the reply 'I don't know.' Nevertheless, it may happen that even with the help of the interviewer the respondent cannot give an answer, because (s)he really does not know. In that case, enter that answer.

In some questions you have to read the answer options to the respondent. Even if one of the options is "Don't know", do not read this. We want to avoid this answer unless the respondent is really not sure.

Check the questionnaire at the end of the interview

After you finished the complete interview and have thanked the household for their cooperation, check the questionnaire! Check that all questions were answered. This is very important, because at that moment you still have the chance to ask a missing question.

Other elements of the survey

Debriefing sessions

You will be meeting to discuss the day's interviews and procedures with your field supervisor or team leader and the rest of the team every day after returning from the field. The purpose of these discussions is to identify challenges and find solutions the team faced while in the field, and to plan for the next day's work. Tell the supervisor about any problems you had.

Data entry and synchronization

The supervisor will check each interview to see if it is complete. Then data from your tablet will be sent to the online data server over the internet every day. Data will be checked the same evening and comments sent back to the supervisors if anything is unclear or mistakes were made. Any issues will be discussed with the enumerators the next morning, before new interviews are done.

Changes in the questionnaires

Questions will not be changed after the pre-test has been completed. During the training and pre-test, if you think that a question has been mistranslated, is unclear, or has any other problem, inform your supervisor and/or principle investigator. It is very important that you say what is not working. Only that way can we improve the questionnaire and avoid problems during the real survey.

You and your Team leader and Project Supervisor

You should always follow the directions given by your supervisor. Your team leader will assign your work each day you are in the villages.

Supervisor/Team leader roles

(S)he will carry out the following checks in the field:

Examining all of your data in the tablets to make sure that each interview has been carried out correctly and completely and there were no problems with the tablets.

The team leader revisits 10 percent of the households that have been surveyed. The team leader will repeat some sections of the questionnaire to verify that they have been recorded correctly and also to determine if the respondent was read the consent statement, greeted politely, and treated with respect. The team leader will observe one or more of the interviews, to evaluate your method of asking the questions.

The team leader will evaluate the interviewer's work and discuss it with them and also will report on your performance to the management team.

What to bring for a day of surveying:

1. Clear bag
2. Android Tablet
3. Notebook
4. Pen(s)
5. Household identification list

The interview

Introduction

Depending on the sampling method, a village guide will take you to the households that were identified beforehand. When you enter a household, the first thing you should do is to greet everyone, introduce yourself and then tell the household a little about the project. You begin the interview by reading the introduction text:

My name is _____ and I am conducting research on behalf of _____ and would like to interview you today. We are collecting information about you and your family and about water, sanitation, farming, and several other topics. This information will help us measure how project activities impact your family over the next few years. Your household was randomly selected for an interview.

You then select the respondent for interview. This should be an **adult (18+) member of the household who spends at least 9 months a year with the household**.

The interview would take about 45 minutes. Please note that all the information you provide will be treated completely confidentially and will not be shared with anyone else. The information will only be used to characterize the area in which you live. All individual information will be added together to determine the average for the whole community, so nobody will be able to identify individual

participants. There are no risks to you from saying no or yes to the survey. While there are no direct benefits to you, your answers will aid in measuring the benefits to your community.

If you have questions later, you may contact the study leader _____ on _____

Taking part in this study is completely voluntary and you can opt to cancel the interview at any time. May we proceed with the interview?

Suggest the following guidelines before you start the interview:

- There are no right or wrong answers. It is your opinion that is important to us.
- Take your time in giving answers. Precision is more important to us than speed in finishing the questionnaire.
- Do not hesitate to ask me to repeat a question or ask for clarification if the question is not clear or needs further explanation.

Interviewer instructions and different fonts

The questionnaire uses different text formats to indicate to you what to do.

1. The questions that you have to read out loud to the respondent are formatted in “normal” text.
2. Some questions are directed to you, and you do have to ask the respondent. For these questions we use capital letters. For example there is the question "DID YOU OBSERVE THE TOILET FACILITIES?" This is a question to you. You do not need to ask this to the respondent.
3. We also use capital letters for messages to you about how to ask a certain question, for example, whether to read the answer options or not, or to probe the respondent for more answers. In the paper questionnaire these messages have the same format as the questions in capital letters that we explained above, but usually they follow a normal question. On the tablet these messages will appear in blue text under the data entry field.
4. Some questions are asked several times for different persons. In those questions you will find %rostertitle%. You should not read this, but should fill in the relevant person or product (it is the code needed for the programming). For example, the question H.2 “What is the relationship of %rostertitle% to the head of the household?” The program automatically changes the names written down in Question H.1.
5. Finally, the questionnaire uses "skip codes". Not all questions have to be asked to all respondents. In the paper questionnaire a skip code looks like this >Q15 and tells you where to go next. Sometimes you will also see on the top of question a message in yellow,

indicating if a question should be asked. In the tablet these skip codes are automatic and you will not be able to enter the questions if they are skipped. This also makes it very important to carefully enter the answers, because if you enter it wrongly, you could skip many questions that were important for this household.

To summarise, the only text to be read out to the respondent is in normal case. All text in capital letters are messages to you or answer categories and should not be read to the respondent, unless you are instructed to do so.

Type of questions

Most questions are multiple choice, and **unless there is an instruction to read the answer options to the respondent, they should not be read out loud or shown to the respondent.** You should ask the question in an open way and if the answer is among the options, tick the right option, or if the answer is different from the options, click "Other (Specify)" and write down the answer in a few words in a separate question that will appear.

In some questions the answer options are included in the text or you will find an INSTRUCTION in capital letters telling you to read the options to the respondent. **Only then should you read the answers out loud.** Never read the answer option "Don't know", even if you have to read the other answer options.

In most multiple choice questions you just have to select one answer from the list. In others, you can select several options. You will see an instruction in these questions such as "MORE THAN ONE ANSWER POSSIBLE" or "READ ALL ANSWER OPTIONS TO THE RESPONDENT AND TICK ALL THAT APPLY". On the tablet these questions also look different from the other multiple choice questions as we will see below.

There are also open questions, where you will have to type in the answer of the respondent. Do this in a short but clear way. Think that the researcher reading the answer later should not have to guess what you meant.

The Questionnaire – question explanation

Now a number of the questions in the questionnaire will be discussed to explain how these should be asked.

Introduction questions

This includes the agreement of the respondent to be interviewed. If (s)he does not want to be interviewed, you still have to finish this section which include selecting your name and the supervisor name, the household ID, the micro-watershed, take the GPS coordinates, and enter the starting time of

the interview. Notice that all these questions are in CAPITALS. Remember that you don't have to ask this to the respondent, but fill these out by yourself (unless you have doubts).

The Household ID number is on your list of households to interview and should be copied very carefully.

For the GPS and time question you only have to click a button.

The Software

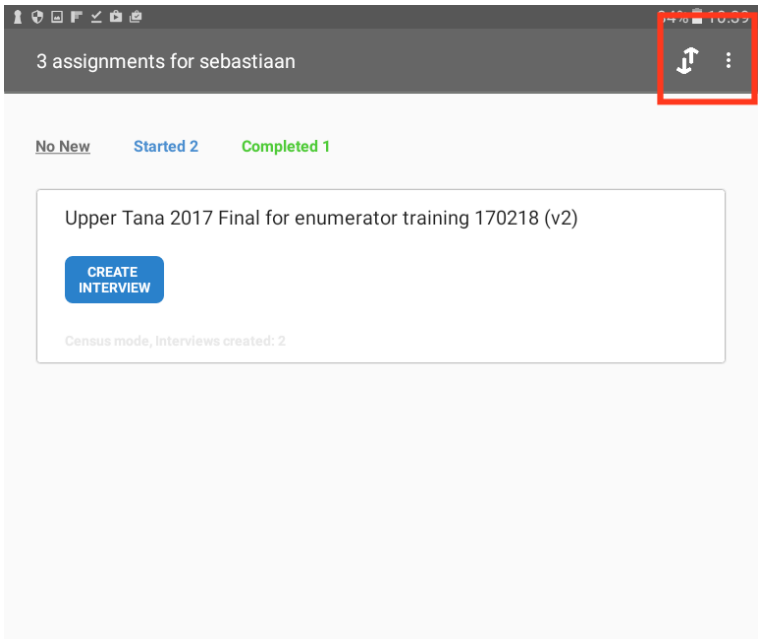
We will be using the World Bank's Survey Solutions software.

Log in

The screen below shows the normal login screen. You each have a login name and password that can only be entered on a specific tablet, so you cannot switch tablets, unless there is a problem with your tablet.

Downloading the questionnaires

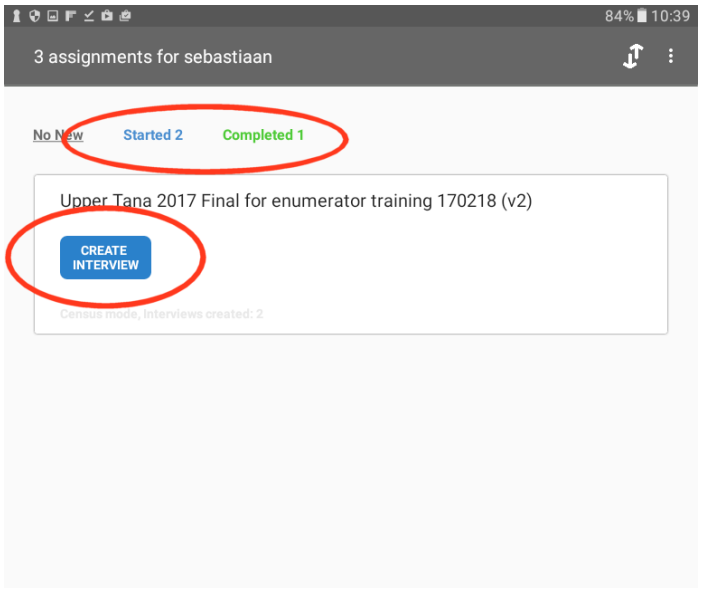
For this you need to synchronize the tablet with the server headquarters. After signing in, you will see the "Dashboard" screen. It has a synchronization (arrows) and menu (three dots) button in the upper right-hand corner of the screen. After tapping the synchronization button the latest questionnaire will be downloaded (and completed interviews uploaded – see below). The menu button, which is visible in all screens is mainly important for the selection of the interview language. A new interview will always open in English, but through this button, you can switch to Shona and Ndebele. The button also allows navigation to the Dashboard, Settings and enumerator Sign out of the tablet, but you will be unlikely to need that.



Starting a new interview and managing your workload

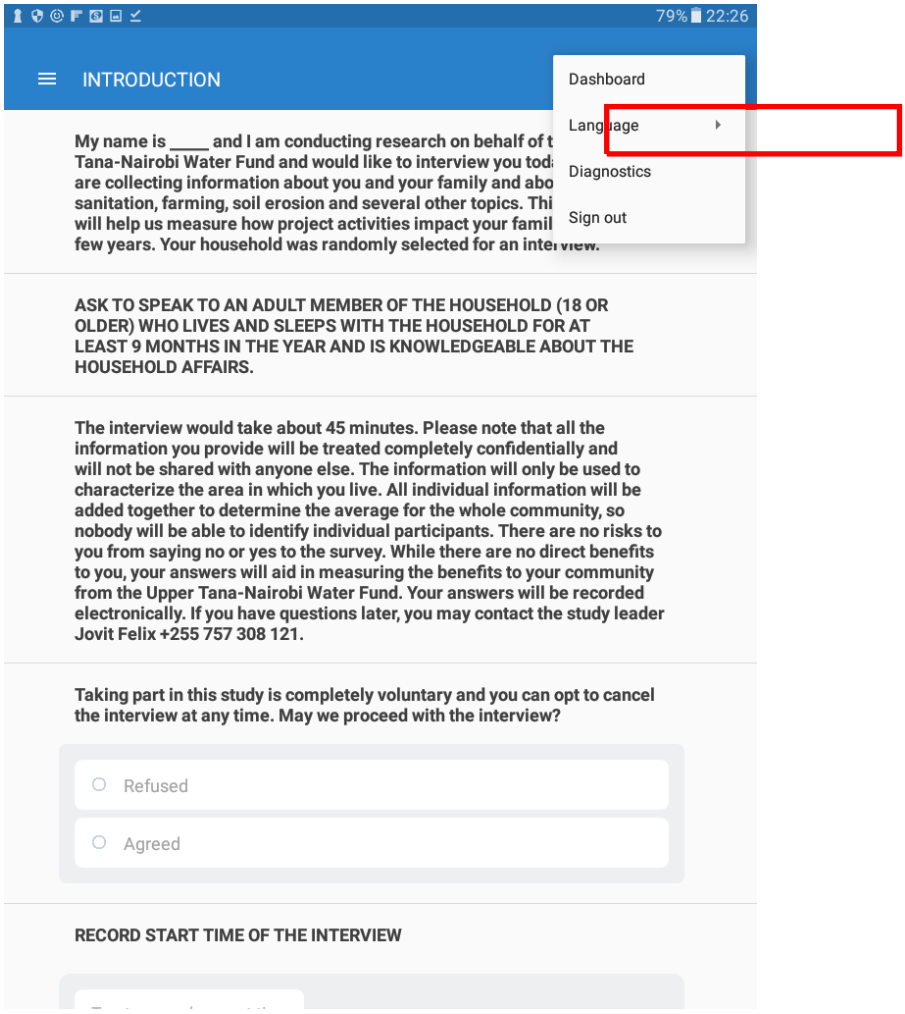
The dashboard offers a functional overview of the interviewer's assignments and their status. To start a new interview, click the CREATE INTERVIEW button.

The links displayed at the top of the dashboard sorts survey cases by their status. Started (in blue) indicates interviews that still have to be completed. Completed (in green), indicates interviews that have been marked by the interviewer as complete. Only completed interviews will be sent to the headquarters database during synchronization.



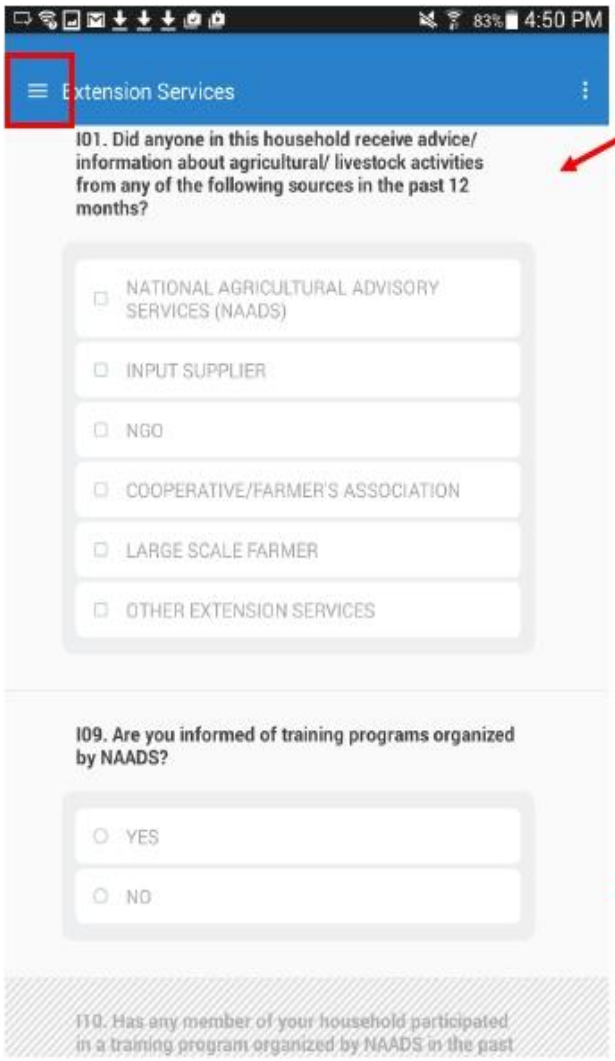
Selecting the correct language

After you have clicked CREATE INTERVIEW, the questionnaire opens on the Introduction screen, which has the introduction text and interview identification questions. Once you have selected a respondent, find out if this person is most comfortable speaking English, Shona, or Ndebele. Select this language for the questionnaire (you may select Shona or Ndebele before, so that the introduction text appears in the right language). Do this by tapping the Menu button (3 vertical dots on the top right of the screen), tap "language" and select the language you need.



Answering questions

Below you see an overview of the questionnaire interface with a description of the different elements.



