ICTS AS A BRIDGE BETWEEN CLIMATE INFORMATION AND LIVELIHOOD STRATEGIES AMONG RURAL WOMEN IN KITUI COUNTY, KENYA

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ABSTRACT

The study was motivated by the increasing challenges of climate variability and climate change, which create problems, such as food insecurity in Kitui County in Kenya. In the current digital age, ICTs are core to all sectors to facilitate access to and enhance efficiency across various services. Although the role of ICTs in improving life in Kenya is widely acknowledged, the focus of most ICT-related developments has been on human experiences at the level of disease and needs for communication and mobility. Less obvious is how such technological interventions may be used to address seemingly abstract yet grave concerns like climate change and its impact on the quality of human life. This study, therefore, investigated the various scenarios where ICTs were deployed in relaying relevant localized climate information to help rural women farmers in Kitui County to make relevant decisions to improve their farm productivity and their livelihoods by extension.

The study incorporated an ICT system to the Sustainable Livelihoods Framework (SLF) that consisted of Digital Capital and ICT Tools, thereby improving on the SLF. This modified SLF, mainstreamed ICT-driven climate information and provided the ideal means by which such information was leveraged to ensure enhanced sustainable livelihoods. Gender and Development (GAD) theory, Bourdieu's ideas of social capital theory, and the Information Needs Assessment Model (INAM) further strengthened the SLF by addressing household power dynamics and climate information relevance in the rural communities. The research drew from emerging variables to demonstrate that regardless of the context in which the SLF was formulated, its versatility makes it the most appropriate tool for such studies in rural Kenya.

The specific objectives of this study were threefold: (1) to assess the extent to which rural women access and use ICT tools in the utilization of climate information including weather, seasonal forecasts and agro-advisories; (2) to analyze the extent to which the use of ICT-based climate information by rural women influence maximize access and utilization of livelihood assets; and (3) to examine the livelihood strategies employed with the increasing availability and use of ICT-based climate information. The author adopted a mixed-methods approach for data collection and analysis that was guided by the SLF. Specific methods used, apart from on-desk review, were a household survey of 419 respondents, 14 key informant interviews, and two focus group discussions. The study merged theoretical and applied research outcomes to narrow the gap between the theory and practice of ICTs use while linking it to climate information and enhanced rural livelihood strategies.

The outcome from the research findings highlighted the need for interventions to empower rural women in the use of ICT tools in exploiting the full potential of climate information, the need for tailoring modern scientific climate information to local needs, translated into simple formats and the local Kikamba language, the need for complementary services such as affordable credit, insurance, livelihood diversification opportunities and access to livelihood assets that can further strengthen their household resilience to climate variability. The results show that community radios combined with mobile phones are the most accessible and cost-effective ICT tools for rural women's access to real-time, relevant climate and agro-advisory information. There is evidence that the women's livelihood strategies have been enhanced which strengthened their livelihood assets, thereby improving their livelihoods under the wider rubric of the sustainable livelihood framework.

The contribution to knowledge for this research was an enhanced SLF where the various responses and systematic analysis made the framework relevant in gaining insights into the link between climate information and livelihood strategies through ICTs among women in

rural communities in Kitui. The modified framework and the research findings are also timely in light of the increasing realization of ICTs potential in contributing to climate change adaptation and mitigation. Also, the thesis builds on the growing body of literature that generated a rich repository that other researchers can use to advance knowledge, and the outcomes are eight peer-reviewed articles.

The output of this study is replicable to other counties in Kenya because rural households depend on agriculture for their livelihood and this economic sector is not exempt to climate change and variability necessitating the need for local specific climate information. The recommendations to the research are that it can be extended to examine outcomes that will look at improved income, sustainable resource utilization, and food security, physical and emotional wellbeing. Further we provide policy recommendations and made suggestions to shape future climate change adaptation policies, plans, and strategies in Kenya that integrates gender equality into ICT and climate change to help farmers adapt to climate change/variability for sustainable development.

Keywords: ICT Tools; Digital Capital; Climate Information; Enhanced Sustainable livelihood Framework; Livelihood Strategies

DECLARATION

I declare that this is my **original** thesis and has not been submitted to any other examination or degree awarding body

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DEDICATION

First, I dedicate this thesis to God, whose love and mercy allow me to live day after day, despite myself.

Secondly, I dedicate this thesis to the loving memory of my parents, Gabriel Mammo Yohannis and Georgina Yohannis; and with sincere gratitude to my uncle, Yohannes Desta. Thoughts of you evoke a fondness beyond measure.

My final dedication is with the tender love to my husband Michael Mbathi and our children Muika and Christopher.

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Michaelina A. Y., Agnes N. W., Margaret J. H. and Timothy M. W., 2019. Enhancing Access and Use of Climate Information through ICTs. J. Clim. Chang. Sustain. Vol 3, issue 1, pp.1- 12. https://doi.org/10.20987/jccs.1.03.2019

Yohannis, A., Wausi, A., Waema, T. and Hutchinson, M., 2019, May. The Role of ICT Tools in the Access of Climate Information in Rural Communities. In *2019 IST-Africa Week Conference (IST-Africa)* (pp. 1-10). IEEE.

Yohannis, M.A., Waema, T.M. and Hutchinson, M., 2017, May. Linking climate information to livelihood strategies through ICTs: The role of integrated sustainable livelihoods framework. In *2017 IST-Africa Week Conference (IST-Africa)* (pp. 1-8). IEEE.

Yohannis, M.A., Waema, T.M. and Wausi, A.N., 2016, May. Provisional findings on linking climate information to livelihood strategies through ICTs among rural women in Kitui County, Kenya. In *2016 IST-Africa Week Conference (IST-Africa)* (pp. 1-7). IEEE.

Yohannis, M.A., Waema, T.M. Hutchinson, M and Wausi, A.N. 2018, February. Enhancing Access and Use of Climate Information through ICTs. In The 13th Kenya Meteorological Society (KMS) International Conference; Uasin Gishu County, Eldoret.

Yohannis, M.A., Waema, T.M. Hutchinson, M and Wausi, A.N., 2017. April. Role of Women in the Achievement of SDGs: Linking ICTs and Climate Information. The International Triple Helix Summit.

Yohannis, M.A., Waema, T.M. Hutchinson, M and Wausi, A.N., 2016. July. The Role of Mobile Telephones in Enhancing Sustainable Development: The Case of Kitui County. AIBUMA Conference University of Nairobi, School of Business.