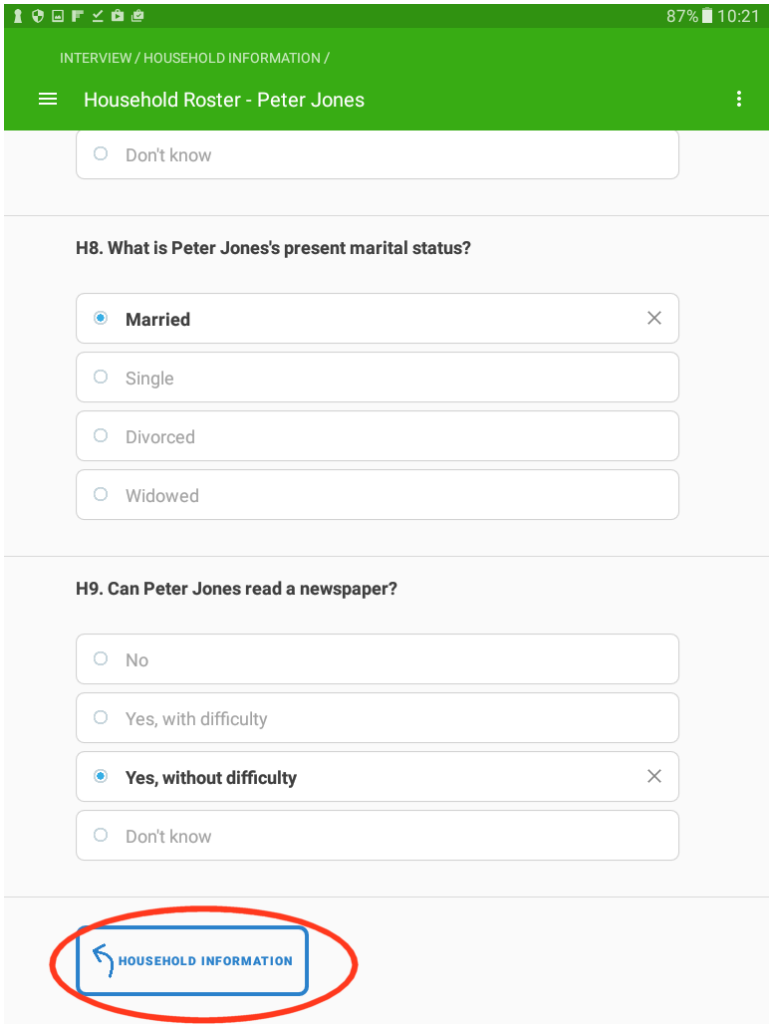
Navigation. Tap to open the navigation pane

Question text

Enabled questions. These questions must be answered. To answer them, tap the relevant answer option or the field to compose an answer.

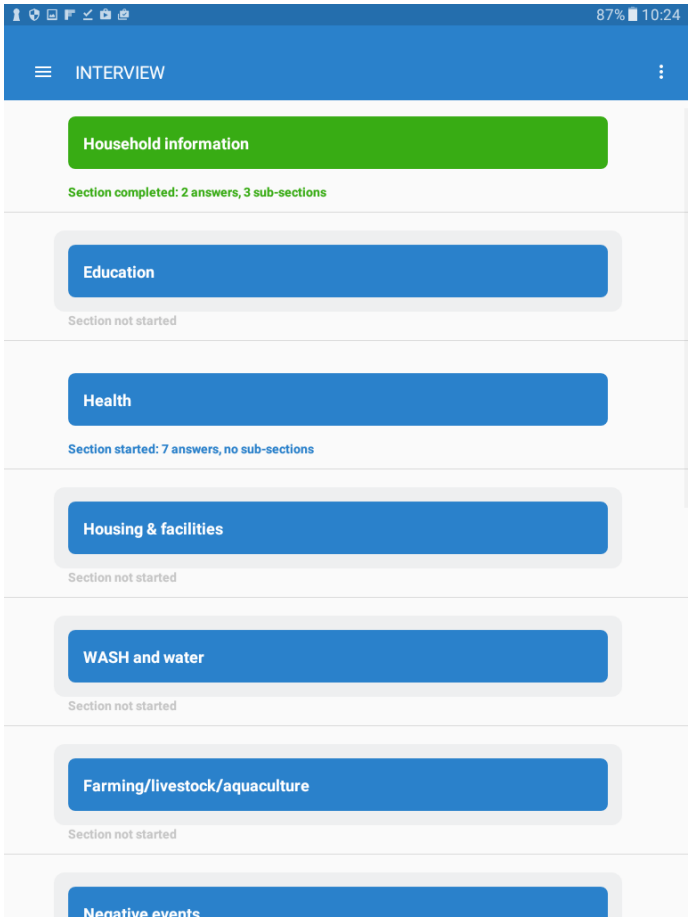
Disabled questions. Based on information you've provided, these questions are irrelevant. But currently disabled questions may become enabled as you answer more questions.

The questionnaire on the tablet is divided into sections, and each section has a number of questions. The main sections are Introduction and Interview. The Interview Section has a number of sub-sections. After finishing a section or subsection, you have to click the button at the bottom of the screen (see image below) to continue to the next section or subsection.



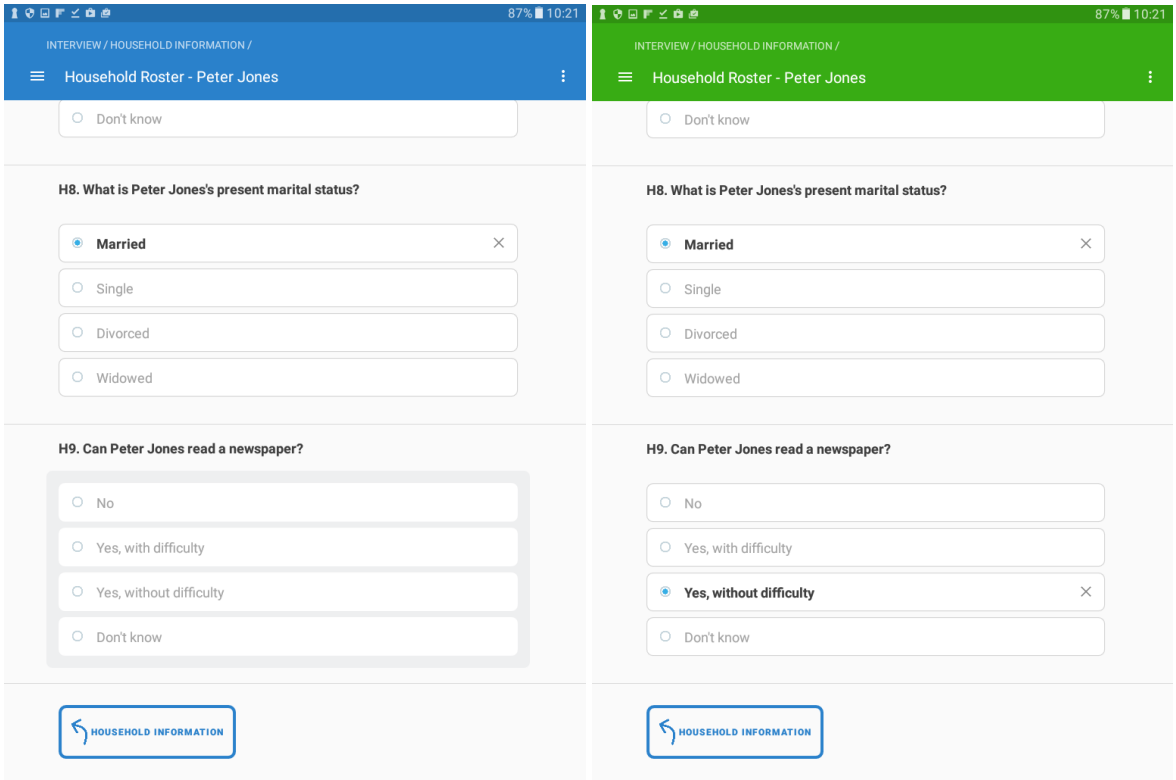
The program uses colours to show progress and problems in a section. Blue indicates that the section still has to be started or is not completed yet. If all questions in a section are answered, it turns green. It turns red if an answer is entered that is not expected. We will come to that later.

After filling out the Introduction Section you will reach a screen with boxes for all the subsections of the main interview. When you first reach this all boxes will be blue, because you haven't finished any subsection yet. You should tap the first blue box (Household Information) to begin. As you finish the different subsections they will turn green. In the image below, the Household Information Subsection has been completed (it is green). To continue with the interview, click the next blue box and ask the questions in that subsection. You keep doing this until all boxes are green.



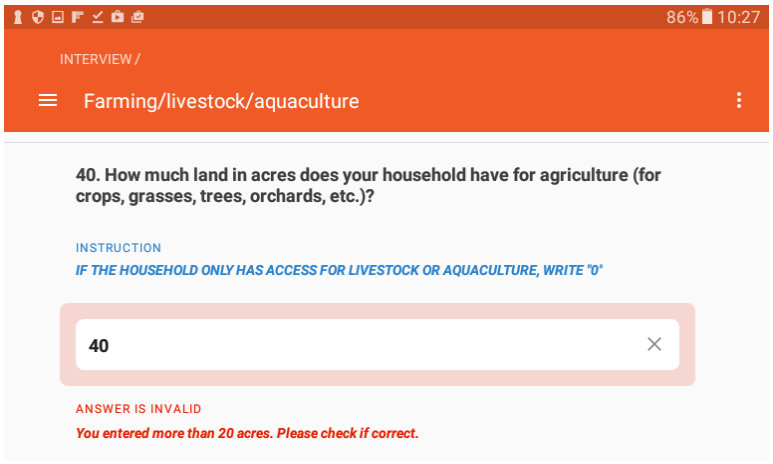
The colours (blue, green and red) also work within a subsection. As long as there are still unanswered questions, the top part of the screen is. Once you enter the last question, it turns green (see below). If you reach the end of the page, but it does not turn green, scroll back up to see what you missed.

These colours are your main indicator that you have completed a section, and you should only continue to a next section if the section you are working on has turned green.

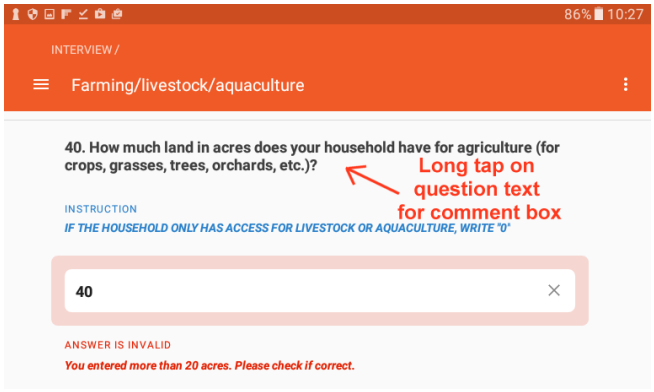


For some questions we expect the answer to lie in a certain range, for example based on an answer in another question or general expectations. If the answer you enter falls outside that range, the question and menu bar turn red. For example, when asking someone's age the screen turns red if you enter a number of 100 or higher, since we think it very unlikely you will find such a person. It is a sign that you should check the answer carefully and probably correct it. If you really think it is the correct answer, you should leave it and both inform your supervisor and add a comment to the question (we will discuss how to do this later on).

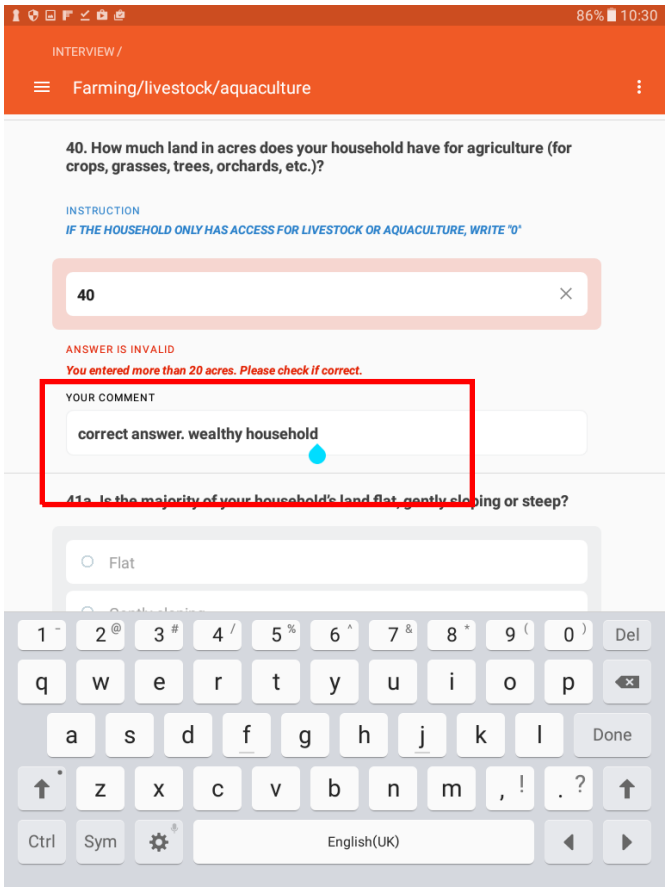
Another example is the question how many acres or land a household has. We expect this to be less than 20 acres, so if you enter a higher number, a warning message appears (see image)



If you checked this answer with the respondent and it is correct, you should make a comment to let us know. You do this by touching the question text for a few seconds (long tap) It only works if you long tap on the question text (see arrow).



When you long tap on the question text a comment box and the keyboard will appear, so you can write your message.



You can make a comment in each question, whether a warning message appears or not. You should use this if you have difficulty answering a question, e.g. because the correct answer is not among the options or you think the answer requires extra explanation or you are not sure how to answer a question. At the end of the day the supervisor will discuss all your comments with you before

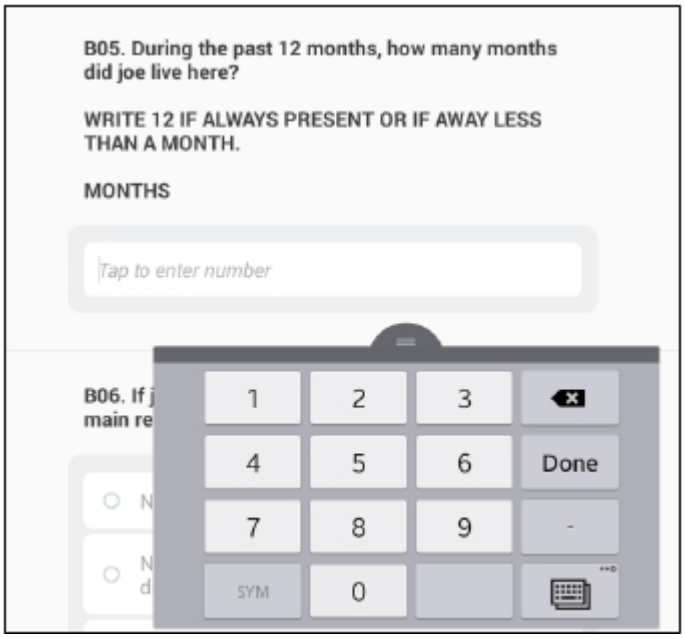
uploading the interviews. Make your comments short but understandable for the supervisors and the data checking person.

Type of questions

We already discussed the different type of questions above, but we will show here how what these look like on the tablet.

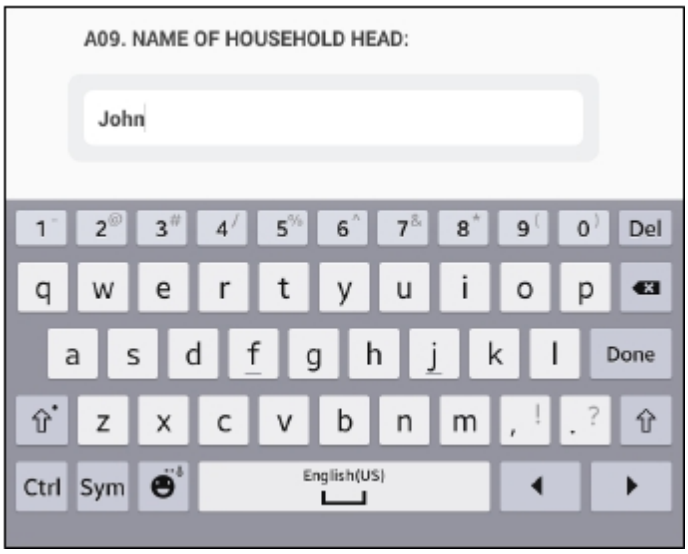
i) Numeric questions

Questions that take a numeric response have a field for an open numeric answer. When that field is tapped, the numeric keyboard appears so that the interviewer can compose an appropriate numerical response.



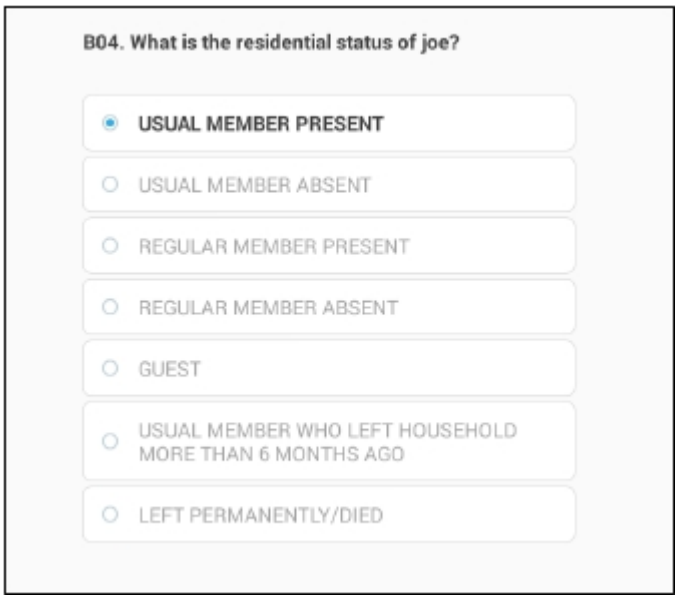
ii) Text questions

Text questions have a field for an open text response. When that field is tapped, the text keyboard appears so that the interviewer can compose an appropriate text response.