ACRONYMS AND ABBREVIATIONS

ACWICT: African Center for Information and Communication Technology
ALIN: Arid Land Information Network
AEZs: Agro-Ecological Zones
ANITEP: African Network of Information Technology Experts and Professionals
ASALs: Arid and Semi-Arid Lands
CA: Communication Authority of Kenya
CIS: Climate Information Services
CSA: Climate Smart Agriculture
CSO: Community Service Organization
DFID: Department of International Development
FAO: Food and Agriculture Organization
FGDs: Focus Group Discussions
FM: Frequency Modulation
GaD: Gender and Development
GHGs: Green House Gases
GoK: Government of Kenya
CGoK: County Government of Kitui
HAWKNet: Horn of Africa Reginal Women's Knowledge Network
ICTs: Information and Communication Technologies
IDRC: International Development Research Centre
ITDG: Intermediate Technology Development Group
INAM: Information Needs Assessment Model
IPCC: Intergovernmental Panel on Climate Change
ITU: International Telecommunication Union
KIIs: Key Informant Interviews
KMD: Kenya Meteorological Department
KNBS: Kenya National Bureau of Statistics
MoA: Ministry of Agriculture
MoAWL: Ministry of Agriculture, Water and Land
NDMA: National Drought Management Authority
NGOs: Non-Governmental Organisation
SDGs: Sustainable Development Goals
SLF: Sustainable Livelihoods Framework
SMS: Short Message Service
UNDP: United Nations Development Programme
UNEP: United Nations Environmental Programme
UNFCCC: United Nations Framework Convention on Climate Change
USA: United States of America
WSF: World Space Foundation

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Information and Communication Technologies (ICTs) have become the norm in this digital age to address human challenges, such as climate change. Climate information, which encompasses weather, seasonal climate forecasts and agro-advisories, is critical for those in marginalized communities, such as those in rural areas. The question in this context is how this climate information can be accessed and utilized; this is where ICTs come in. A number of authors have addressed the relationship between ICTs and development. Some have gone a step further to show how ICTs help communities employ innovative approaches to prepare, respond and adapt to climate change (Cherotich *et al.*, 2012; Owusu *et al*., 2017; Waema and Okinda, 2011).

At the same time, academic studies on these dynamics have emerged, focusing on key variables related to these issues. For instance, Adera *et al*. (2014) examined how ICTs have been used to understand the 'ICT/poverty nexus' in Africa, while drawing evidence from Rwanda, Kenya, Namibia, and Tanzania. Elsewhere, Wu *et al*. (2018) investigated the relationship between Sustainable Development Goals (SDGs) and ICTs by highlighting how ICTs catalyze the achievement of climate change goals (SDG13), gender equity (SDG5) and food security (SDG2). ICT can further improve sustainable development by facilitating the sharing of climate information, and in making better weather predictions to enable early warning systems and promote sustainability in climate change adaptation (UNDP, 2016). Ospina and Heeks (2012: 10) support UNDP (2016) by sharing that ICTs "can enable new responses to the challenges posed by more frequent and intense unpredictable climatic events and stress."

For marginalized communities, their ability and nature of climate adaptation response depend on their access to information about climate risks and their appropriate responses to those risks. While many communities have developed their own systems for monitoring climate conditions, this information may not be adequate to inform climate change adaptation if the climate changes in unprecedented ways.

However, despite progress in the prediction of climate change, inadequate and timely climate information remains an issue in the rural communities. This has partially been attributed to

uncertainty in localized climate projections, seasonal forecasts and lack of enough information on specific climate indicators, such as rainfall and temperature variability (Hulme *et al*., 2005; Roncoli, Ingram, and Kirshen, 2002; Vogel and O'Brien, 2006). While climate information may be accessible, timely and relevant, its incorporation into local decision-making processes may not occur often because it is communicated in abstract and culturally insensitive ways (Patt and Gwata, 2002; Vogel and O'Brien, 2006). The utilization of ICTs to access to climate information for adaptation is, therefore, essential to enable actors to anticipate long-term risks and make the appropriate adjustments to increase their resilience.

This study started with ethnographic research that the researcher was involved in with the Kenya Meteorological Departments training of trainers (TOT) on matters of interpretation of climate information that commenced in 2014 and took into recognizant that farmer are not homogenous. The project that consisted of a consortium of organizations, the climate service funders (DfID, Christian Aid), University of Sussex, UK Met Office, KMD, Kings College UK, the implementers, Anglican Development Services-Eastern (ADA-Eastern) and South Eastern Kitui University (SEKU) took into consideration the distribution of benefits to rural women, and socially or economically disadvantaged groups in the climate information delivery. It was estimated (KNBS, 2015) that fifty-four percent of rural women and girls are living below the poverty line, making them more vulnerable to the impacts of climate change in Kenya. Also, the fact that Kitui County and other development partners targeted rural women who mobilized themselves around Self Help Groups (SHGs), 161 in Kitui, which guided them in dealing with their day-to-day challenges, including the formulation of livelihood strategies.

Yohannis *et al.* (2016) scoping study established that women in Kitui County mobilized themselves around 161 Self Help Groups (SHGs) that guide them in addressing their everyday challenges, including the formulation of livelihood strategies. For research purposes, the focus was on such women's groups (some headed by men). It was, therefore, appropriate that rural women of Kitui County were the subject of our research.

It is in this context that the study targeted these rural women (SHGs) in the arid and semi-arid lands (ASALs) of Kitui County and evaluated (at the end of December 2017) what combinations of communication processes (ICT tools) improved their understanding of and action on climate information in the adoption of livelihood strategies; taking into

consideration the intra-household decision-making dynamics. The study was based on gender, social-cultural context and climate change dynamics; the challenges that these engender; and how the concerned communities deploy specific ICT tools (mobile phones and Frequency Modulation (FM) radios) to surmount the challenges. The mobile phone and FM radio stations lend themselves to more focused study because they are most widespread and most effective in influencing the lives of people (Okinda and Adera, 2014).

1.1.1 The Role of Media in Relaying Climate Information

The use of mobile phones and FM Radio stations transcend the boundaries of class, geography, and gender. Research and anecdotal evidence suggests that virtually every household in Kenya owns a mobile phone and/or a radio. Indeed, the current brands of mobile phones have FM radio features that enable the owners to tune to radio stations of their choice. In a sense, these FM radio stations provide portable information via mobile phones (Cherotich *et al.*, 2012; Owusu *et al*., 2017; Waema and Okinda, 2011).

In addition, the government, corporations, educational institutions, and the mass media consider mobile phones and FM Radio stations to be essential outlets in communication especially for news, debates on topical issues and commercial advertisements. Indeed, the public, even in ASALs, rural villages and informal settlements in Kenya, relies on the mobile phone and the FM radios as their source of information and entertainment. For example, farmers have accessed agricultural extension officers through their mobile phones, while also learning valuable lessons through FM radio programs on essential market related and technical information. This enhances people's livelihoods at a time when food insecurity has become a concern to many stakeholders (Grimshaw and Kala, 2011; Odhiambo, 2007; McOmber *et al.*, 2013).

Eighty percent of Kenya is ASAL and particularly vulnerable to the impacts of climate change and Kitui County is part of this. Over 90% of the county's population lives in rural areas where agriculture plays a vital role in terms of food provision, employment creation, and also a source of income and livelihoods and therefore highly vulnerable to climate change. Additionally, the county is food insecure with food poverty rate reported at 55.5% (ASDSP Report, 2014). Farmers have experienced prolonged drought and crop failure because of climate change and unsustainable agricultural practices (Kitui County CIDP, 2018-2022). Experts have proposed changes to agricultural practices/technologies, but local

farmers have often been risk-averse due to lack of sufficient knowledge and the probabilistic nature of climate change. This has resulted in food insecurity, poverty, and loss of livelihoods (Kitui County CIDP, 2018-2022). As such, a significant challenge in such areas is to ensure adequate food production for the growing population without further degrading the limited resources.

There is, therefore, the urgent need to improve access to this climate information services to the rural populations to solve the issue of food and nutrition insecurity, increase agricultural yields and the farmer's livelihoods. Some related concerns were revealed in Yohannis *et al.* (2016) scoping study that needs to be borne in mind by decision-makers in Kitui County. Kitui County is highly patriarchal similar to most rural settings in Kenya, and therefore climate change affects women and men in different ways, mainly due to the divergent roles that men and women play within a household and community. Abdimajid *et al.* (2019) did a comparative analysis between Kajiado and Kiambu Counties in Kenya confirming how many regions in the country, as Kitui County is highly patriarchal, which means an intra-household decision has to be considered. The region also suffers from extreme climatic and weather conditions; there is soil erosion when it rains and crops failure is common during the dry season (Kitui County Government, 2013). Throughout, deforestation takes place due to complex relationships between poverty and lack of information. In all these, the place of women is at once precarious as it is critical; the women remain central to the survival of the communities in material, social, cultural, and economic terms. Additionally, women suffer disproportionately during adverse climatic conditions and for intervention measures to succeed in solving these problems; there is a need to focus on women in this context (Aguilar, 2009; Carr and Onzere, 2018; Jost *et al*., 2016; Oluoko-Odingo, 2019).

1.2 The Problem Statement

There exists a disconnect between the availability of ICT tools for information sharing and access to information by people who need it most to improve their livelihoods. Although many people own mobile phones and transistor radios which can relay correct and timely climate information, the same information is not always packaged in a comprehensible language and usable manner to be utilized by resource-poor and marginalized groups like in many Female-Headed Households (FHHs) (County Government of Kitui, 2014).

A scoping study done by Yohannis *et al.* (2016) and other studies by (African Science News, 2016), established that the women in Kitui County are particularly vulnerable to economic and socio-cultural barriers to improved livelihoods, due to a complex web of reasons. They are more vulnerable to climate change. Their role as primary caregivers and providers of food and fuel makes them more vulnerable when flooding and drought occur. When nearby wells and waters sources run dry, women traveled long distances to search for water. Longer dry seasons meant that women worked harder to feed and care for their families. In both urban and rural areas, women had multiple demands in the home, workplace and community that left less time for political involvement and active participation in decision-making processes. Due to the community traditional setting, women were subjected to cultural beliefs that denied them equal opportunities and rights. They were more likely to experience poverty, less likely to own land and have less socioeconomic power than men making it more difficult for them to recover from climate disasters. Various scholars established similar patterns elsewhere in the world (Archer, 2003; Denton, 2002, 2004; Gurumurthy, 2004; FAO and CARE, 2019). Due to cultural socialization, rural women particularly smallholders, generally adopt a risk-averse behavior aimed more at self-preservation at the expense of possible higher returns, even under challenging circumstances. Also true is that most women, particularly in sub-Saharan Africa (SSA), face other hurdles such as restrictions in land ownership and tenure, limited credit, inadequate training and education, heavy workloads, weak extension services and lack of supportive policies (Aguilar, 2009; Carr and Onzere, 2018; Oluoko-Odingo, 2019).

Although relevant agencies in Kenya have attempted to disseminate climate information to rural communities, the geographical reach for such information to make farm-level decisions is minimal in the country generally and rural parts particularly. It is also unclear whether the gendered dynamics are considered when designing and disseminating climate information in the Kenyan context, although statistics from elsewhere show that they are not (Carr, Fleming and Kalala, 2016; Cherotich *et al*., 2012). Several studies (CICERO, 2018; Manfre and Nordehn, 2013; Ngigi *et al*., 2017; Roncoli *et al*., 2003; Venktatasubramanian *et al*., 2014; Zamasiya, Nyikahadzoi, and Mukamuri, 2017) indicate that differential access to peer groups and social networks and ICTs have significant factors limiting women's access to climate information. Social-cultural norms that define women's and men's labor roles influence the resources and decisions under women's and men's control, affecting their differing climate information needs and demands. In contrast, when extension agents can travel to local

communities and when sources of information and services are located within the village, women's capacity to access climate information is enhanced (Venkatasubramanian *et al*., 2014; Rengalakshmi, Manjula and Devaraj, 2018). Due to socio-culturally defined beliefs surrounding women's and men's proper places and activities, women prefer to receive weather and climate information from sources familiar to them as discussed by Rengalakshmi *et al*. (2018) and at places they frequent such as prayer meetings and water boreholes, as discussed by Roncoli *et al*., (2009) and Tall *et al*., (2014c).