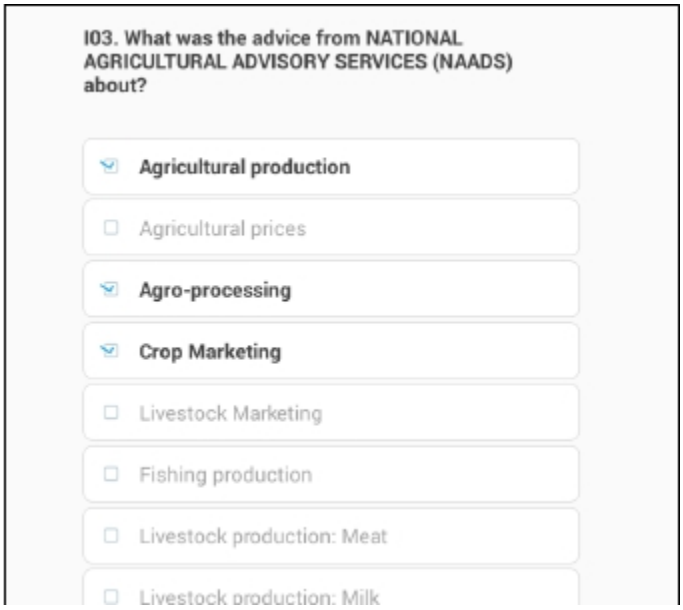
iii) Multiple choice, single-select questions

Single-select multiple choice questions have answer options with "radio buttons" (circles). To answer this type of question, the interviewer taps the radio button associated with the most appropriate answer.



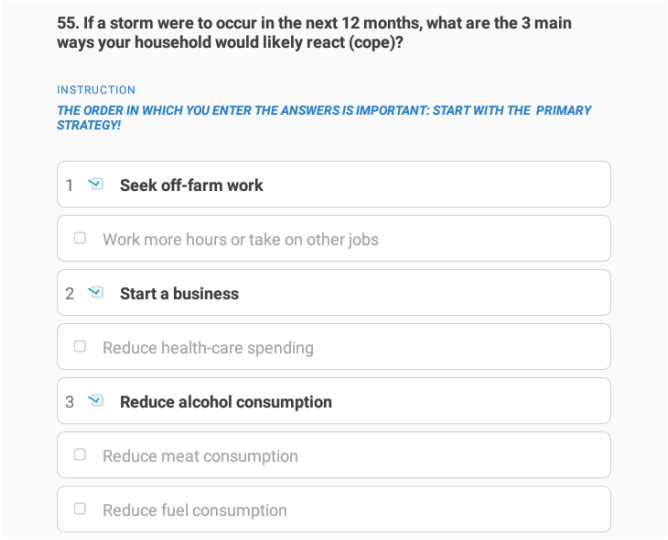
iv) Multiple choice, multi-select questions

Multi-select multiple choice questions have answer options with "check boxes" (squares). To answer this type of question, the interviewer taps in all appropriate check boxes. Selected answers will show a check in the box.



v) Multiple choice, multi-select RANKED questions

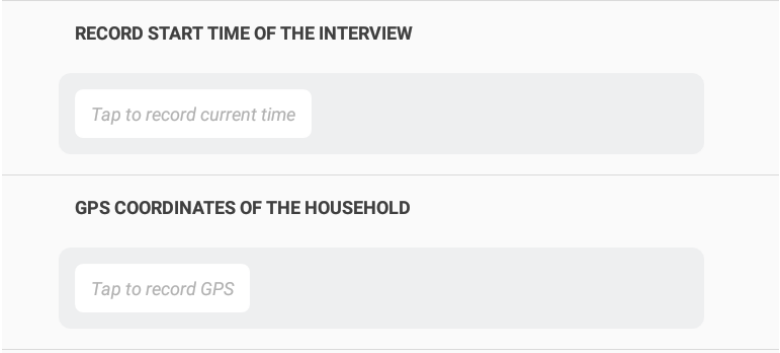
Multi-select ranked questions also have check boxes, but you can only enter a maximum of 3 answers. It is also possible to give only 1 or 2 answers, but not more than 3. The order with which you select the answers is also very important. The most important or primary answer should be tapped first, followed by the second most important answer and then the third. Numbers will appear next to the check boxes to show which you entered first. If you want to change the order, you have to tap a check box again to empty it again.



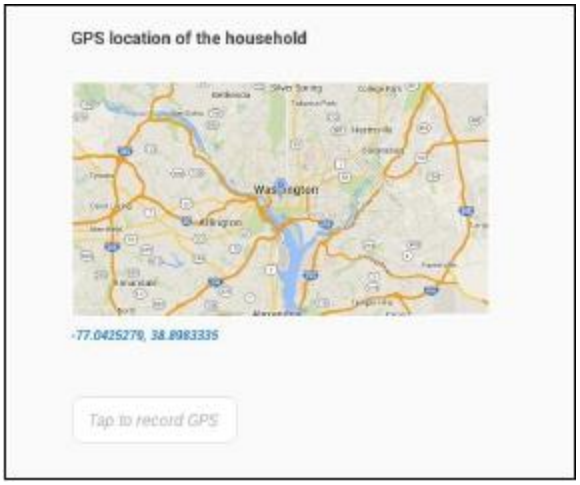
vi) Time and GPS questions

For Time and GPS questions you don't have to enter anything, just tap the button in the question. For the time question the button says "Tap to record current time" (see image below). The time will then show below the button.

For the GPS question, you will first have to turn on the positioning option of the tablet. This should only be switched on when taking the GPS and switched off right after to safe battery power. To record the GPS tap on the “record GPS” textbox. This will open a window informing you that the tablet is searching for the GPS location. Just wait (closing this window will stop the tablet from searching for GPS).

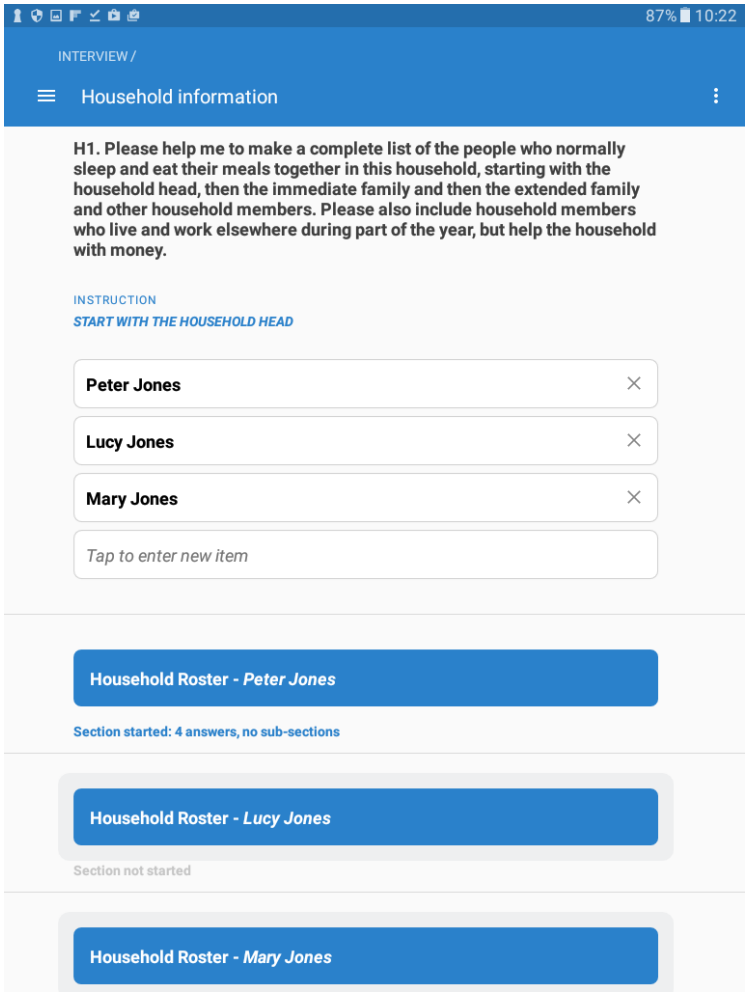


Once the tablet has recorded the GPS coordinates, the location is displayed immediately below the question text, showing the longitude, latitude, accuracy, and altitude. If the GPS reading is not accurate enough, you may tap on the “record GPS” textbox again. Doing so will replace the old GPS reading with the new GPS reading. You can continue in this fashion until you obtain and adequately precise GPS reading.



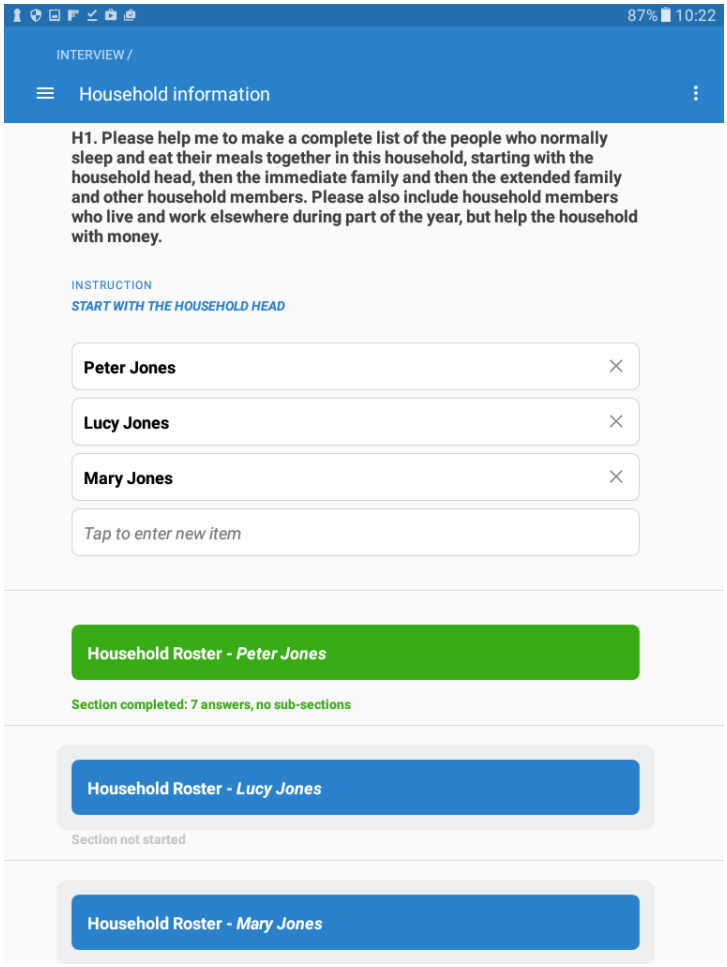
vii) Roster questions

The questionnaire contains one roster in which all household members are entered. There is an initial question in which you first make a list of the names of all household members. One you have completed the list of all members, we want to ask a few questions for each member. On the tablet this will look like this:



For each of the household members names that you enter a blue box appears with the name of the person. In this case "Peter Jones", "Lucy Jones" and "Mary Jones". If we would add another person in the question above (where it says "Tap to enter new item"), another blue box would appear below "Mary Jones" with the new name we entered.

First you make sure you have a complete list of all household members. Then you have to click on the first blue box to start entering questions about that person. When you have answered all the questions about that person, the screen becomes green and you can click the button to go back to the overview screen. You will see that the first blue box "Peter Jones" has turned green to indicate you have completed the roster for that household member:

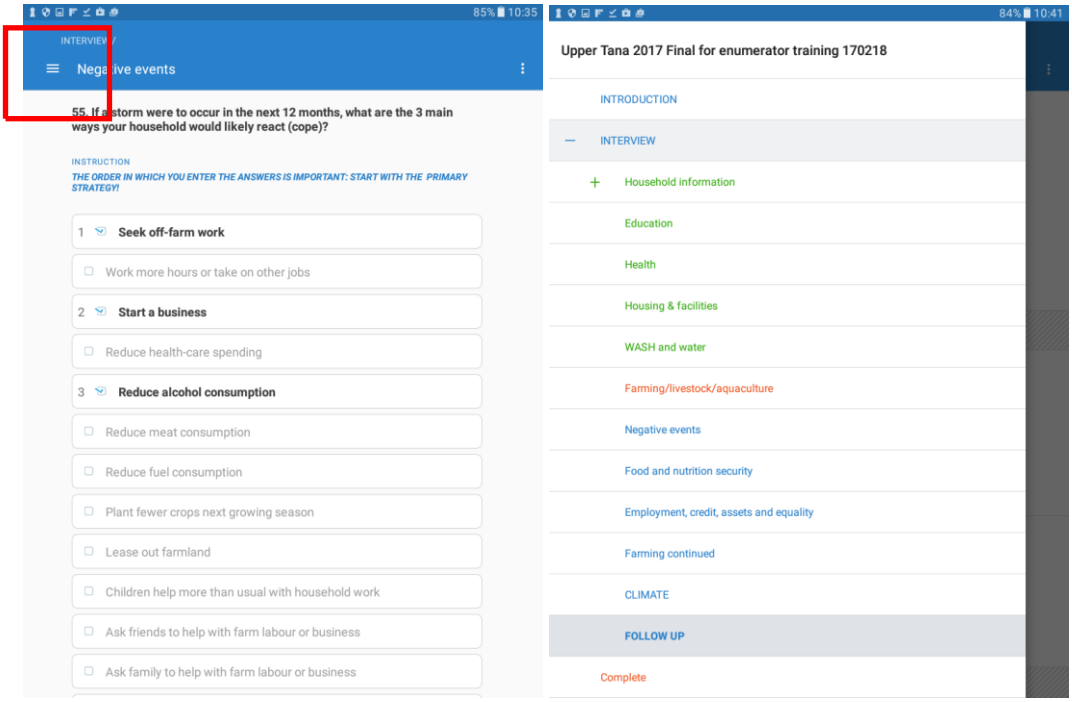


You should now click on the next blue box ("Mary Jones") and enter the questions for the second person. You continue doing this until all the boxes have turned green. Then you can continue with the remaining questions on the page.

Moving through the questionnaire

In normal circumstances you should simply follow the questionnaire structure, answering questions and sections in the order that they appear: answer all questions on a page, see that it turns green and click the button at the bottom to move to the next page.

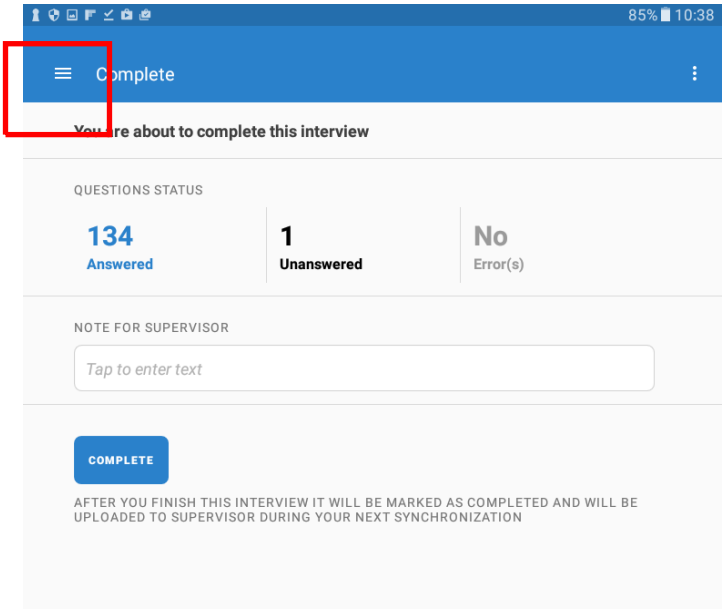
However, you may sometimes need to go back, for example to review your work or to correct a mistake in a previous section. To do this go to the navigation pane by clicking the button with the three horizontal lines on the top left of the screen (see red rectangle in image below). It will show the interactive table of contents of the questionnaire. You can then go to any section of the questionnaire (if it has been enabled).



There is no need to press a button in order to save progress. The app automatically saves progress throughout the interview so that the interviewer could stop the interview at any moment and have their progress saved up until that point.

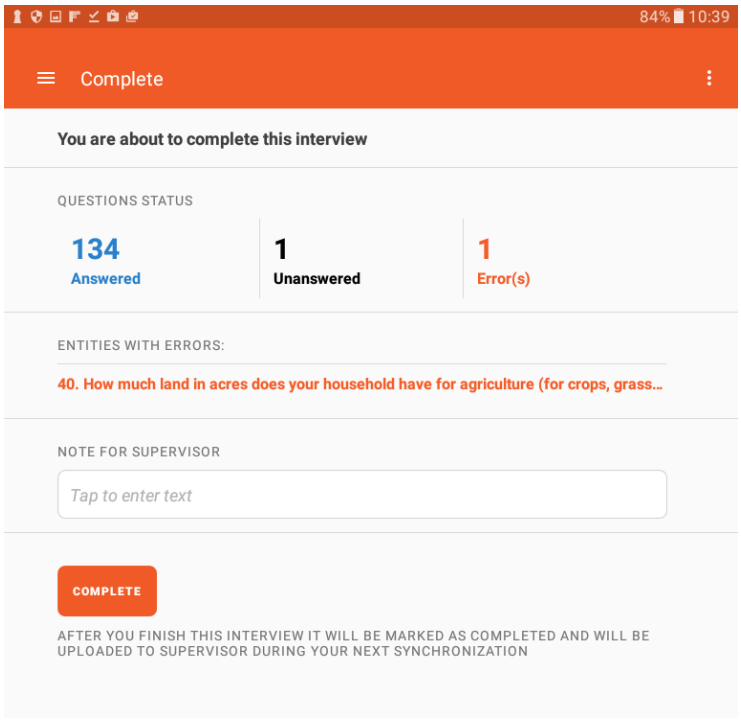
Finishing and checking an interview for completeness

Once an interview is finished, the button at the bottom of the screen will say "COMPLETE". Tapping that will take you to the screen below. It shows you the number of questions answered, unanswered and if there are any errors.