Despite the challenges of accessing social network groups, community-based and female-dominated groups have allowed women to access group processes important for climate information dissemination. Venkatasubramanian *et al*.'s (2014) research highlight that community and women's self-help groups are important means for disseminating climate information to women. Rengalakshmi *et al*. (2018) similarly note that a women-managed Village Knowledge Center and the incorporation of gender-sensitive group processes in communication channels has helped to stimulate women's confidence to seek weather and climate information in

Tamil Nadu, India. Similarly, Coulier's (2016) study in Vietnam emphasizes already-formed women's groups as critical networks for farmer-to-farmer information exchange. Studies in India also note that women "communicators" have played an essential role in disseminating and enhancing the utility of agro-climatic information for women (Venkatasubramanian *et al*., 2014; Rengalakshmi *et al*., 2018). Additionally, Ngigi *et al.*'s (2017) research in Kenya indicates that belonging to social groups help facilitate enhanced access to climate information.

In general, rural communities and women in particular, are aware of the variability and changes in the local climatic conditions and are frustrated by impediments to accessing the climate information needed to have a real impact on the productivity of livelihoods (Mcomber *et al.,* 2013; Ngigi *et al*., 2017; Skinner, 2011; Yohannis *et al*., 2016). Where important farm decisions that depend on the amount and distribution of rainfall during the season ought to be made in advance, it is crucial that household decision-makers access necessary information. As Rao *et al.* (2015) observe, communicating this information via traditional methods such as the print media, traditional radio, and TV announcements used by the Kenya Meteorological Service, are inadequate and ineffective because they reach a much narrower audience than a more contemporary and innovative approach. Against this background, it is essential to evaluate the links between ICTs, relevant and timely climate

information, and livelihoods as experienced by marginalized demographics, in this case, the women of Kitui.

Studies by (Ospina and Heeks, 2010a; 2010b; Ospina *et al*., 2012; Cherotich *et al.*, 2012; Owusu *et al*., 2017) have indicated that while ICTs have recently become more widespread, their use in addressing real problems like lack of region-specific climate information has not been well established. The use of ICTs can be vital in checking the adverse effects of climate change, and its attendant socio-economic challenges and therefore further studies are required to determine the specific ways in which ICTs can be used facilitate resilience to climate variability and change and to enhance livelihoods.

The research, therefore, established the extent to which ICTs were used to communicate localized climate information among rural women in Kitui County in Kenya; and how this information leads to enhanced livelihood strategies.

1.3 Research Objective

This study evaluates the access and use of ICT tools in communicating localized climate information with a special focus on rural women living in Kitui County, Kenya. Using an extended sustainable livelihood framework, the study further examined the extent to which the ICT mediated approaches influenced how rural women accessed and utilized their livelihood assets as strategies of ensuring sustainable livelihoods. Therefore, the general research objective seeks to achieve these aims by answering the questions below.

1.4 Research Questions

This research sought answers to the following questions:

1) To what extent do rural women access and use ICT tools in the utilization of climate information?
2) To what extent does the use of ICT-based climate information by rural women influence maximize access and utilization of livelihood assets?
3) What are the effects of using ICT-based climate information in the adoption of livelihood strategies by rural women?

1.5 The scope of the Study

In geographical terms, this study was situated within the larger Kitui County, and credible data was accessed from 419 respondents in villages that reflect Agro-Ecological Zones (AEZs), Upper Midland (UM4), Lower Midland (LM4, LM5,) Inner Lowland (IL5) zones, and socio-economic strata. Within this geographical locale, the key thematic concern for this study focused on the circulation and use of climate information in the dominant livelihood strategies among the households in rural Kitui County. Although our broad focus was on ICTs in general, we zeroed in on FM Radio stations (County FM LTD, Radio Thome FM, and Syokimau FM), mobile phones, television, and computers, where the FM Radio stations and mobile phones are widely spread, while the television and computers are scarce among demographics across all socio-economic groups.

1.6 Rationale for the Study

While many Kenyans either own or have access to various ICT tools, the extent to which these tools are employed to enhance livelihoods remains unclear. Anecdotal evidence suggests that people with access to ICTs have at their disposal information on many subjects, including climate-related information. People also use ICTs to deal with the routine challenges of their lives, including poverty, besides cash transfer and social interactions (May, Waema and Bjastad, 2014: Waema and Miroro, 2014). Therefore, the rationale to study the link between ICTs, individuals and communities – and how they intersect with climate information for enhanced livelihood strategies is justified.

Further, how people use ICT tools to transform their lives has only been described in general terms (Heeks, 2010; Ospina and Heeks, 2010a; 2010b; Wong, 2012; Marolla, 2018). As such, there was need for a study that focuses on specific aspects related to the climate change sector and livelihood strategies. Apgar *et al*. (2016) identify access to climate information as critical in the rural setting in order to improve livelihoods and hence achieve sustainable development. This study, therefore, aimed at evaluating the effectiveness of ICT mediated approaches to communicate climate information to rural communities, especially women, in Kitui County.

The choice of Kitui County is deliberate because it is an ASAL region characterized by harsh climatic conditions that call for innovative strategies in adaptation. The county's population generally has low and erratic incomes, although the people still reach out to access relevant

information that may enhance their livelihoods (County Government of Kitui, 2013). Being mostly rural, Kitui County was particularly important for the research because it fits in with emerging issues of ICTs, including how they can be adapted to local conditions to enhance human economic growth and development. As Chapman, Slaymaker, and Young (2001) call for the integration of local information and communication networks into newer systems. Their view is that historically, rural communities have developed local information and communication networks, but these were sidelined by modern developments. There is now an increasing need to integrate these historical networks with the new ones.

The communication networks that these scholars talk about could also be of a digital form. All these dynamics are compounded by patriarchy that limits women's agency and decision-making opportunities, especially regarding economic and cultural resources like land. Yet, women contribute significantly to the agricultural workforce, either as family members or as household heads (Aguilar, 2009; Aregu *et al*., 2011; Oluoko-Odingo, 2019). A study by the Centre for Governance and Development (2015) on the role of gender in Kitui established that women take part in land preparation, weeding, harvesting, threshing, and storage, besides their primary roles in household chores. Again, because more men than women venture beyond rural areas to pursue opportunities in urban area and women are left behind in the rural villages to take charge of family land, till them and extract whatever little the climate can allow (FAO and CARE, 2019).

1.7 Operational Definitions of Terms

The research used key concepts and terms, whose conceptual and operational meanings are provided below.

- *Information Communication Technologies (ICTs)*: include communication devices such as radio, mobile phones, computer, television, hardware and software, and satellite systems, along with the various services and applications (ITAA, 2010).
- *Digital Capital*: the *"availability* of ICT supply infrastructure, *affordability* of ICT service and *accessibility* in skills of access and use of ICT tools" (May *et al.*, 2011).
- *Climate Information* (CI): historical climatic observations, short/medium/long-term forecasts and projections. Short-term CI includes weather and seasonal forecasts with periods less than a year; medium- and long-term projections focus on changes to the climate instead of weather, on longer timeframes, such as decades and centuries.

Specifically, we refer to weather and climate time-scales, seasonal forecasts and related agro-advisories (UNEP, 2009).

- *Climate- Change*: this occurs when a significant change in climatic patterns persists for decades or longer. The change can be extreme or in the frequency of climatic parameters (IPCC, 2007).
- *Weather*: refers to the day-to-day alterations in atmospheric conditions, which is experienced as wet/dry, warm/cold, windy/calm conditions (GWP, 2000).
- *Drought*: A prolonged period of abnormally low or scanty rainfall, especially one that adversely affects growing or living conditions.
- *Climate Variability*: refers to variations in climate conditions for more extended periods in comparison to weather patterns(IPCC, 2001).
- *Climate hazards*: these are potentially adverse meteorological events or phenomena; they may be events with an identifiable onset and end, for example, storms, flood or droughts, or shifting climatic states (IPCC, 2012).
- *Climate impact*: The effects of adverse climate change and climate extremes on natural and human systems (IPCC, 2012).
- *Climate Information Services* (CIS): The institutional framework for interpreting and disseminating climate information. It is also "the dissemination of climate information to the public or a specific user." They involve strong partnerships among providers, such as National Meteorological and Hydrological Services (NMHSs), and stakeholders, including government agencies, private interests, and academia, for the purpose of interpreting and applying climate information for decision making, sustainable development, and improving climate information products, predictions, and outlooks" (WMO, 2015).
- *Livelihoods*: Combined resources, such as financial, natural, physical, social and political, that together determine how an individual or a household makes a living (Ellis, 2000).
- *Livelihood Strategies*: A combination of activities that people make to address their vulnerabilities and achieve their livelihood outcomes and objectives (Sen, 1999).
- *Livelihood Outcomes*: Livelihood strategies 'achievements, which according to the framework of DFID, lists five 'categories of livelihood outcomes: (1) reduced vulnerability, (2) increased well-being, (3) increased income, (4) improved food security, and (5) increased sustainable use of the natural resource base.

- *Sustainable Livelihoods*: forms of livelihoods that can cope and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation. (Chambers and Conway, 1992)
- *Sustainable Development Goals (SDGs)* Global goals geared towards the eradication of poverty, food security, protection of the environment, and enjoyment of peace and prosperity. The 17 goals help achieve Millennium Development Goals while allowing the inclusion of new areas, for example, climate change, innovation, economic inequality, peace and justice, and sustainable consumption (UNDP, 2016).
- *Climate Adaptation*: the practice of adjusting human/natural systems to respond to actual or expected climate stimuli or their effects that moderate harm or take advantage of beneficial possibilities and also the ability of populations to recover from short-term and long-term climate-related effects (IPCC, 2007a).
- *Coping*: the short-term ability of vulnerable populations to adapt to environmental shocks and changes (Folke *et al*., 2005).
- *Adaptive capacity:* The systems ability to adjust to climate change and taking advantage of opportunities, or coping with the consequences to moderate potential damages. This capacity depends mainly on one's access to assets (physical, human, natural, social, and financial), and how well they are utilized. Often individuals with higher adaptive capacity can recover or adapt to new circumstances. Greater adaptive capacity means the individual can handle and reduce their levels of exposure and sensitivity to climate change variability (IPCC, 2014).
- *Vulnerability to Climate change*: the level to which biological, geophysical and socio-economic systems are predisposed, to enable one to cope with adverse climate change impacts. The components: sensitivity, exposure, and adaptive capacity are usually used to define vulnerability (IPCC, 2007).
- *Capital*: This refers to the commodification of resources whose investment can attract profitable returns. Over time, the idea of capital has spread to refer to virtually anything that is used to gain leverage in social, economic, political and even cultural terms, hence concepts like social capital and political capital.
- *Gender*: refers to the relations of power between women and men, which are revealed in practices, ideas and representations, including the division of labor, roles, and responsibilities, and resources among men and women and ascribing to them different abilities, attitudes, desire, personality traits, and behavioral patterns. They are tied to

their historical, social, economic, and cultural roles, depending on their location (Moser, 2012).

- *Household:* Individuals living under the same roof, where their labor, income, and expenditures are considered as part of the household's economic conditions.

1.8 Organization Of The Thesis

Chapter 1 provides the general aspects of the research, including the background to the study, which entails a summary of commonly available ICT tools in relaying climate information; the problem statement that gives a clear and succinct description of the area of concern; and the aim of the objective and research questions. Also addressed is the scope and rationale for the study.

Chapter 2 covers the review of literature, which includes a discussion of various theoretical and empirical underpinnings of the study leading to the conceptual framework that outlines the hypotheses.

Chapter 3 introduces and develops the methodology, starting with the philosophical research paradigms, and research design. Next is an overview of the population and sampling strategy, which includes the selection of respondents for the research. The collection and analysis of data that includes issues of the formulation of the instrument, verification, and validity of both the instrument and the data are presented in this chapter.

Chapter 4 compiles the analysis and interprets the results of the collected quantitative data. A rigorous analysis was followed using the steps provided by Structural Equation Modeling (SEM) to evaluate the fit of the measurement and structural models.

Chapter 5 presents the transcribed and coded results of the Focused Group Discussions (FGD) and Key Informant Interviews (KIIs).

Chapter 6 synthesizes and discusses the quantitative and qualitative findings.

Chapter 7 brings the study to a close with the achievements, conclusions, and recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Climate change, ICTs and marginalized communities are common themes in literature today. Therefore, this study on the effectiveness of ICT mediated approaches in communicating localized climate information to rural communities living in Kitui County had to be undertaken in context of background literature that supports the need for this research.

This chapter reviews the literature on ICTs with a focus on access to, and use of, ICTs among women. The relevance of climate information in rural areas and the role of ICTs in relaying climate information follows. This study discusses the topic of sustainable rural livelihoods and focuses on the nexus between climate information, livelihood assets, and ICTs, under which the literature on livelihood strategies, transforming structures processes and vulnerability context are reviewed. A study of this magnitude cannot be complete without a discussion of theories and models that sets the theoretical background that leads to the conceptual framework.