Always check for unanswered questions before completing an interview and leaving the household. You or the supervisor will have to go back otherwise, which will take much more time. If there are unanswered questions or problems, you should go back to the sections by clicking the three horizontal lines in the top left of the screen to go to the table of contents (see red rectangle in image above). There you can tell by the colour of the section where the missing answers or problems are. Ask any forgotten questions or make sure you made a comment why you couldn't ask a certain question.

If there are warning messages they will be shown in the complete screen (see below). Tapping the question will take you back there (make sure you made a comment with the question).



Once you have check everything is okay, click the COMPLETE button. This will mark the questionnaire as complete and be reflected in the status of that assignment on the interviewer's Dashboard.

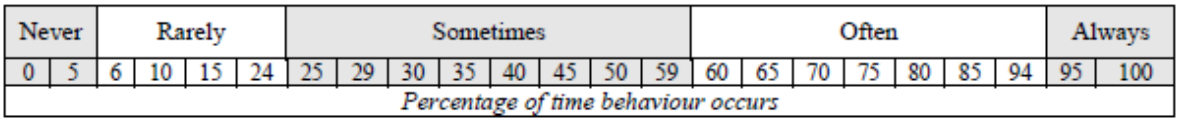
Supervisor checks

Before uploading the data, your supervisor will check all the interviews of the day on your tablet for completeness.

Annex 3: Definitions (in the context of the MPAT survey)

- An **'*adult*'** is anyone 15 years or older (However, the respondent has to be 18 or older).
- A **'*child*'** is anyone up to age 14.
- A **'*school-age*'** child is anyone from 5 to 14 years old.
- The **'*head of the household*'** is the adult or those adults that make decisions affecting the household (both on a day-to-day basis and for larger, more important decisions). This is usually the husband or wife or both.
- An appropriate person to answer the Household Survey, called an *adult of the household*, is a person 18 years or older who spends at least nine months of the year living in the household.
- A **'*household*'** is defined as a housing unit in which a group of people reside. If adult children are married and live in the same housing unit with their parents, they are considered part of the same household. Another way of understanding the definition of a household is based on joint cooking and eating. That is, if two families almost always cook and eat together, then they can be considered one household, even if they do not sleep in the same physical structure. Similarly, in cases where people have multiple spouses and children, if all spouses and their children live in the same physical structure or structures built closely together, or all cook and share food together, then they are considered a single household. A '*household member*' is someone who belongs to the household (usually due to familial relations). For the purposes of the MPAT survey, household members may also include people who spend nine or more months of the year living and working outside of the household, have the potential to send money back to support the household, and still consider themselves part of the household and that area/village to be their home. Household members who are living outside the household/village (more than nine months per year) for the purpose of studying *full-time* (university, trade school, etc.) or who are at boarding school are also included, as long as they are still dependent upon the household financially. People hired to work in the home are only considered household members if they both sleep and eat in the household.
- **'*Affordable*'** means that the fee/payment in question can be paid in a relatively short period of time with little or no assistance from people outside the household. There is no precise definition; it is the opinion of the respondent. This term is found in questions (hereafter 'Q') 6, Q14, Q37 and Q44.
- ***'Never-rarely-sometimes-often-always'*.** A time frame is not specified for the terms never, rarely, sometimes, often and always, and the enumerator should understand that *never* and *always* are the two extremes of the scale. *Rarely* is close to *never*, and *often* is close to *always*. *Sometimes* lies in the middle. The specific timescales or quantities involved depend on the behaviour in question, which in turn is contextually specific. For example, in Q29, cleaning hands before eating, the response will depend on the culture. Thus, if hand washing occurs

only once every few days in a culture where people usually eat three meals a day, this is *rarely*. If some days respondents wash their hands before one, two or three meals, and other days they do not, this would be *sometimes*. If respondents usually wash their hands, but not *always* (e.g. two times a day out of three meals) this is often. For further clarification, the choices can be thought of in terms of percentages (frequencies of the behaviour, as far as the percentage of time that the behaviour occurs). Thus, *never* would be 0 to 5 per cent of the time, *rarely* 6 to 24 per cent, *sometimes* 25 to 59 per cent, *often* 60 to 94 per cent and *always* 95 to 100 per cent – as depicted in the figure below. Again, these are not firm definitions, but are to be used as approximations when the enumerator does not otherwise understand which is the appropriate scale (based on the behaviour or action).



- Enumerators should keep in mind that most household survey questions are about *the majority of the household* and the situation of the majority, not just about the respondents' situation or the head of the household's situation. (xxii) In general, when the question applies to more than one person, the enumerator should attempt to record the response that best fits the *average* situation. For example, if asking about the time it takes to travel to school (Q5) and the household's children attend two different schools, then the enumerator should record the average of the time it takes for *both* schools.
- In some questions where numbers are expected (e.g., the number of minutes or months) there is often the option to use codes if the respondent does not know the answer and can't give a somewhat accurate estimate. The most used code is "-99", but "-88" and "-77" is also used. It is very important to enter these codes exactly like this and not enter for example "-999" or "99" without the minus sign. The skip codes of the next questions sometimes depend on this (warnings are built in if it looks like the minus was forgotten).

NOTES ON SPECIFIC QUESTIONS

In this section, specific notes are provided to help guide enumerators in understanding both the intent of specific questions and how to mark responses given atypical situations. ('H' before a number refers household roster questions).

- **Household roster.** First, a full list of all household members should be made, based on the criteria given above in the definitions file and starting with the household head. Only once the list is complete, should the enumerator move on to the next questions in the roster. Once the list is complete the remaining roster questions H.2-H.9 are then asked for each person. That means the enumerator finishes questions H.2-H.9 for the first person, before starting with H.2 again for the second person, etc.

We ask the names only to facilitate the interview. The names will not be used for anything else and will not be made known to anyone.

- **H.4. Age**. In many rural areas, people may not know their exact age. In these cases, best estimates are fine, but try to think of the important categories for the next questions: it is important to know if household members are below 5, between 5 and 14, or 15 and older. Following questions depend on these ages (see below). To help respondents, the enumerator can work with the respondent, referencing historic events, to help estimate ages as needed. Similarly, in instances where a respondent is not comfortable giving their age, enumerators should remind them that their responses are treated confidentially and gently ask again.
- **H.5. School attendance**. This is only asked for household members between 5 and 14. It is possible that children 15 years and older also go to school, but for the purpose of this study, school attendance is only measured for those between 5 and 14. For those 15 and older who are in school, and for whom this is their main activity, this can be indicated in question H.6 by choosing '*Student*'.
- **H.6. Main activity**. This is only asked for those 15 and older. Remember that it is the main activity. If someone goes to school all days, but helps on the farm after school and in weekends, the answer would be '*Student*'. But if someone for example works on the household farm or in the household shop most of the time but studies in the evenings, the main activity would not be a student, but a '*Farmer/livestock keeper'* or '*Household business*'. If the person gets a fixed wage for helping in the shop, it could also be '*Employee'*. In doubt, the enumerator should ask follow up questions until (s)he is sure about the answer.
- **H.8. Marital status**. This is only asked for the household head. 'Single' means someone who has not married. An adult who is separated from their spouse (but still technically married) and is in the process of getting a divorce can be marked 'Divorced'. If they are separated, but not planning to get divorced, then for the purposes of this survey they are still considered 'Married'.
- **H.9.** This is only asked for the household head. This question on literacy asks about a newspaper because the level of reading ability required to read a newspaper is usually similar across countries (whereas the ability to read a book would be much more ambiguous).
- **5** (Numbering for the questions following the household roster starts at 5, this is not a mistake). Do not forget that Q5 and Q6 concern only children living in the household that are between the ages of 5 and 14; they do not include 'children' 15 and older. If there are no children between 5 and 14 in the household, or these children do not go to school regularly, the software will skip these questions (also skips if one child goes to school, but two or more between 5 and 14 don't; this is the MPAT instruction).

  Please note that Q5 is asking for *one-way* travel time for children to get to school. If there is more than one school-age child in the household, with some children living at their school

(that is, they sleep there most school nights) and the others travelling to school, the enumerator should record the time (in minutes) that it takes those children travelling to school to arrive at school. If there are multiple children in the household and they attend different schools, then enumerators should calculate the average amount of travel time needed. Lastly, if there are seasonal differences (for example, more time needed during the rainy seasons because some roads are washed out), take the average time needed over the entire school year.

- **6** If there are multiple children in the household, the enumerator should attempt to record the response that best fits the average situation across these children (note that this is a common approach for answering MPAT questions that apply to more than one person). The response 'Household does not pay fees or supply costs (8)' means that the household does not need to pay the fees or supply costs because they are already paid (by government, an aid agency, scholarship, etc.).
- **7 & 8** Q7 and Q8 apply to all children in the household between the ages of 0 to 14 (they do not apply to children 15 or older. These questions ask for the *likely* level of education the children in the household will complete, *not* the *ideal* or *desired* level of education, but the *probable* level of education the child/children will complete. This is, of course, determined by multiple factors: the household's circumstances (socio-economic), the educational opportunities available, the intellectual capacity of the children, the need for the children to assist with farm/non-farm work, etc. Enumerators should ensure that respondents understand this notion of *likely/ probable*.

  If there are two or more girls, or boys, in the household, then the *average* highest level of education they will likely complete should be recorded. For example, if there are two male children, and the respondent expects that one will eventually attend junior school and the other technical school, then the average would be 'High school' (answer code 4). If two children are expected to achieve two different levels of schooling that are ranked next to each other, such as junior school and high school, then the more advanced level of schooling should be used as the average ('High school' in this example). The answer choices in the table to the right of the questions provide standard levels of education. The ages provided after each answer choice (in parentheses) are intended only as a guide to help understand the typical ages of students at each educational level.
- **9 & 10** These questions measure the frequency of illness, 'averaged' together for all members of the household. For Q9, a 'non-serious illness' is one where the person is clearly ill (i.e. they have symptoms that make it obvious to others that they are ill), but they do not have to remain lying down during the day. 'Serious illness', in Q10, by contrast, is defined as an illness that is so severe that the person must remain lying down for two days or more. For example, in Q9, assume that there is a household with two people: if one of these people is always suffering from a minor illness and the other person is almost never ill (over the last 12

months), then the best answer choice for this household would be ‘Sometimes (3)’ because this is, roughly speaking, the average of the two situations (i.e. ‘Always’ and ‘Never’). It should be kept in mind from the ‘Definitions’ in Section 6.2 that ‘Sometimes’ means roughly 25-59 per cent of the time. In the case of this question referring to the last 12 months, ‘Sometimes’ means roughly three-to-seven months. Anything more than that is ‘Often’ or ‘Always’ and anything less than that is ‘Rarely’ or ‘Never’. The MPAT Design Team recognizes that this approach sacrifices some precision and accuracy, and that different enumerators will inevitably come to slightly different answers in households where the health situation is more complicated. But by following these guidelines, enumerators should arrive at similar answers across similar households.

- **11 & 13** These questions are asking for the *one-way* travel time to the health centre by whatever means of transport would usually be used (walking, bicycle, motorcycle, bus, etc.). The enumerator should record the number of *minutes*. For example, if a respondent answers ‘two hours’, the enumerator should record 120 minutes. If the respondents use the same health centre for both simple and serious illnesses (Q11 and Q13), then the number of minutes should be the same. In Q11, it is assumed that if there is no health centre in the area, or the health centre is ‘Too far to travel to’, then this applies also to a health centre that could treat serious illness or injury (as such a centre should also be able to treat the simple illnesses that are the focus of Q11). Clearly, the notion of ‘too far’ is subjective and each household will have a different conception of how far is ‘too far’. This is acceptable, as MPAT is designed to identify issues surrounding physical access and perceptions of access.
- **12** ‘This health centre’ refers to the health centre discussed in Q11. ‘Supplies’ means anything the health-care staff need to be able to work (such as medicine, bandages, crutches, beds, etc.). The term ‘adequate’ is subjective, that is, what is adequate for one person may not be for another. Again, this is acceptable, as the purpose of the question is to get the opinion of the respondent.
- **14** If the respondent verbally responds with a simple ‘yes’, the enumerator should then discuss the question with them further in order to understand which ‘Yes’ response is most appropriate. The definition of ‘professional treatment’ is not specifically defined here and is up to the respondent to define (professional treatment might include traditional medicines or medicines from other sources.
- **16** This question seeks the opinion of the respondent in order to better understand gender and social equality in the village relative to access to health care. It asks about the health-care services for women at the health-care centre ‘*if* they seek it’. That said, the answer choice, ‘Yes, but women prefer not to go’ tries to capture the idea that, even though a health-care centre may provide reasonable health care, there may be other reasons that prevent women

from accessing it (e.g. that the doctor is a man and the women are uncomfortable using his services due to personal discomfort, mistrust or prevailing gender norms in the area).

- **17 and 18** For both these questions, the enumerator should not ask the respondent, but observe the house and note the answer. If the enumerator cannot tell what the material is, or if the enumerator is interviewing the respondent at a location that is not at the house, they should choose the answer '*Not possible to observe*'. The answer should be the *primary* construction material. For exterior walls, this would be the material that bears the load of the house (upper floors and/or ceiling) and protects the interior of the house from weather. In areas where households have multiple structures (e.g. in small compounds), these questions refer to the *primary* housing structure. The 'housing unit' is the structure that people sleep in, the 'main house'. If either the exterior walls or roof are made of multiple materials and it is not clear which is the primary material, then select 'Other' and specify the materials in the margin (using the answer codes if desired). Answer choice 'Brick (fired/burned) (4)' refers to fired/burned permanent bricks, which may come from a large commercial brick company or a small-scale brick-firing operation (i.e. a local kiln). Answer choice 'Metal sheeting' (response 5 in Q17 and 4 in Q18) refers to any kind of metal sheeting – zinc, iron, corrugated iron sheets, etc.
- **19** This question refers to the current housing structure as described in Q17 and Q18. 'Severe rain' can, of course, cause flooding, so this question also applies to the home's ability to withstand flooding (or wave action in some areas).
- **20, 21 and 22** For all three questions, the energy/fuel source is the *primary* source; that is, the source that is used the majority of the time or in most of the housing unit. For example, in Q20, if the housing unit is lit by candles and light bulbs, but more rooms are usually lit by light bulbs, then light bulbs are the primary source, and the enumerator should determine the source of electricity of those light bulbs and mark that as the response. Concerning answer choices '3' and '4', the enumerator can talk with the respondent to determine if the electrical supply is stable or not. For example, if the lights dim or brighten randomly, or when other electrical devices in the home are turned on (such as a water kettle), this suggests that the electrical supply is not stable. 'Electricity from a generator (5)' refers to generators powered by any fuel/energy source (including human/animal power). 'None (1)' suggests that the household would use an energy source were it available (but that no energy source is available). This is different than, for example, 'Heat not needed in the region (2)' because, in such instances, respondents could heat their home if necessary, but they do not need to. For households using peat or animal dung (e.g. cow dung) as a fuel source, the answer code 'Wood, sawdust, grass or other natural material (12)' should be used.
- **23** For this question, it is not important where the household's human waste (fecal matter) goes after defecation (e.g. a pour-flush toilet that flushes into a river or into a septic tank are,

for this question, the same, and the answer would be ‘Enclosed pour-flush toilet’). The only exception is for ‘Compost or biogas’, as it is useful to learn if a toilet facility converts waste into compost or biogas.