2.2 An Overview of Information and Communication Technologies

Information and Communication Technologies (ICTs) were considered generally as 'technologies' that transfer old and new information (Curtain, 2003; Heffernan, Lin and Thomson, 2012). Greenberg (2005:16) also, holds that ICTs are often categorized based on how long they have been in use and what it is used for; he categorized:

i. New ICTs are those that are based on digital technologies like satellites, computers, wireless communications, mobile phones and the internet.
ii. Traditional (Old) ICTs depend on analog technology, such as the television, radio, telegraph, and landline telephones and have been in use over for many decades.
iii. Really Old ICTs, which have existed for several hundred years, such as books, newspapers, and libraries.

Similarly, Mallalieu and Rocke (2007) also identify three types of ICTs though from an access approach: access technologies; access device technologies; and technology applications. The first plays a central role in ICT's penetration into digitally poor communities, while the second and third are significant to community participation in the

uptake of ICTs. Access technologies enable and act as pathways for communications delivery. Access device technologies range from radio, mobile phones and television. Application technologies, on the other hand, are the end-user capabilities enabled by ICTs. These include software and applications programs that facilitate communication like email and web browsers. An encompassing definition is that ICTs are any tool, device, or application that allows the exchange or collection of data via transmission or interaction (World Bank, 2011). This study has focused on access device technologies, specifically radio and mobile phones.

i. *The Radio*

The radio is a universal ICT tool because it renders a universal service that cuts across socio-economic and geographical barriers. It has been the bedrock of communication in rural parts of Africa. Even though the television was as expected to be a better communication channel, it is still too costly for most and not as portable as the radio in the rural communities (Munyua, 2000; ITU, 2005; Waema and Okinda 2014). In Kenya, the expansion of the media space from the late 1990s saw the spread of the FM radio stations, which broadcast in the language of the catchment area, quite often-indigenous languages like Gikuyu, Luhyia, Dholuo and Kikamba, which is the universal language in Kitui where this research was conducted. It is noteworthy that while the potential of high-tech gadgets, such as mobile phones has attracted many development workers, access and use of these resources in many rural communities, especially among women, is limited (Myers, 2008).

ii. Mobile Phones

Access to mobile phones and their services has expanded rapidly across the developing countries since the early 2000s, providing a viable option for the propagation of information into communities. About a decade ago, Aker and Mbiti (2010) reported how the mobile phone service and owners tripled in size from 2006 to 2009, where more than 17 million people were connected. This was due to the sharp fall in prices following the exemption of VAT on mobile phones by the Kenya government in 2009 (GSMA 2011; RIA, 2012; Waema and Ndung'u, 2013). By mid-2017, more than 60% of Kenyans at the base of the pyramid had a mobile phone. The use of mobile services in Kenya continues to grow exponentially with a current increase in mobile subscribers from 42.8 to 44.1 million and an increase in mobile penetration of 100% (CA, 2018). Figure 2.1. illustrates the trends in mobile subscriptions and penetration levels

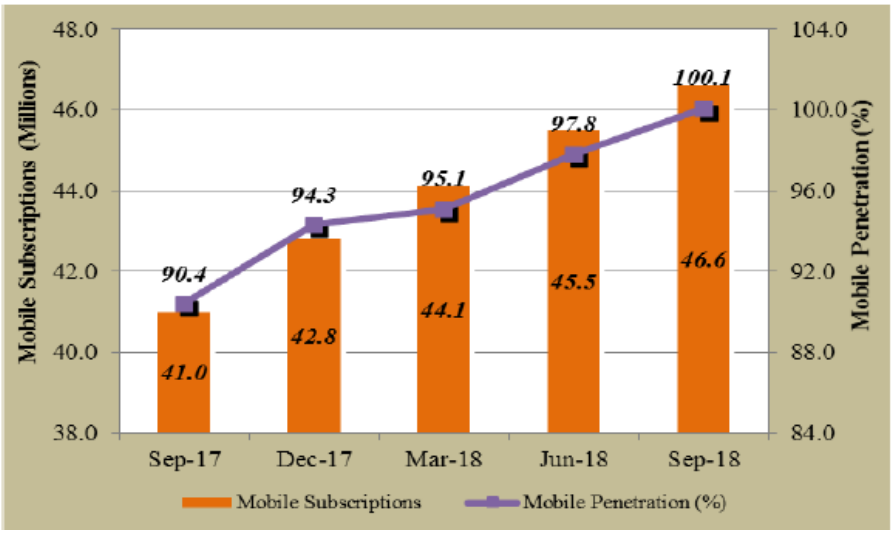


Figure 2.1: Trends in mobile subscriptions and penetration levels
(**Source**: CA, 2018)

Cellular towers have provided wireless opportunities in areas where infrastructure and geography barriers prevent the extensive landline telephone networks from reaching customers in rural areas (GSMA, 2019), this attributes to the success of mobile phone use. Therefore, rural villages and urban centers are connected in new ways that have provided new development opportunities. This has led to many service providers entering the Kenyan market.

A competitive Kenya market study showed that although the telecommunications sector is subject to free-market dynamics in Kenya, a few private players continue to dominate the playing field. Safaricom, Airtel, Telkom, and Equitel dominate the terrain of mobile telephony (Piot *et al.*, 2017). The competition has been healthy for marginalized areas like rural Kitui where such providers are looking for market too. Mobile phones have contributed to improved livelihoods and this further justifies this study for their use in climate change awareness and adaptive livelihood strategies.

According to the International Telecommunications Union's (ITU) (2009) definitions, access to ICTs denotes its availability within the home; operationalization by at least one individual in the household defines its use (George *et al.*, 2011). Further, access is not only to the physical proximity and accessibility of ICTs but also to their affordability. Access to and use of ICTs is recognized as Digital Capital (May et al., 2011), yet in rural areas it is limited (Chapman and Slaymaker, 2002; World Bank, 2011). Research carried out by Winther,

Ulsrud and Saini, (2018) in Eastern Kenya found that even in "seemingly ideal" conditions for rural electrification, that is, where there is high rural population density with grid coverage, electrification rates remained dismally low, averaging 5% for rural households limiting recharging facilities amongst other challenges. Specifically, Kitui County has relatively poor infrastructure to support high-tech innovation. Electricity access is 4.8%, good roads 39.9%, paved roads 2.4% and the poverty rate sits at 63.7%. Furthermore, some level of technical knowledge is required to effectively operate some ICTs and this comes with a level of education that could be lacking in many rural areas (Rathgeber, 2000). Some people have found a way around these challenges by accessing ICTs through social networks that allow sharing of technological tools and operational skills (Alampay, 2006; ITU, 2010; Owusu *et al*., 2017). Social networks that include family, friends, colleagues, and neighbors can facilitate such sharing. However, this can only happen in situations where social capital exists and can be exploited by communities of ICT users in their various relationships (ITU, 2005; Alampay, 2006).

Overall, advances in ICTs have led to the spread of and access to new technologies, in Kenya, though mostly in the urban areas. The demands for various services has brought about innovative use of mobile phones, which has led to more sophisticated devices being developed; smart-phones are now very popular in Kenya. There are many ways to use ICTs including mediating the flow of climate information in the agricultural sector; this is discussed in the next section

2.2.1 The Place of ICTs in the Agricultural Sector

The increasing technological innovations has been beneficial to the agricultural sector, for example, the use of Decision Support Systems (DSS), Geographic Information Systems (GIS), and Market Information Systems (MIS) and distance learning. Besides, mobile applications, land use planning, database management, personal digital assistants (PDAs), public access facilities, financial services, spatial analysis, extension, education and virtual aggregation of stakeholders have contributed to modern agricultural methods and services (Munyua, 2007; Deloitte, 2012).

The World Bank (2011) has supported the above by identifying five drivers that are key to the use of ICTs in agriculture. These are: i) low-cost and universal connectivity; ii) ICT tools that are adaptable and more affordable; iii) advances in storing and exchanging data; iv) innovative models of business and partnerships; and, v) democratizing information through

movement for open access and social media. This study focuses on all these drivers of ICT use in agriculture and their interface with climate information and livelihood strategies among respondents in Kitui County.

2.3 Access To and Use of ICTs by Rural Women in Kenya

ICTs profitable opportunities for social and economic development are limited by the underdeveloped infrastructure in rural settings, which can measure primary indicators like levels of food security (Cramer *et al.,* 2016). Women in rural Kenya have not fully accessed ICTs partially because the country was slow in reforming the ICT industry derailed by socio-cultural barriers, market monopoly, corruption and under-investment (Manfre and Nordehn, 2013; May *et al*., 2014; Mudhai, 2004). These, coupled with limited infrastructural support and erratic connectivity, have further limited the extent to which rural women can access and meaningfully use ICT tools, especially in their routine endeavors to mitigate against climatic extremes that make life difficult (Cramer *et al*., 2016 ; McOmber *et al.,* 2013; Owusu *et al*., 2018). In the case of Kitui County, for instance, the perennial drought and the attendant food insecurity means there is an urgent need to embrace ICTs as a way of sharing information on how to formulate new livelihood strategies in order to overcome the challenges. While the problem was more aggravated for landline telephones, the advent of mobile telephony has improved the situation.

The low use of ICTs tends to affect women in rural areas more than any other population group due to various challenges like limited education and entrenched patriarchal societies (Wyche and Olson, 2018). The result is gender-based inequalities as women living in rural areas continue to have less access to livelihood assets such as income, education, time, mobility (Denton, 2002; Kituyi-Kwake and Adigun, 2008; USAID, 2012). There are exceptions, however, some women are affected differently as different variables intersect to yield different experiential outcomes. For instance, older, illiterate, and poor rural women are more disadvantaged compared to their younger, educated, wealthier and urban counterparts (Odame, 2005). Ballantyne, Labelle, and Rudgard (2000) support the authors above confirming that rural women's use of ICTs is limited by the lack of skills, awareness, and the absence of livelihood capital resources for sustainability. It is on this basis that this current study focuses on the intersection between gender and place of residence; and to see how ICTs can influence these two variables in linking climate information and livelihood strategies in

rural Kitui County. Nevertheless, despite the challenges related to ICTs in rural development, the study's intervention is from the understanding that other players, such as Non-Government Organizations (NGO) have launched initiatives involving women and ICTs in different realms of life. The next section reviews some of these initiatives, especially with regards to access to and use of ICTs from a gender perspective.

2.3.1 The History of Women's Access To and Use of ICT Initiatives

The section above has outlined how in the past many women faced hurdles in accessing ICTs. In the last five years, a lot has changed with interventions from various NGOs and other non-state actors (FAO and CARE, 2019). Some NGOs use wireless technologies integrated with new and traditional media. By way of illustration, the Arid Lands Information Network, Eastern Africa (ALIN-EA) partnered with World Space Foundation (WSF) of USA and Rural Information Service from Rongo (Kenya) to facilitate the provision of information to remote areas in Kenya using digital satellite broadcasting. This program was used to relay information on agriculture, micro-enterprise, conflict resolution and health-related information in Kenya, Uganda, Tanzania and Ethiopia (Ayieko, 2001). While this initiative was laudable, its broad thematic and regional mandate meant that its impact on a specific area like Kitui County's informational requirements could not be addressed.

This study aims to bridge this gap with empirical evidence on specific access to and use of ICTs in rural areas. More specifically, it established how to link climate and agro-related information to livelihood strategies using ICTs, among rural women in Kitui County. This will assist policymakers and other related stakeholders to ensure they provide the right intervention to improve food security in such arid areas. McOmber *et al.* (2013) confirm that climatic changes have adverse effects on key sectors that impact women's lives directly – from farming to domestic responsibilities. And thus, a crucial factor in enhancing women's adaptive capacity is to ensure that they have access to information they need for accurate decision-making. For example, a delay in the onset of rain or forecast of drought can ensure they plan alternative means to achieve their goals.

'Women's Voices' is a second initiative that supports the use of ICTs to communicate and disseminate information in Kenya. It has programs in Kenya, Peru, and Zimbabwe (ITDG, 2005). They use video recording showing poor living conditions of rural women, health, alcohol and drug-related issues. The program ensures that decision- and policy-makers hear

the voices of women on issues related to diseases, sanitation and drainage systems. Such video recordings are featured on some national television programs, in Kenya, Africa-wide and even globally. They also appear in scientific newsletters and media articles. In recognition of its use of ICT for social justice, the women's initiative won the *APC Herbert de Souza "Betinho" Communication Prize* (ITDG, 2005). Again, this initiative suggests the multiple ways in which ICTs can be used to relay necessary information to women. Yet it does not focus on the link of climate, weather and agro-related information to livelihood strategies, nor on the geographical locale of the research area, that of rural areas of Kitui County.