- **24** This question refers to any type of toilet facility. Only those households that answered ‘None, open defecation (1)’ in Q23 will not answer Q24. 25, 26 and 27 Q25 refers to non-edible food waste (e.g. orange peels, corn cobs, bones, etc.). If the respondent answers that they discard waste in a ‘dust bin’, ‘garbage can’ or ‘hole in the ground’, the enumerator should ask further questions to determine what happens to the waste afterwards. Is it discarded near the house, far from the house, collected or burned? These follow-up questions will help the enumerator determine the most appropriate answer choice for this question. The answer choice ‘Discard near a house (2)’ means that waste is discarded near *any* house, either the house of the respondent or someone else’s house. ‘Feed to livestock (4)’ refers to chickens, ducks, goats, cows, etc. (but not ‘pets or guard dogs’ as they are not considered livestock because they are not raised to augment food consumption). In Q27, wastewater from ‘the toilet’ refers to water used for any type of toilet, and which is then also used for another purpose, such as irrigating plants near the toilet or collected to irrigate fodder crops, etc. If the wastewater is put down a drain that drains under the house, the enumerator should select ‘Discard close to a house (1)’ as wastewater is not being disposed of in a drain that leads to a piped sewage network (in the case that it is, mark ‘Put down the drain [piped sewage network] (8)’).
- **28** This question asks for the frequency with which the *majority* of household members clean their teeth (by any means, with or without toothpaste, using a wildgrowing root, etc.). Thus, if there are three people in the household and one cleans their teeth every day, but the other two never clean their teeth, the answer should be ‘Never’. If there is an even number of people in the household, the enumerator should choose the answer that represents the better behaviour. For example, if two people ‘Rarely’ clean their teeth and two people clean their teeth ‘Most days of the week’, then ‘Most days of the week’ should be chosen as the answer. Please note that questions 29, 30 and 31 are asking about the adults in the household, whereas 28 refers to most members of the household.
- **29 and 30** ‘Cleaning’ signifies employing any means to sanitize the hands (for example, with or without soap, with sand).
- **31** ‘Soap’ refers to any kind of cleaning agent designed for washing hands, dishes or clothing. It can be in a solid form (as in a bar of soap), a liquid form (as in detergent) or in a powder form (as in laundry detergent). This question refers only to using soap to clean hands, not the body (as when bathing).

- **32 Water sources.** The purpose of this question is to learn about the quality of the water, based on the water source type. 'Primary source' indicates the source from which the water comes immediately before being used.

  This question is asked for the rainy and dry seasons separately. If the household uses two different sources in those seasons, we also ask which of these is used *during most of the year*. This should be either the source mentioned for the rainy season or that mentioned for the dry season.

  In cases where it may not be clear what is meant by these types of water sources, enumerator trainers should provide enumerator trainees with pictures of the most relevant water sources in the region, so that everyone is in agreement as to what is meant by these terms.

  Simple/common definitions should also be used when possible; for example, a 'River' is a flowing body of water too wide to jump over, whereas a 'Stream' is a smaller body of water that may be narrow enough that an adult could leap over it.

  Sometimes the enumerator will have to ask follow-up questions. If the respondent says they use a well, the enumerator has to ask if it is a private or communal well. 'Private' means used primarily by the household, but may also be shared with **two to four** other households, and is located within 100 metres of the household. 'Communal' means shared by **five or more** households. These definitions are, in this case, not about ownership, but about how many households use a given water source. If the respondent says piped water, it should be asked where it is piped from. It could be 'Piped from water treatment plant (chlorinated)' which should only be used when the water comes through pipes from a water treatment plant that uses chlorine (any form). If the water is piped from a water treatment plant that does not chlorinate the water (for any reason, such as broken equipment, lack of supplies, etc.), the answer choice 'Piped from water treatment plant (not chlorinated)' should be selected. But the water could also be piped from a borehole, and this can be a deep or shallow borehole. As rain is, ultimately, the source of all freshwater, 'Rainwater harvesting container' would only be an appropriate response if the household collected water from a rainwater harvesting tank or other container, such as buckets placed under a metal roof. Rainwater that falls into an irrigation canal and is then collected from the irrigation canal would be marked as 'Irrigation canal'.

  If the household uses multiple water sources for drinking and cooking (e.g. from the well for drinking and from the river for cooking), the enumerator should only record the drinking water source, *but should make a* note of this, so it is clear that the drinking and cooking water sources are different.
- **33 to 38** For Q33-38, 'water' refers to the water the household uses for drinking and cooking.
- **33 Time to collect water** This is the total time needed to collect water for one day. Thus, it is found by adding together the round-trip time for each trip for each person in the household.

For example, if a mother and daughter both make one trip to the water source and it takes 30 minutes to get there, the recorded response should be 120 minutes (30 minutes to get there, 30 minutes to get back = 60 minutes round trip for one person. Because there are two people, mother and daughter, 60 + 60 = 120 minutes total). Also, if respondents spend a significant amount of time (more than 10 minutes) waiting to collect water once they reach the water source, this amount of time (in minutes) should be added to the total time needed (i.e. travel time to the water source + waiting time + travel time back home). If one person collects water for the household but does so in the course of multiple trips taken in one day, the enumerator should add up the total number of minutes used for all trips. Similarly, if two people make multiple trips together, the enumerator should take the total number of minutes for the multiple trips for each individual and add them together. If the household collects water from within the household or yard compound, the enumerator should write '1' minute. This form of collection can be from any withinhousehold source – for example, a rainwater container, a well within the household compound or a piped water supply. If the household collects water from two sources (e.g. for drinking and cooking), then the enumerator should add the time together and use the *total time* for both sources. Again, the enumerator should record the time in minutes (one hour is 60 minutes, two hours is 120 minutes, etc.). If the respondent is having difficulty providing an answer (after the question is read twice), the enumerator can provide them with broader ranges of time to make answering easier. That is, the enumerator can suggest: 'less than 10 minutes, 10 minutes to 20 minutes, 30 minutes, one hour,' and so on.

- **34** If the respondent says that the household does not treat its water, the enumerator should attempt to understand whether this is because the respondent believes that the water source is of good quality and therefore does not need to be treated, or if the water should probably be treated, but is not. In the first case, the enumerator should mark answer choice 'No treatment is necessary (1)', in the second case, they should mark answer choice 'Never (2)'.
- **38** This question asks for the respondent's opinion to get an understanding of the household's subjective assessment of its water's quality. These perceptions may be based on water colour or smell, local rumours, public health information campaigns, etc.
- **39a** This refers to land that the household can *reliably* use for any agricultural purpose (crops, grasses, trees/orchards and so on), for livestock and/or for aquaculture (fish-farming). This is any kind of reliable access, whether the land is owned outright, leased, squatted on or shared with a few other households. If the adults in the household work as wage-labourers, then, for the purposes of this question, they are considered *not* to have access and the response should be marked 'No access to land (4)'. If, on the other hand, the household has a share-cropping arrangement with the landowners, then this *is* considered access and the response should be marked 'Yes, have access and using the land (1)'. [*Note:* land-tenure is addressed specifically

in Q50.] To clarify the difference between fisheries and aquaculture: aquaculture, or fish-farming, entails the intentional rearing of fish by providing, at a minimum, fish feed (which is why it is somewhat akin to agriculture, wherein one intentionally cultivates crops – rather than harvesting wild plants or plant products). Fisheries, on the other hand, entails the catching of fish that have not been reared/fed by people. See the note for Q48 and Q49 as well.

- **40** This question is focused on the land the household uses regularly for agriculture, orchards or forestry (legally or illegally, leasehold or not). It also includes land that the household could use for agricultural purposes, but may not be using in that way at the current time (for example because left fallow). This question does not include common access land that is used for grazing livestock or for aquaculture, in which case the enumerator should mark 'None, only access for livestock/aquaculture' and skip to Q46. If the respondent is not sure, ask them to estimate or ask another household member.
- **41 and 42** For both these questions, 'majority' is meant to designate the spatial majority of the land in question (so if the household has 100 square metres of land, the enumerator is asking what the slope/ soil type is for 50+ square metres of the household's property). If no one slope or soil type represents a majority, then the answer is 'Mixed'. If possible, the enumerator should specify the particular mixture by writing it in the margin of the survey. For example, they might use the answer codes, 'Mixed (4) and (5)' or, better still, '40% (4), 40% (5) and 20% (3)'. (It should be noted that in instances of mixed land types, if the enumerator does not attempt to determine specific mixtures, the MPAT Excel Spreadsheet will view the question's answers as missing data and they will be omitted.) If the respondent is not able to communicate the kind of soil clearly, the enumerator can help them understand the different options, as farmers will know their soils well, but may not always be able to articulate this (sandy, clay or wet, etc.).
- **43** If the respondent says that their household does not use compost/ manure/fertilizer, the enumerator should first clarify the reason they do not use it before marking the response. If the respondent feels they do not need it, then the enumerator should mark 'Household does not think they need to use compost/manure or fertilizer (1)'. If the respondent suggests that they might like to use it, but cannot afford it or were not able to make it, then the enumerator should mark 'No (2)'.
- **45 and 46** 'Enough water' is water from any and all sources and combinations of sources needed/ used for crops/livestock. For example, a household may not usually have enough rainwater to support livestock, but when rainwater is combined with water from a borehole, that household usually has enough water to do so. These questions are not about the ease or difficulty of collecting water, but rather if there is or is not enough water for crops/ *livestock* (however it is collected/acquired).

- **46a** ‘Livestock’ is considered to be the ownership of more than a few animals. Owning a few chickens or one or two sheep, for example, would not qualify as livestock. However, the local context and the specific animals owned by the household can affect this definition: for example, owning one cow in some regions might indeed be considered owning livestock, as cattle tend to be highly valued animals. Thus**,** it is important to *consider the local context and local conception of what it means to own livestock when asking this question.*
- **48 and 49** MPAT uses the FAO definition of aquaculture,16 which essentially defines it as being an intentional activity of raising fish, as opposed to fisheries, which are areas where people may go to fish. The lines between aquaculture and fisheries can be blurry in cases where there is management of a body of water; however, if fish are not intentionally raised, fed and/or protected, then for the purposes of MPAT, the source of fish is considered a fishery – and not aquaculture.
- **50** ‘Farm’ refers to any farm-related activities that the household is engaged in, such as agriculture (crops), orchards, forestry, livestock-rearing and aquaculture.
- **51** This question refers agricultural land. If a household does not have access to nor own any land, except for the land that the house is on, this question should be skipped. The answer choice ‘Common-law ownership (4)’ is basically a freehold arrangement, but without a title or deed to prove legal ownership (i.e. it is not technically legal, but it is expected that the government will likely continue allowing people to use the land). The distinction between answer choice ‘Illegal access, squatting (1)’ and ‘Common-law ownership (4)’ is that in the former, people using the land will likely face the threat of eviction by the landowners, police or government. In the case of commonlaw ownership, the land users know that there is not a legal arrangement, but they are not worried about eviction anytime in the near future. In a country such as China, where the government technically owns the land, answer choice 10 would be most appropriate.
- **52** This series of questions asks respondents to think about possible negative *events* (not to be confused with *outcomes* of these events). This is a potentially confusing question, so detailed instructions are provided below. First, the enumerator should read Q52 aloud exactly as it is written. Then the enumerator should read it aloud a second time if it was not easily understood the first time. If the respondent is still not clear on the meaning of the question, the enumerator should break the question into two parts: (i) The enumerator should ask the respondent to ‘Please think about all the possible negative events that could occur in the next 12 months’. They should allow the respondent to list as many potential events as they like. Allowing the respondent to talk freely makes it more likely that they will identify multiple events. The enumerator should ensure that it is understood that the events in question are *negative*, meaning that they would harm or limit the well-being of the household, the household members’ livelihoods, the household’s agriculture, livestock or aquaculture, and so

on. If the respondent has difficulty understanding this question (its hypothetical nature may be challenging in some contexts), and the enumerator has already repeated the question and it is still not understood, then the enumerator may use examples to help the respondent understand the question's intention. However, these examples should not be of negative events (disasters) that are relevant to the area in question, so as to avoid the risk of influencing the respondent's thinking and answer. Thus, for an inland area the enumerator might suggest a hurricane, for a tropical area they might suggest a blizzard, etc. (ii) Once the respondent has finished talking, the enumerator should ask the respondent 'Which of the negative events *you* just mentioned are *you most* worried about?' The enumerator should write the answer in the box for 52.1. The enumerator should continue with the second most-worried-about event (52.2) and third (52.3), and should only record the first three events. It is acceptable if the respondent mentions only one or two events. In that case, write "-99" in the remaining one or two spaces. DO NOT LEAVE BLANK. In the event that the respondent answers this question by saying that it is impossible to determine, that 'only God knows' or some variant of this, the enumerator may politely continue to pursue an appropriate line of questioning, such as asking the respondent to think about what God might expect them to reasonably prepare for or expect as far as negative events. It should be noted that the answer choices 'Don't know (-99)' and 'Not very worried about any negative events (-88)' have two distinct meanings. If a respondent does not have an answer for Q52, the enumerator should try to determine which of these is the most appropriate answer choice through additional follow-up questions.

- **53 and 54** After the enumerator has received answers for Q52 and filled in the boxes for 52.1, 52.2 and 52.3, they should then ask Q53 (likely severity of the most- worried- about event) and Q54 (likely frequency for the most-worried-about event) for the negative events recorded in Q52 (either one, two or three events). The enumerator should record the responses in the boxes for 53.1 and 54.1 using the codes provided. Then they should repeat questions Q53 and Q54 for the remaining events. If the respondent mentions a higher likely damage AND frequency for the second event than for the first, the enumerator should ask again, because the event the respondent is MOST worried about should be entered in the first box.
- **55-58** These questions are designed to gain an understanding of how the household would likely react to the occurrence of one or more of the negative events that the respondent mentioned in question Q52.
- **55** The respondent should be given time to think about this and consider different possible responses. This will make it easier for the enumerator to then ask the respondent to identify their primary, secondary and tertiary coping mechanisms in the case of such an event (the respondent may list more than three coping mechanisms). The order of entering the answers here is important. You should tick the primary strategy first. You will see a 1, 2 and 3 before

the tick boxes to indicate the order. If the respondent can only think of one likely coping mechanism, the enumerator should only tick one box.

This question has many answer options. Try to get to know the answers so it is easier to find what an option that matches what the respondent said. Do not use the "Other" option because you think it easier than looking through the long list. We will check if this happens.

- **56 and 57** As with the other questions that ask for an estimated time period, the enumerator should convert the time into months (e.g. three years would be 36 months). For Q57, if the response is less than one month, the enumerator should just write '1' in the box. Q57 asks about rebuilding the home to something that is similar to the condition/type of home before the shock/disaster (as opposed to an ideal type of home). For Q57, the response choice 'We would move' means that the household would move *outside* its current village. Meanwhile, the response 'Our household could not rebuild' means that the household would try to stay in the village but would have to find a new home or move in with friends/ relatives.
- **58** In some countries many respondents may answer 'God' for Q58. In such instances, the enumerator should politely continue to pursue an appropriate line of questioning, asking, for example, 'Who do you think God would have help you?' If the answer is 'neighbours', this should be marked as friends, as unfriendly neighbours would likely not help.
- **60** 'Hungry' means hungry not by choice, but due to a food-limited situation.
- **63.5** 'Dairy' refers to the consumption of even small quantities of dairy products (such as milk in tea/coffee).
- **64** This question asks about a business in which someone in the household made an initial and/or continued investment of money, equipment or other. There are many types of possible 'non-agricultural businesses' in rural areas, but some examples might be a small retail shop, a tea house, a battery-charging station, transport (bike taxi, motorcycle taxi, etc.).
- **65** This question refers to people in the household (not people living away from the household several months of the year and working) and specifically to skills outside the basic agricultural sector, that is, skills other than sowing/ planting, harvesting, etc. Special processing of crops for eventual sale at market *is* considered a skill in *Q65* (i.e. processing that requires skills or special equipment, such as making sunflower seed oil, harvesting honey or grinding groundnut flour, but not simply putting crops in the sun to dry). Bookkeeping services, basic accounting services, carpentry, metalworking and crafts are other examples of skilled service provision.
- **66** If the respondent simply answers 'yes', then the enumerator should ask additional questions to clarify which response is most appropriate.
- **67** The severity of the household's debt – a little, a moderate amount or a lot – is to be determined by the respondent. That is, the amount of debt that the household owes is *not* determined by the actual amount of monies in question, but rather by the household's

perception of that sum and its perception of how difficult it will be to repay the amount. This is because the same amount of money will be perceived differently by different households – what is considered to be an extreme amount of debt by one household may be seen as a small amount of debt by a more-financially secure household.

- **68** If the 'majority' of the household debt is owed to two or more different sources, then the enumerator should select 'Other' and specify.
- **69 Footwear.** 'Adequate footwear' refers to any kind of footwear (for example, sandals, boots, cloth shoes) that is appropriate for the climate and weather of the region in question, sufficiently protecting the individual's foot from injury and local weather (sun, rain, wind and so on, in accordance with the region).
- **70 Clothing for extreme weather.** 'Sufficient clothing' refers to clothing that will keep the individual warm if the weather is cold, or dry if the weather is very wet, or provide sufficient protection to the skin in areas with strong sunlight. 'Severe weather' may range from a blizzard to a sandstorm; thus, the enumerator should understand that 'sufficient' for 'severe weather' depends on the area and climate in question.
- **71 Number of televisions.** Q71 refers to working televisions of any size (colour or black-and-white) that the household owns, or that are regularly used by the household and stored in its housing unit. If the answer is 'Yes', the enumerator should ask if the household has more than one television and write the number (0, 1, 2, etc.) in the box. If the household has a television that is broken but is currently being repaired (and will likely be usable after repairs), that television should be included in the answer to this question.
- **72** Depending on the particulars of the village, the enumerator may find it helpful to remind the respondent that there are some minority households in their village (whether based on ethnicity, religion, caste or other minority group status), as it may be that a majority (e.g. ethnic majority) household may not consider these issues to be related to minority status. If the answer choice 'Don't know' is selected, the enumerator can ask Q73 and, most likely, the respondent will also reply that they do not know, in which case 'Don't know' should also be selected for Q73.
- **73** The three answer choices for 'Improved' indicate that the situation has become *more equitable*, and thus it has improved in this sense. Meanwhile, the situation of inequality has 'Worsened' if it has become increasingly inequitable.
- **74 & 75** In these questions, other than before, you have to read out all the options to the respondent and tick the box for all the apply. Be very careful, because it is easy to miss a tick box.
- **76** Here you have to enter the 3 main sources of water, but if the household only uses 1 or 2 sources, just tick those. The order of entering the answers here is important. You should tick

the primary water source first. You will see a 1, 2 and 3 before the tick boxes to indicate the order.

- **81** By young we mean since the respondent was about 15. For some young respondents this may be only a few years ago, making it harder to have observed changes, but in that case the answer should be 'No'. The respondent should only answer about his own perceptions, not about stories (s)he has heard from parents or other villagers.
- **82-83** This could be that they changed the timing of planting, or plant different crops, but the enumerator should not mention examples, because this could change the answers of the respondents.

Annex 4: MPAT Supervisor manual

MPAT Supervisor Manual

Repeat interviews

One short 10 question repeat questionnaires has been programmed into Survey Solutions. Only the two supervisors have access to these questionnaires. Supervisors should resample 10% of the interviewed households.

- The tablets of the supervisors will be preloaded with 30 repeat questionnaires.

- How to select re-interview households: Rotate by enumerator so equal checking is done. Select close and far away households to check. Do the repeat questionnaires on the same day as the original interview, so data can be uploaded together.

- Repeat questionnaires will be compared together with the main data on the evening of each day and if there are significant differences, this will be reported back with the main comments.

- If the answers don’t match: If there are big differences between the answers, then you must return to the household and confirm together. Then use the new figure. Send any corrections with name and household ID to the data quality manager.

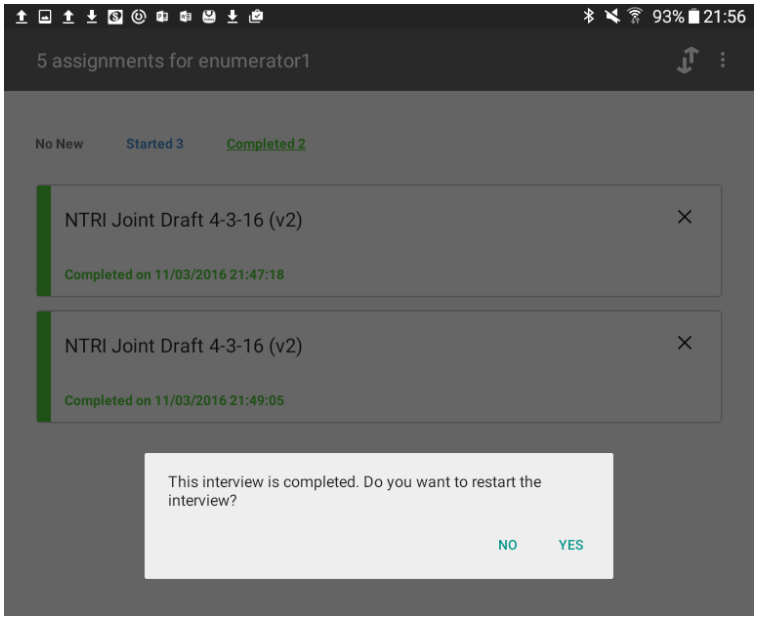
Debriefing

Supervisors will hold a debriefing with all enumerators at the end of the day in which any problems or issues met during the day are discussed. If the supervisors cannot solve an issue, they will confer with the study lead, Fanny Minjauw.

Supervisor checks

Before uploading the data, the supervisor will check all the interviews of the day for completeness on their enumerators' tablets. To do this, the supervisor will go to the Dashboard. There he can open the "Started" (blue) interviews and "Completed" (green) interviews. In principle interviews should be completed.

Click on "Completed" (and "Started" if there are any open interviews) and a list of interviews will appear. Click on an interview to open it. If you try to open an interview from the Completed list, you will see this message (see screen shot). Click yes to open.



The interview will open on the first question. Go to the table of contents (by clicking the navigation button) and select the "Complete" option at the bottom of the table of contents. This will take you to the Complete screen. Follow the steps in Software Section L of the enumerator manual to check the questionnaire for completeness.

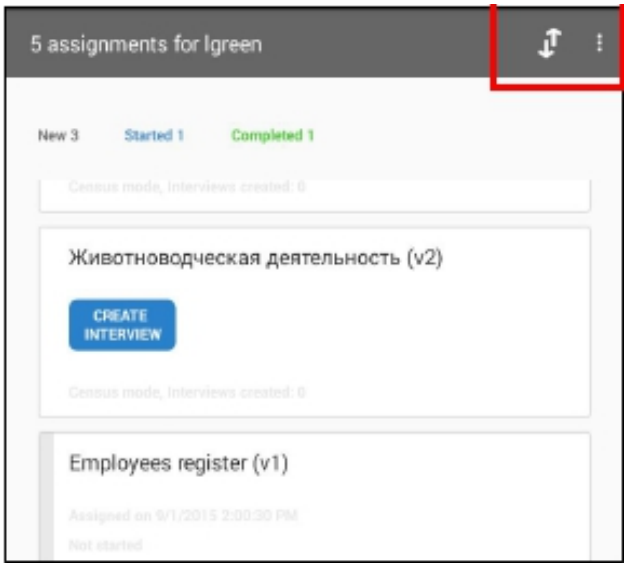
The supervisor will discuss any unanswered questions (blue) and problems (red) with the enumerator and fill out comments if these are missing. If everything is correct and the interview is ready for uploading, click complete. Do this for all interviews on the tablet.

Uploading data

This is the job of the supervisor. At the end of each day, the interviews should be uploaded to the main database. By clicking the menu button (three dots) in the top right hand corner, you can navigate to the Dashboard.

Only interviews marked as "Completed" on the Dashboard will be uploaded. Interviews marked as "Started" will remain on the tablets (if these are to be finished the next day, leave them, but if they are interviews opened by mistake, remove them).

For uploading the interviews take the same steps as for downloading questionnaires: click the two arrows (synchronization) button at the top right of the Dashboard screen. Finishing one tablet before starting another will prevent errors if there is little bandwidth.



Checking errors in the data

Supervisors should agree a procedure with the data quality person to let her know when all data has been uploaded and how many interviews to expect (including how many Supervisor repeat questionnaires). The data quality person will compile an error report with the errors per enumerator in Dropbox or by email (agree with data quality person on procedure). This file will also include the comparison of the 10% repeat questionnaires. This will arrive late. The supervisors will discuss the errors with the enumerators the next day before starting new interviews that day. They will also comment back on all errors (if they should be corrected and how, but also if the enumerator does not have an explanation), and send this back to the data quality person every day.

Software

1. Installing the software on the tablets.

The tablets will come with the software already installed, and it should not be necessary to download the software again, but the steps to do so are given below for completeness:

Step 1: On the tablet, go to Applications—>Settings. Select "Security" and make sure that "Allow installing application from outside Play Store" is ticked.

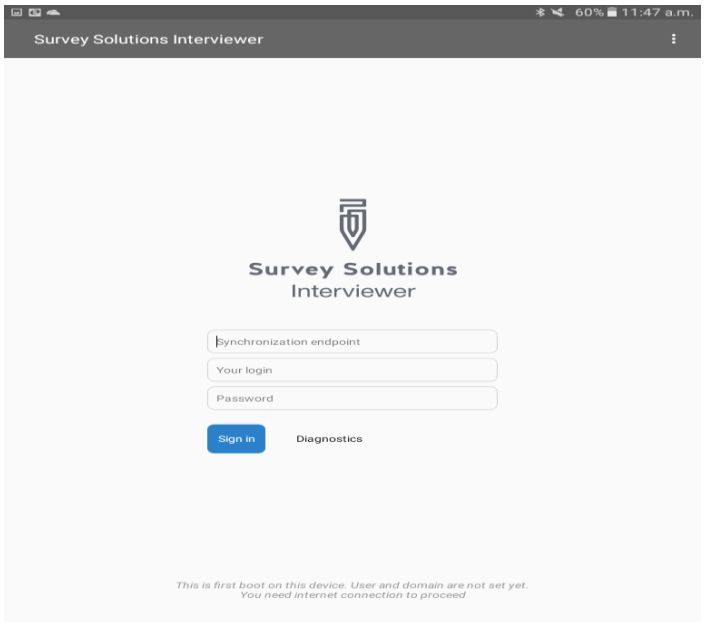
Step 2: Open the Chrome browser and navigate to the address demo.mysurvey.solutions

Step 3: At the very bottom of the login screen, click on the "Get Interviewer App" button and wait until the download is completed

Step 4: Go back to the home screen and select Applications—>Downloads. Click on the last version downloaded and choose "Install".

2. Assigning tablets to enumerators

A tablet is assigned to an enumerator by logging into the Interviewer app with pre-determined sign-in data. The first time an enumerator signs in, the server address must also be entered in the field called "Synchronization endpoint". The server address is: https://mpatsirp.mysurvey.solutions. This has to be entered completely. The next two fields are the user name and password. Initial login requires an internet connection.

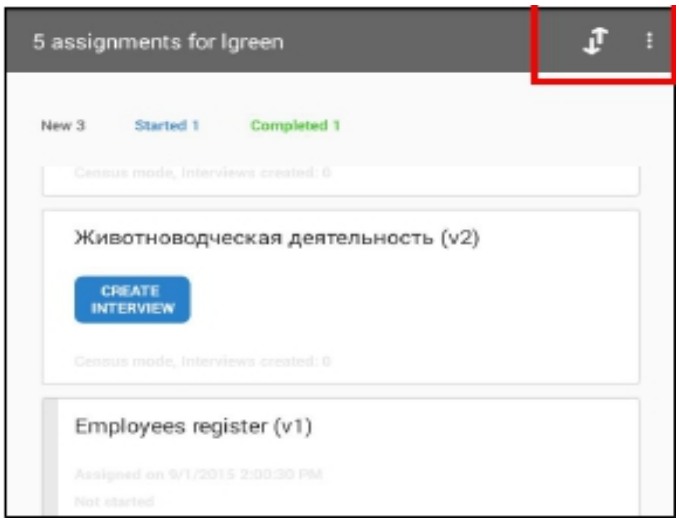


Once logged in, a tablet is assigned to that specific enumerator and only this enumerator can login to the Survey Solution application on that tablet. To re-assign a tablet to a different enumerator, the Interviewer app has to be deleted and re-installed. The installation file should still be available in downloaded files, otherwise it needs to be downloaded again (30 MB).

To assign a new tablet to an enumerator, for example because a tablet crashes and cannot be restored, the enumerator has to login on the new tablet as described above. All interviews that were not yet uploaded on the enumerator's original tablet will be lost. The old tablet cannot be used before the application is deleted and reinstalled (the old enumerator can still login, and start a new interview but cannot synchronize anymore, so data would be lost).

3. Downloading the questionnaires

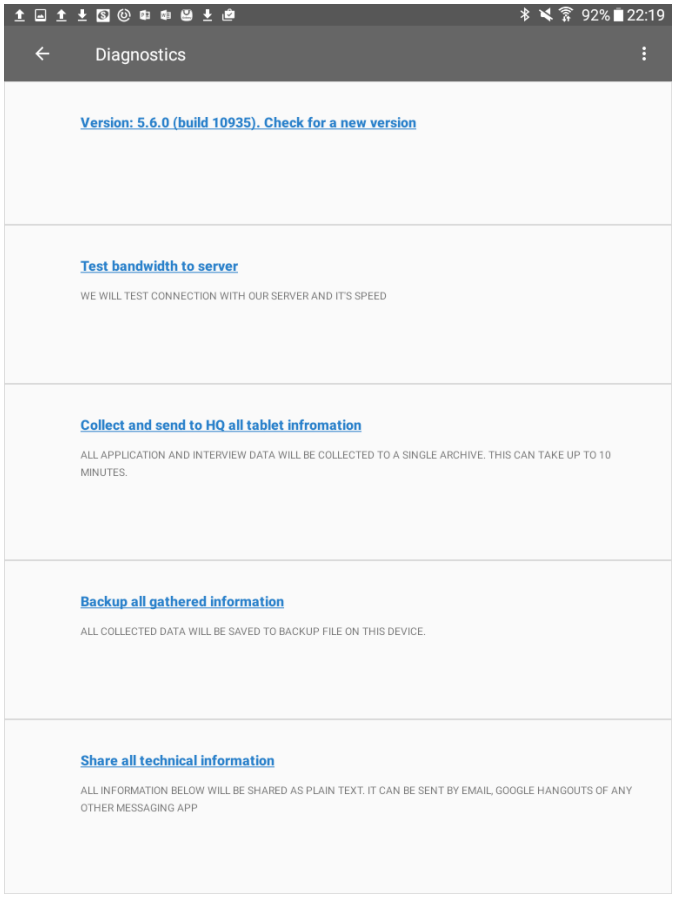
For this you need to synchronize the tablet with the server headquarters. After signing in, you will see the "Dashboard" screen. It has a synchronization (arrows) and menu (three dots) button in the upper right-hand corner of the screen. After tapping the synchronization button the latest questionnaire will be downloaded (and completed interviews uploaded – see below). The menu button allows navigation to the Dashboard, Settings and enumerator Sign out of the tablet.



4. Troubleshooting:

The diagnostics option under the menu button (three dot, top right corner) provides a number of options for troubleshooting problems with synchronization. Under this menu you can:

- Check for updates to the interviewer application
- Test your network connection
- Manually back up the data collected to Headquarters
- Create a backup of data collected on the tablet device
- Share device specifications and information


92% 22:19
Diagnostics
Version: 5.6.0 (build 10935). Check for a new version
Test bandwidth to server
WE WILL TEST CONNECTION WITH OUR SERVER AND IT'S SPEED
Collect and send to HQ all tablet infromation
ALL APPLICATION AND INTERVIEW DATA WILL BE COLLECTED TO A SINGLE ARCHIVE. THIS CAN TAKE UP TO 10 MINUTES.
Backup all gathered information
ALL COLLECTED DATA WILL BE SAVED TO BACKUP FILE ON THIS DEVICE.
Share all technical information
ALL INFORMATION BELOW WILL BE SHARED AS PLAIN TEXT. IT CAN BE SENT BY EMAIL, GOOGLE HANGOUTS OF ANY OTHER MESSAGING APP

Annex 5: Details on ethical process

This research study uses data collected by IFAD in accordance with official IFAD and United Nations regulations. Direct reference is made to confidentiality in the UN principles on personal data protection & privacy and direct reference is made to consent in IFAD's data privacy guidelines. More information on data governance, processing, ethics and confidentiality can be accessed in the following policies and resolutions:

- **Updated IFAD Data Governance Policy** (IFAD, 2022, p. 2) which governs the ways in which IFAD uses, processes and disseminates data, including operational and administrative data.
    - "The principles guiding the policy are as follows: it should be people-centred to generate benefits for rural people through data use, and do no harm; all data should be systematically assessed for quality and integrity; data should be findable, accessible, interoperable and reusable, and ensure accountability and transparency; data management should be proportional and minimally burdensome; and IFAD should promote a data-driven culture of decision-making".
- **IFAD Personal Data Privacy Guidelines** (IFAD, 2021b, p. 8)
    - "Principle 1 (b) The consent of the Data Subject is obtained: Consent means any freely given, specific, informed and unambiguous indication of the Data Subject's wishes by which it agrees to the Processing of its Personal Data. Requests for consent shall be separate from other terms and conditions, and easy to understand. Consent is valid if the Data Subject:
        - Is free to deny the request without undue adverse effects for her/him;
        - Is provided with enough information about the intended Processing (if Processing has multiple purposes, consent must be obtained for each of them); and
        - Is made aware of how to control her/his Personal Data.
        - Consent can be withdrawn by the Data Subject at any time. The withdrawal shall not affect the legitimacy of the Processing based on consent before withdrawal".
- IFAD is a member of the UN Property Preservation Group (UNPPG) and group of UN organizations that prepared and endorsed the **Principles on personal Data Protection and Privacy** (CEB, 2023, p. 1) which stipulate that

- "Personal data should be processed with due regard to confidentiality.
- The Principles aim to: (i) harmonize standards for the protection of personal data across the UN System; (ii) facilitate the accountable processing of personal data; and (iii) ensure respect for the human rights and fundamental freedoms of individuals, in particular the right to privacy.
- The United Nations System Organizations should process personal data in a fair manner, in accordance with their mandates and governing instruments and on the basis of the consent of the data subject".

- **IFAD Information and Communication Technology for Development (ICT4D) Strategy** (IFAD, 2019, p. 13)
  - "IFAD will strive to strengthen its legal framework under the authority of the President and in line with the United Nations Personal Data Protection and Privacy Principles, and the Data Privacy, Ethics and Protection – a guidance note on big data for achievement of the 2030 Agenda, approved by the United Nations Sustainable Development Group".
- **United Nations Fundamental Principles of Official Statistics** (ECOSOC, 2013, p. 2)
  - "Principle 6. Individual data collected by statistical agencies for statistical compilation, whether they refer to natural or legal persons, are to be strictly confidential and used exclusively for statistical purposes".

Annex 6: Survey Data Quality Checking Procedures[3]

DOWNLOAD DATA

Step 1: Make sure all interviews have been uploaded. Agree with the supervisors to upload asap after finishing the daily interviews. Have them send you a text/email once all has been uploaded saying how many interviews and how many Supervisor check interviews were done.

Log on to the Survey Solutions server for this survey at: tnzmpat.mysurvey.solutions (Login=admin; Password=Foodsecurity2019) Go to "Interviews" on the top row. Select the main questionnaire under "Template" (top left hand side) and see if the number of newly uploaded interviews (these will have Status "Completed" – see below) matches the expected number. You can do the same for the Supervisor check questionnaires.

Step 2: Downloading. Go to "Data Export", select the main questionnaire under "(version) Survey Template". Just below this there is a selection box "Status of exported interviews". Select "Completed" and click the green "Generate" button for the "Tabular format" option. Once generated, click the blue "Download" button and save the zip file to a desired location. I create a folder for each day of the survey as it moves along, so that the raw daily data are saved. Do the same for the Supervisor check questionnaires (you have to click "Generate" again). Once you are sure to have downloaded all the files, you have to change the status of the interviews you just downloaded to make sure you won't download them the next day again (I usually do this only after I have done all the steps below just in case I missed a file and need to download again). To do this, go back to "Interviews" and tick the boxes for all interviews with Status "Completed" and click "Approve". This will change their status to "ApprovedByHeadquarters". Each page only shows 20 interviews, so you will have to do this a number of times, until the status of all of the day's interviews is changed. This will make sure that you only download new interviews for the daily checks and not ones that you already checked (because when downloading you selected to download only those with status "Completed").

Step 3: Creating a data entry file. Extract the zip file into the daily folder. The tabular files have to be opened from within Excel. Start with the main survey data (=name questionnaire). When you open it, the "Text import wizard" window will open. Make sure it is set to Tab delimited and click "Finish". Copy all data from that file except the top row with variable names into the Excel file *Data entry empty* and save this file under a new name (for example "18AprilMain" – this date format is easiest to order).

The data entry file has several sheets. You copy the raw data into sheet 1. It has all the variable names in the second row, and colours in the top two rows to indicate the different sections. The first 4

[3]Example from Tanzania

columns in the entry file have formulas to extract the enumerator, supervisor and respondent and watershed names using Lookup functions and lookup tables which are in the last sheet, so you should paste the copied raw data in the first free column F, *Id*. Sheet 2 and 3 of the data entry file extract data from sheet 1 for those questions that are in the Supervisor check questionnaire.

PREPARING THE COMMENTS FILE

Step 4: Prepare a Comments file for the supervisors. From sheet 1 in the data entry file, copy the first 4 columns plus the *Id* column (as far down as there are interviews) and "**paste as values**" into sheet 1 of the Excel file called *Comments empty*. Then save as for example *Comments 180419* to indicate the date. This is the basis of the comments file you will send to the supervisors. They can use the information in the first 4 columns to identify the interview. Whenever you find something funny or inconsistent, you can create a new column, starting from column F, identifying the question number in the column heading and write your comment in the row of the relevant interview.

Quality checking

Step 5: Enumerator comments. Within Excel open the *interview_comments.tab* file from the unzipped folder of the main questionnaire. It contains the comments the enumerators made during and at the end of the interview. It indicates in which interview the comment was made (*InterviewId*), at which question (Variable) and by which enumerator (*Originator*). This software generated comments file It is a good place to start, because if there are funny data somewhere, perhaps the enumerator already explained it in a comment. It is also good to check if the comments that are made are necessary and make sense. If not, note this in the first sheet of the *Comments* file by creating a column for the relevant question. This is important because unnecessary comments makes the interviews last longer and makes the comments file more time consuming to check.

Step 6: Consistency and errors in the household roster file. The household roster data are in a separate file in the zipped folder of the main questionnaire. Within Excel open the *hhr.tab* file from the unzipped folder of the main questionnaire. There is a row for every household member entered. To make the file easier to check, start by adding a filter to the top row, then sort on the first column, *Id.* Colour highlight all the rows with Id = 1. Next sort on the last column, *ParentId1*. You now have the file ordered by household, with each household starting with a highlighted row for the household head. This will make it easier to do the checks. Save this file as an Excel file in the daily folder (e.g.. *hhr* 18april). Now run the following checks:

- Check that there is a HH head (rel_head=1) in each household. If there are two, create a column in the *Comments* file with the heading of the question and make a comment (you can match the interview using the *ParentId1* variable in the HH roster and the *Id* variable in the Comments file).

- Also check that the other household roles and corresponding ages make sense.
- Check that if the HH head marital status is married there is a spouse listed and if widowed or single there is not.
- Also see if there are missing data. This should be indicated by -999999999. Make a note in the *Comments* file if there are.
- After a few days check whether you are getting many members who are away from the household for more than 9 months. If this appears unnaturally high, discuss with supervisors.

Step 7: Consistency and errors in the main file. Now compare the main data set in sheet 1 (*Data entry*) of the data entry file.

- Check for missings in the GPS variables (-999999999).
- Check that the hh_ids are unique.
- Check that open answers make sense (arrange with translator if necessary).
- Check that specified "Other" answers make sense and do not match a prelisted answer option.
- Check that if the respondent said they have terraces in Q39b, they also mention these in Q74 and vice versa.
- Check that the negative event 2 (and 3) are not more damaging AND more likely than event 1 (and 2).
- In Qs 32 & 33 check that the time in minutes corresponds to the water source. [e.g 90 minutes for piped water is strange. 1 minute for river water is also strange].
- In Q35 check the answers that are very low. Perhaps the enumerators means that there was *insufficient* water for just 1 month when in fact writing 1 means that there was *sufficient* water for one month.
- Check that Q36 corresponds to Q35. If they always have water but are always worried then this should be checked.
- Q37- remind respondents that when water is free, the answer should not be 1 (No), it should be 6 (hh does not need to pay fees)
- Check that Q59, Q60 and Q61 correspond. If 1 is entered to Q59 then Q60 & Q61 should also only have 1.
- If Q63 is answered with 1 then remind enumerators that this includes ugali.
- Anything else that looks funny or inconsistent, for instance if one enumerator always or often gives the same response to a certain question that the others don't use.

Step 8: Send the *Comments* file to the supervisors. (Once this is done, I usually change the status of the downloaded interviews on the Survey Solutions server – see Step 2. Remember changing the status in the main questionnaire and both Supervisor check questionnaires).

Step 9: Making corrections. You will have received corrections and comments back from the supervisors on the comments you sent the previous day. Use these to clean the data from the corresponding day's data entry file and household roster file. Once cleaned, add that day's data to an overall main file and an overall household roster file. That way you will have a complete and cleaned database (main and roster) at the end of the survey, and you have a database ready to do more thorough checks midway (see Step 12).

Step 10: enumerator differences. After say five days, once you have enough interviews per enumerator, do a more thorough check on enumerator differences. For example on duration of the interviews and a number of the – more difficult questions – such as the negative events. Are some enumerators more often saying that the respondent is not worried about anything; choose the "Not possible to observe" option often for house building materials, etc. Repeat this after the second five days. If you find anything report to supervisors and suggest they talk with the enumerator, or focus the repeat checks on them (this can be done earlier if you get a feeling about a particular enumerator).

Annex 7 : MPAT Valuations and Weightings

Table 1: An overview of all MPAT components and subcomponents, including their descriptions, weights, relevant questions, and aggregation weights.

Component	Subcomponent	Description	Weight (%)	Questions	Aggregation Weights (%)
1. Food & Nutrition Security	1.1 Consumption	Assesses whether the household has a sufficient quantity of food most of the time.	43%	Q59, Q60	Q59: 60%, Q60: 40%
	1.2 Access Stability	Assesses the stability of the household's access to food.	32%	Q61, Q62	Q61: 55%, Q62: 45%
	1.3 Nutrition Quality	Assesses the diversity of the household's diet as a proxy measure for balanced nutrition intake.	25%	Q63.1-Q63.7	Varies based on options (e.g., Q63.1: 7.5%, Q63.2: 7.5%, etc.)
2. Domestic Water Supply	2.1 Quality	Assesses the likely quality of the water the household uses for domestic purposes.	29%	Q32, Q34, Q38	Q32: 45%, Q34: 20%, Q38: 35%
	2.2 Availability	Assesses the stability and quantity of domestic water supply to the household.	38%	Q35, Q36	Q35: 70%, Q36: 30%
	2.3 Access	Assesses the degree of access households have to their main water source.	33%	Q33, Q37	Q33: 60%, Q37: 40%
3. Health & Health Care	3.1 Health Status	Assesses the status of people's health.	38%	Q9, Q10, v21	Q9: 30%, Q10: 45%, v21: 25%
	3.2 Access & Affordability	Assesses the household's access to health-care centres and the affordability of the health care those centres provide.	34%	Q11, Q13, Q14	Q11: 25%, Q13: 35%, Q14: 40%
	3.3 Health-Care Quality	Assesses the likely quality of health care provided in the village/area.	28%	Q12, v1, v17, v18, v19, v20	Q12: 30%, v1 & v18: 25%, v17: 15%, v19: 15%, v20: 15%
4. Sanitation & Hygiene	4.1 Toilet Facility	Assesses the general quality of the toilet	38%	Q23, Q24	Q23: 60%, Q24: 40%

		facilities the household uses.			
	4.2 Waste Management	Assesses how the household manages its waste materials.	26%	Q25, Q26, Q27	Q25: 35%, Q26: 25%, Q27: 40%
	4.3 Hygiene Practices	Assesses the quality of the household's general hygiene practices.	36%	Q28, Q29, Q30, Q31	Q28: 20%, Q29: 35%, Q30: 30%, Q31: 15%
5. Housing, Clothing & Energy	5.1 Housing Structure Quality	Assesses the physical quality of the housing structure and its ability to withstand extreme weather events.	38%	Q17, Q19	Q17: 70%, Q19: 30%
	5.2 Clothing	Assesses the general availability and quality of footwear and clothing in the household.	33%	Q69, Q70	Q69: 40%, Q70: 60%
	5.3 Energy Sources	Assesses the likely quality of the fuel(s) the home uses for lighting, cooking, and heating.	29%	Q20, Q21, Q22	Q20: 30%, Q21: 40%, Q22: 30%
6. Education	6.1 Quality	Assesses the likely quality of the education provided in the village/area.	31%	v5, v6, v7, v10	v6 & v5: 40%, v7: 25%, v10: 35%
	6.2 Availability	Assesses the availability of education.	33%	v8, v9, v11	v8: 37.5%, v9: 37.5%, v11: 25%
	6.3 Access	Assesses how easily school-age children in the household can attend school.	36%	Q5, Q6	Q5: 50%, Q6: 50%
7. Farm Assets	7.1 Land Tenure	Assesses the household's land tenure status.	36%, 39%, or 60%	Q39, Q40, Q51	Varies based on options (e.g., Q40: 35%, Q51: 65%)
	7.2 Land Quality	Assesses the likely quality of the household's land and soil.	24%, 26%, or 40%	Q41, Q42	Q41: 50%, Q42: 50%
	7.3 Crop Inputs	Assesses the availability of water, compost/manure/fertilizer,	20% or 35%	Q43, Q44, Q45, Q50	Varies based on options (e.g., Q43:

		seed, and food for crop production.			25%, Q44: 25%, etc.)
	7.4 Livestock/Aquaculture Inputs	Assesses the availability of water, fodder, and/or fish feed for livestock and/or aquaculture.	20% or 35%	Q46, Q47, Q48, Q49	Varies based on options (e.g., Q46.1: 10%, Q46.2: 15%, etc.)
8. Non-Farm Assets	8.1 Employment & Skills	Assesses the household's income-earning potential from small business and/or skilled service provision.	39%	Q64, Q65, Q1	Q64: 25%, Q65: 50%, Q1: 25%
	8.2 Financial Services	Assesses the household's access to financial services and degree of debt.	33%	Q66, Q67, Q68	Q66: 40%, Q67: 30%, Q68: 30%
	8.3 Fixed Assets & Remittances	Assesses the household's likely wealth.	28%	Q2, Q3, Q18, Q71	Q2 & Q3: 40%, Q18: 40%, Q71: 20%
9. Exposure & Resilience to Shocks	9.1 Degree of Exposure	Assesses the severity and likelihood of exposure to natural and/or socio-economic shocks/hazards.	33%	Q52, Q53, Q54	Q53.1: 25%, Q54.1: 25%, Q53.2: 25%, Q54.2: 25%
	9.2 Coping Ability	Assesses the household's ability to cope with natural and/or socio-economic shocks/hazards.	34%	Q55	Q55.1: 40%, Q55.2: 35%, Q55.3: 25%
	9.3 Recovery Ability	Assesses the household's ability to recover from natural and/or socio-economic shocks/hazards.	33%	Q56, Q57, Q58	Q56: 45%, Q57: 35%, Q58: 20%
10. Gender & Social Equality	10.1 Access to Education	Assesses the equality of children's access to education.	31%	Q7, Q8	Q7: 60%, Q8: 40%
	10.2 Access to Health Care	Assesses the equality of access to health care for women and men.	36%	Q15, Q16	Q15: 50%, Q16: 50%
	10.3 Social Equality	Assesses the degree of social equality in the village/area and how/if it has changed.	33%	Q72, Q73, v12, v13, v22, v23	Q72: 45%, Q73: 20%, v12: 10%, v13: 7.5%, v22: 10%, v23: 7.5%
11. Adaptation	11.1 Climate-resilient agricultural practices	Assess which and how many agricultural practices the household is doing	25%	Q74, Q75	Q74: 50%, Q75: 50%

to Climate Change		Assesses which climate & environmental problems the household is facing with its land			
	11.2 Water for agriculture	Assesses the main sources of freshwater for crops and livestock for most of the year	25%	Q76	Q76: 100%
	11.3 Human capacity	Assesses the types of weather information the household has access to	25%	Q77, Q78	Q77: 50% Q78:50%

Valuations and weightings for MPAT Component 9 on Exposure and Resilience to Shocks (IFAD, 2014, pp. 295–301)

9. Exposure & Resilience to Shocks

This component measures the household's exposure to natural and socio-economic shocks and its ability to cope and recover from such shocks.

9.1 Degree of Exposure – 33% of Exposure & Resilience to Shocks component

This subcomponent assesses the severity and likelihood of exposure the household faces from natural and/or socio-economic shocks/hazards.

52	Of all the **possible negative events** (natural or socio-economic) that **could** occur in the next 12 months, and that would have a bad or damaging impact on your household, which 3 are you most worried about? (as far as negative impacts on household members, livelihoods, agriculture, livestock, aquaculture …) *[Enumerator to write down up to 3 events in the spaces provided, from most worried about (52.1) to less worried about (52.3)]*
53	For these events, **how damaging** would each be for your household? *['Likely severity']*
54	For these events, **how likely** is it that the event will occur in the next 12 months? *['Likely frequency']*

Don't know (-1) *[skip to question 59]*	Not very worried about any negative events (-2) *[skip to question 59]*			
Likely severity (53) =	Low-minor (1)	Medium-moderate (2)	High-major (3)	
Likely frequency (54) =	Unlikely (1)	Likely (2)	Very likely (3)	

1st	52.1)	write in	53.1) Likely severity=		54.1) Likely frequency=
2nd	52.2)	write in	53.2) Likely severity=		54.2) Likely frequency=
3rd	52.3)	write in	53.3) Likely severity=		54.3) Likely frequency=

For Q52.1

Answer code	Value (1-10)
-1	MD
-2	10

For Q53

Answer code	Value (1-10)
1	10
2	5
3	1

For Q54

Answer code	Value (1-10)
1	10
2	5
3	1

Aggregation for subcomponent 9.1 – option 1

53.1	25
54.1	25
53.2	25
54.2	25
Total	100%

Note: When calculating the values for subcomponent 9.1, only use the values for the first two events listed (that is, whether there are two or three events listed, only use the first two values). If there are other events listed by the household, these should be analysed and presented in any MPAT reports alongside the indicators for subcomponent 9.1 (the reason for this is that, in many areas, respondents usually provide two events they are concerned about, but there is variability with respect to whether households provide two or three). If only one event is listed, then use the aggregation **case 1** shown below.

Aggregation for subcomponent 9.1 – case 1 (if data for one event only)

53.1	50
54.1	50
Total	100%

Aggregation for subcomponent 9.1 – option 2 (if Q52.1 answer choice -1 or -2)

52.1	100
53	0
54	0
Total	100%

9.2 Coping Ability – 34% of Exposure & Resilience to Shocks component

This subcomponent assesses the household's ability to cope with natural and/or socio-economic shocks/hazards.

(Valuations for the items listed in the table below will likely not apply perfectly to all situations. Users are encouraged to check the valuations and determine their applicability.)

55 If the worst of the negative events you just mentioned *[in question 52]* were to occur in the next 12 months, what are the 3 main ways your household would likely react (cope)?

Don't know (-1) | Primary strategy ☐ | Secondary strategy ☐ | Tertiary strategy ☐

1. Seek off-farm work	10. Children help more than usual with household work	19. Sell stored grain	28. Postpone payment of debts
2. Work more hours or take on other jobs	11. Ask friends to help with farm labour or business	20. Sell livestock	29. Borrow money from relatives
3. Start a business	12. Ask family to help with farm labour or business	21. Use savings or sell jewellery	30. Borrow money from friends
4. Reduce health-care spending	13. Rely on local government	22. Sell durable goods	31. Borrow money from cooperative or village fund (community source)
5. Reduce alcohol consumption	14. Rely on national government	23. Sell farmland	32. Borrow money from bank or other financial service provider
6. Reduce meat consumption	15. Rely on aid organizations	24. Sell business	33. Borrow money from private lender
7. Reduce fuel consumption	16. Rely on group insurance	25. Sell/leave home (live with relatives in area)	34. Send children to work outside the household
8. Plant fewer crops next growing season	17. Rely on private insurance	26. Sell/leave home (move to another area)	35. Take children out of school so they can work
9. Lease out farmland	18. Seek technical assistance	27. Seek medical treatment	36. Beg for money/food
37. Other, specify:			

For Q55

Answer code	Value (1-10)
1	8.5
2	8
3	9.5
4	3
5	9
6	7
7	5
8	4.5
9	4
10	4
11	7.5
12	8
13	7.5
14	6.5
15	6.5
16	8
17	10
18	8
19	4.5
20	4.5

For Q55 continued

Answer code	Value (1-10)
21	6
22	3.5
23	1.5
24	2
25	2
26	3.5
27	MD[a]
28	6
29	8
30	7
31	7
32	7
33	3
34	3
35	1
36	1.5
37	MD
(-1)	MD

[a] Note: This is intentionally scored as MD (as determined by MPAT contributors during MPAT's development).

Aggregation for subcomponent 9.2 (if data for all three coping strategies)

55.1 Primary strategy	40
55.2 Secondary strategy	35
55.3 Tertiary strategy	25
Total	100%

Aggregation for subcomponent 9.2 – case 1 (if data for only primary and secondary strategies)

55.1 Primary strategy	53
55.2 Secondary strategy	47
55.3 Tertiary strategy	0
Total	100%

Aggregation for subcomponent 9.2 – case 2 (if data for only primary strategy)

55.1 Primary strategy	100
55.2 Secondary strategy	0
55.3 Tertiary strategy	0
Total	100%

9.3 Recovery Ability – 33% of Exposure & Resilience to Shocks component

This subcomponent assesses the household's ability to recover from natural and/or socio-economic shocks/hazards.

56	If the worst of the negative events you just mentioned *[in question 52]* were to occur in the next 12 months, how long do you think it would take for your household to return to a satisfactory situation? *[Record answer in months (for example, 2 years = 24 months)]* Don't know (-1) | Less than 1 month (-2) | Months= [ ] | Our household could not recover (-3)
57	If in an extreme disaster (of any sort) your household's home was completely destroyed, but your family members were not injured, how long would it take for your household to rebuild your home? *[Record answer in months (for example, 2 years = 24 months)]* Don't know (-1) | We would move (-2) | Months= [ ] | Our household could not rebuild (-3)
58	If the worst of the negative events you just mentioned [in question 52] were to occur in the next 12 months, who do you think would be most likely to assist your household? No one (1) | Family/relatives (2) | Friends (3) | Insurance company (4) Financial institution (5) | Local government (6) | National government (7) Government (general) (8) | Aid organizations (9) | Don't know (10) | Other, specify: (11)

For Q56

Answer code	Value (1-10)
-1	MD
-2	10
-3	1
Unit (months) interval	Value (1-10)
1-3	8
4-6	7
7-12	6
13-24	4
25-48	2.5
48+	1

For Q57

Answer code	Value (1-10)
-1	MD
-2	6.5
-3	1
Unit (months) interval	Value (1-10)
1-3	10
4-6	9
7-12	7.5
13-24	6.5
25-48	4.5
48+	1

For Q58

Answer code	Value (1-10)
1	1
2	7
3	5
4	10
5	8
6	9
7	9
8	9
9	5.5
10	4
11	MD

Aggregation for subcomponent 9.3

56	45
57	35
58	20
Total	100%

Annex 8: Bonferroni Post-Hoc Test Results

Table A8.1: ANOVA Results for Food_Nutrition_Security

Variable	F_value	P_value
Food_Nutrition_Security	302.0942	<2e-16

Table A8.2: Bonferroni Post-Hoc Test Results for Food_Nutrition_Security

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-15.6193009	(-17.98,-13.26)	1.348e-12
263-254	Zimbabwe vs Kenya	-0.9191145	(-3.19,1.35)	0.8034
266-254	Lesotho vs Kenya	-7.2660703	(-9.4,-5.14)	1.400e-12
268-254	Eswatini vs Kenya	-22.8483632	(-25.02,-20.68)	1.348e-12
263-255	Zimbabwe vs Tanzania	14.7001864	(12.33,17.07)	1.348e-12
266-255	Lesotho vs Tanzania	8.3532307	(6.12,10.59)	1.396e-12
268-255	Eswatini vs Tanzania	-7.2290623	(-9.5,-4.96)	1.390e-12
266-263	Lesotho vs Zimbabwe	-6.3469557	(-8.48,-4.21)	1.416e-12
268-263	Eswatini vs Zimbabwe	-21.9292487	(-24.1,-19.76)	1.348e-12
268-266	Eswatini vs Lesotho	-15.5822929	(-17.61,-13.56)	1.348e-12

Table A8.3: ANOVA Results for Domestic_Water_Supply

Variable	F_value	P_value
Domestic_Water_Supply	296.3282	<2e-16

Table A8.4: Bonferroni Post-Hoc Test Results for Domestic_Water_Supply

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-11.1084424	(-13.21,-9.01)	< 2.2e-16
263-254	Zimbabwe vs Kenya	4.9531443	(2.94,6.97)	2.007e-10
266-254	Lesotho vs Kenya	4.9271178	(3.04,6.82)	6.962e-12
268-254	Eswatini vs Kenya	-12.7133361	(-14.64,-10.79)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	16.0615867	(13.96,18.16)	< 2.2e-16
266-255	Lesotho vs Tanzania	16.0355602	(14.05,18.02)	< 2.2e-16
268-255	Eswatini vs Tanzania	-1.6048937	(-3.62,0.41)	0.1895
266-263	Lesotho vs Zimbabwe	-0.0260265	(-1.92,1.87)	1.0000
268-263	Eswatini vs Zimbabwe	-17.6664804	(-19.59,-15.74)	< 2.2e-16
268-266	Eswatini vs Lesotho	-17.6404539	(-19.44,-15.84)	< 2.2e-16

Table A8.5: ANOVA Results for Health_Health_Care

Variable	F_value	P_value
Health_Health_Care	123.9825	<2e-16

Table A8.6: Bonferroni Post-Hoc Test Results for Health_Health_Care

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-3.660191	(-5.34,-1.98)	2.960e-08
263-254	Zimbabwe vs Kenya	-2.507976	(-4.12,-0.9)	0.0002176
266-254	Lesotho vs Kenya	7.085787	(5.57,8.6)	< 2.2e-16
268-254	Eswatini vs Kenya	3.553883	(2.01,5.1)	3.366e-09
263-255	Zimbabwe vs Tanzania	1.152215	(-0.53,2.83)	0.3346029
266-255	Lesotho vs Tanzania	10.745978	(9.16,12.34)	< 2.2e-16
268-255	Eswatini vs Tanzania	7.214074	(5.6,8.83)	< 2.2e-16
266-263	Lesotho vs Zimbabwe	9.593763	(8.08,11.11)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	6.061859	(4.52,7.61)	< 2.2e-16
268-266	Eswatini vs Lesotho	-3.531904	(-4.97,-2.09)	2.471e-10

Table A8.7: ANOVA Results for Sanitation_Hygiene

Variable	F_value	P_value
Sanitation_Hygiene	204.0293	<2e-16

Table A8.8: Bonferroni Post-Hoc Test Results for Sanitation_Hygiene

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-15.446319	(-17.41,-13.48)	< 2.2e-16
263-254	Zimbabwe vs Kenya	-13.701707	(-15.59,-11.81)	< 2.2e-16
266-254	Lesotho vs Kenya	-7.882058	(-9.66,-6.11)	< 2.2e-16
268-254	Eswatini vs Kenya	-16.595213	(-18.4,-14.79)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	1.744611	(-0.22,3.71)	0.1107493
266-255	Lesotho vs Tanzania	7.564261	(5.7,9.42)	< 2.2e-16
268-255	Eswatini vs Tanzania	-1.148894	(-3.04,0.74)	0.4591888
266-263	Lesotho vs Zimbabwe	5.819650	(4.04,7.6)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	-2.893506	(-4.7,-1.09)	0.0001231
268-266	Eswatini vs Lesotho	-8.713156	(-10.4,-7.03)	< 2.2e-16

Table A8.9: ANOVA Results for Housing_Clothing_Energy

Variable	F_value	P_value
Housing_Clothing_Energy	281.8611	<2e-16

Table A8.10: Bonferroni Post-Hoc Test Results for Housing_Clothing_Energy

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-12.646615	(-14.67,-10.63)	< 2.2e-16
263-254	Zimbabwe vs Kenya	-6.186305	(-8.13,-4.25)	< 2.2e-16
266-254	Lesotho vs Kenya	8.000737	(6.18,9.82)	< 2.2e-16
268-254	Eswatini vs Kenya	-7.895796	(-9.75,-6.04)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	6.460309	(4.44,8.48)	< 2.2e-16
266-255	Lesotho vs Tanzania	20.647352	(18.74,22.56)	< 2.2e-16
268-255	Eswatini vs Tanzania	4.750819	(2.81,6.69)	2.58e-10
266-263	Lesotho vs Zimbabwe	14.187043	(12.36,16.01)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	-1.709491	(-3.57,0.15)	0.08786
268-266	Eswatini vs Lesotho	-15.896533	(-17.63,-14.16)	< 2.2e-16

Table A8.11: ANOVA Results for Education

Variable	F_value	P_value
Education	595.7454	<2e-16

Table A8.12: Bonferroni Post-Hoc Test Results for Education

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-15.8679826	(-18.19,-13.54)	4.256e-08
263-254	Zimbabwe vs Kenya	-15.4161430	(-17.78,-13.06)	4.256e-08
266-254	Lesotho vs Kenya	10.8642554	(8.69,13.04)	4.256e-08
268-254	Eswatini vs Kenya	-5.6160392	(-7.81,-3.42)	4.260e-08
263-255	Zimbabwe vs Tanzania	0.4518396	(-1.55,2.45)	0.9724
266-255	Lesotho vs Tanzania	26.7322381	(24.95,28.51)	4.256e-08
268-255	Eswatini vs Tanzania	10.2519434	(8.45,12.06)	4.256e-08
266-263	Lesotho vs Zimbabwe	26.2803984	(24.46,28.1)	4.256e-08
268-263	Eswatini vs Zimbabwe	9.8001038	(7.95,11.65)	4.256e-08
268-266	Eswatini vs Lesotho	-16.4802947	(-18.09,-14.87)	4.256e-08

Table A8.13: ANOVA Results for Farm_Assets

Variable	F_value	P_value

Farm_Assets	344.7457	<2e-16

Table A8.14: Bonferroni Post-Hoc Test Results for Farm_Assets

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-22.414574	(-25.13,-19.7)	< 2.2e-16
263-254	Zimbabwe vs Kenya	-1.584104	(-4.19,1.03)	0.461614
266-254	Lesotho vs Kenya	-25.955964	(-28.41,-23.5)	< 2.2e-16
268-254	Eswatini vs Kenya	-19.457019	(-21.95,-16.96)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	20.830470	(18.11,23.55)	< 2.2e-16
266-255	Lesotho vs Tanzania	-3.541390	(-6.11,-0.97)	0.001633
268-255	Eswatini vs Tanzania	2.957555	(0.35,5.57)	0.017210
266-263	Lesotho vs Zimbabwe	-24.371860	(-26.83,-21.92)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	-17.872915	(-20.37,-15.37)	< 2.2e-16
268-266	Eswatini vs Lesotho	6.498946	(4.17,8.83)	< 2.2e-16

Table A8.15: ANOVA Results for Non_Farm_Assets

Variable	F_value	P_value
Non_Farm_Assets	94.81735	<2e-16

Table A8.16: Bonferroni Post-Hoc Test Results for Non_Farm_Assets

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-3.6109459	(-4.91,-2.31)	< 2.2e-16
263-254	Zimbabwe vs Kenya	-4.3645335	(-5.61,-3.12)	< 2.2e-16
266-254	Lesotho vs Kenya	-7.2128367	(-8.38,-6.04)	< 2.2e-16
268-254	Eswatini vs Kenya	-7.2840779	(-8.47,-6.09)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	-0.7535875	(-2.05,0.55)	0.5088
266-255	Lesotho vs Tanzania	-3.6018908	(-4.83,-2.37)	< 2.2e-16
268-255	Eswatini vs Tanzania	-3.6731320	(-4.92,-2.43)	< 2.2e-16
266-263	Lesotho vs Zimbabwe	-2.8483033	(-4.02,-1.68)	3.643e-10
268-263	Eswatini vs Zimbabwe	-2.9195444	(-4.11,-1.73)	2.529e-10
268-266	Eswatini vs Lesotho	-0.0712412	(-1.18,1.04)	0.9998

Table A8.17: ANOVA Results for Exposure_Resilience_to_Shocks

Variable	F_value	P_value
Exposure_Resilience_to_Shocks	164.5762	<2e-16

Table A8.18: Bonferroni Post-Hoc Test Results for Exposure_Resilience_to_Shocks

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	9.217260	(6.71,11.73)	7.389e-13
263-254	Zimbabwe vs Kenya	8.060142	(5.77,10.35)	7.369e-13
266-254	Lesotho vs Kenya	-2.752954	(-4.91,-0.6)	0.004446
268-254	Eswatini vs Kenya	-8.851052	(-11.03,-6.68)	7.158e-13
263-255	Zimbabwe vs Tanzania	-1.157117	(-3.67,1.36)	0.718336
266-255	Lesotho vs Tanzania	-11.970213	(-14.36,-9.58)	6.924e-13
268-255	Eswatini vs Tanzania	-18.068311	(-20.48,-15.66)	6.924e-13
266-263	Lesotho vs Zimbabwe	-10.813096	(-12.97,-8.66)	6.924e-13
268-263	Eswatini vs Zimbabwe	-16.911194	(-19.09,-14.73)	6.924e-13
268-266	Eswatini vs Lesotho	-6.098098	(-8.13,-4.06)	7.557e-13

Table A8.19: ANOVA Results for Gender_Social_Equality

Variable	F_value	P_value
Gender_Social_Equality	169.5694	<2e-16

Table A8.20: Bonferroni Post-Hoc Test Results for Gender_Social_Equality

	Countries	diff	Confidence Interval	p-value
255-254	Tanzania vs Kenya	-11.6051916	(-13.43,-9.78)	< 2.2e-16
263-254	Zimbabwe vs Kenya	-10.7653302	(-12.52,-9.01)	< 2.2e-16
266-254	Lesotho vs Kenya	-2.9912220	(-4.64,-1.34)	7.460e-06
268-254	Eswatini vs Kenya	0.8685153	(-0.81,2.54)	0.6185
263-255	Zimbabwe vs Tanzania	0.8398614	(-0.99,2.67)	0.7204
266-255	Lesotho vs Tanzania	8.6139696	(6.89,10.34)	< 2.2e-16
268-255	Eswatini vs Tanzania	12.4737070	(10.72,14.23)	< 2.2e-16
266-263	Lesotho vs Zimbabwe	7.7741082	(6.12,9.42)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	11.6338455	(9.96,13.31)	< 2.2e-16
268-266	Eswatini vs Lesotho	3.8597373	(2.29,5.43)	1.957e-10

Table A8.21: ANOVA Results for Adaptation_to_climate_change

Variable	F_value	P_value
Adaptation_to_climate_change	1142.298	<2e-16

Table A8.22: Bonferroni Post-Hoc Test Results for Adaptation_to_climate_change

	Countries	diff	Confidence Interval	p-value

255-254	Tanzania vs Kenya	0.6914334	(-0.67,2.05)	0.637
263-254	Zimbabwe vs Kenya	-2.2615363	(-3.57,-0.95)	2.367e-05
266-254	Lesotho vs Kenya	-15.5183280	(-16.75,-14.29)	< 2.2e-16
268-254	Eswatini vs Kenya	-23.7752766	(-25.02,-22.53)	< 2.2e-16
263-255	Zimbabwe vs Tanzania	-2.9529696	(-4.32,-1.59)	3.639e-08
266-255	Lesotho vs Tanzania	-16.2097613	(-17.5,-14.92)	< 2.2e-16
268-255	Eswatini vs Tanzania	-24.4667100	(-25.77,-23.16)	< 2.2e-16
266-263	Lesotho vs Zimbabwe	-13.2567917	(-14.49,-12.03)	< 2.2e-16
268-263	Eswatini vs Zimbabwe	-21.5137404	(-22.76,-20.26)	< 2.2e-16
268-266	Eswatini vs Lesotho	-8.2569487	(-9.43,-7.09)	< 2.2e-16