The literature is detailed on initiatives that address the socio-cultural issues of women through ICTs. The African Center for Information and Communication Technology (ACWICT) is not different and adds the need for gender responsive policies (Obuya, 2003). The organization is committed to promoting ICTs among girls/women to improve the women's livelihood in the Greater Horn of Africa. The Horn of Africa Regional Women's Knowledge Network (HAWKNet) does similar work like ACWICT but also pools the resources of the radio and the Internet to support the women to share information amongst themselves. They consist of women and girls from mostly Kenya, Ethiopia, Uganda, Eritrea, Tanzania, Rwanda Sudan and Djibouti (Kituyi-Kwake and Adigun, 2008). ICTs are being used for education today, making inroads more so amongst urban women versus rural women. Distance education based on ICT can help disadvantaged rural women and communities in rural areas like in Kitui to attain education and training by using ICTs. Select programs according to the women's various needs can make a significant impact and give the rural women in Kitui a second chance.

2.3.2 Other ICT Initiatives

Opala (2004) reported how Cyber Cafes and Telecenters, are areas in which ICTs gained popularity amongst rural women in Kenya. These centers offered affordable services to low income people. They were centralized locations for communal mobile telephony (called 'simu ya jamii)' word-processing, photocopying and for general email access. By 2004, more than 200 E-Touch Centres were operated in rural Kenya by local entrepreneurs with support from Africa Online, one of the first ISPs in Kenya.

The mobile phone has provided an ICT outlet which has somewhat become ubiquitous with both urban and rural life, and popular with FM radio stations that broadcast in local

languages. Both the national radio service provider, the Kenya Broadcasting Corporation, and its competitor, Royal Media Services, have targeted all ethnic and linguistic communities with information packages that are rendered in local languages, often addressing local issues (Kituyi-Kwake and Adigun, 2008). Information on agriculture and challenges on farming is thus broadcast to many listeners from all corners of the country such as in the *Shamba Shape Up* on Citizen Television (USAID. 2013).

While the foregoing examples show how NGOs and other players have empowered communities via ICTs to access and use information, two gaps are glaring. First, the initiatives are broad in terms of their focus, population or demographic groups, and on the ICT outlets. Second, they all tend to speak of information generally, not the specific climate and agro-related information that women can use to make decisions that impact on their livelihood strategies. This research study was guided by the assumption that women in rural areas despite the differentiated access to resources make important livelihood-related gendered decisions to improve lives of their households. In the next section, the concept of climate information among rural communities is addressed.

2.4 Climate Information and its Relevance among Rural Communities

Generally, climate information refers to all that data relating to amounts and seasons of rainfall, trends in temperature fluctuations, intensity and direction of the wind, intensity of sunshine, cloudiness, among others. Such information is organized in terms of temporal currency or historical patterns (Gunasekera, 2004). This study focuses on how rural communities use climate information to make decisions on land use and other resource mobilization mechanisms to improve rural livelihood strategies. Cherotich *et al*. (2012) in Baringo County and Wamalwa *et al.* (2016) in Kisii County show that such information, if well packaged and appropriate to the farmers' needs, can attain greater acceptance and more influential in decision-making. Other studies done in Kitui County include Kniveton *et al.* (2012), Barret and Ndegwa (2016) whose findings on the enhancement of livelihood strategies in rain-fed dependent economies is relevant but does not consider the role of ICTs. The fact that these studies were conducted in Kenya renders their findings applicable to the study. Hence, the study focused on climate information and support services relevant to climate change adaptation in semi-arid areas that include weather forecast, seasonal forecasts, early warning signals, and their corresponding agro-advisories. Weather and climate

variability information are mostly short-term and of immediate relevance to rural communities, and if well packaged will help in increasing farm productivity and help farmers adapt to climate change and improve livelihoods by extension (Cherotich *et al*., 2012).

Climate information is at the core of decision making for farmers in rural Kitui County, especially weather and climate patterns, to ensure they cope with climate change and adapt to it. Hence, accurate and timely climate information enables the farmers to make decisions on the timing of planting and fertilizer application, selection of crop types and varieties that can yield optimum results in the dominant weather and climatic conditions. Information on livestock stocking rates, market trends and change in farming systems is also useful at this level. Table 2.1 displays a more unobstructed view of the differences in detail and timeliness of different forms of climate information, the different timescales associated with the type of weather and climate patterns, and the medium of delivery that relate to the information needs of the rural farmers in Kitui County.

Table 2.1: Climate Information across Timescales

Term/Timescales	Type of Information	Source of Predictability	Treatment of uncertainty	The medium of delivering CI	Relevance to Rural Farmers (Livelihood Strategies)
Weather (Days to Weeks)	• Observed rainfall and temperature • Daily Forecasts of one week in advance • Pests and diseases alert • Early warning (drought, floods) of life-threatening weather occurrences	Atmospheric initial conditions	**Deterministic**: Weather sequences on an hourly-daily	• Mobile Phones • Radio • Television • Call Centres	• Timing of planting and harvesting • Timing of application of fertilizers, herbicides, pesticides and irrigation • Protecting lives and property (Livestock) against extreme events
Climate Variability (Months to Years)	• Seasonal rainfall and temperature condition probabilities • Seasonal climate variables focused on specific agricultural risks (dry spells, onset and cessation dates and duration of rainy season)	Boundary conditions (land surfaces and ocean)	**Probabilistic**: shifts in the distribution of seasonal statistics in terms of probability	• Workshops with experts • Conversion with agricultural extension agents (farm educators) • Mobile Phones • Radio • Television • Call Centres	• Crops and seed varieties selection • Storage rates and feeding strategies of livestock • Intensity of agricultural input(fertilizer, pesticides) use • Labor contracts or contracts for marketing • Intensification and diversification of crops • Diversification of income sources
Climate Change (decades or longer)	• Future rainfall and temperature forecasts • Historical rainfall, temperature and wind trends and historical changes in extreme climate events	Anthropogenic and natural changes in the composition of the atmosphere and heat balance	**Scenarios**: Plausible future climate projections with unknown uncertainty	• Workshops with researchers, • Agricultural extension agents and • Meteorological services	• Major investment in capital (purchase or expansion of landholding, farm equipment, irrigation systems.) • Changing the agricultural system or the livelihood strategy • Pursuing other livelihood options

Source: Meinke and Stone (2005), CCA

Although significant progress has been achieved in the archiving, collection and analysis of weather and climate data, their transformation into usable information by the small-scale rural farmers remains poor. Some attributes are required for such information to be useful to farmers. Tall and Hansen (2013) outline some of these to include:

- Salience: Ensuring content, scale, format, and lead-time of the climate information are tailored to decision making at the farm level.
- Access: providing timely access to rural communities that are isolated and have poor infrastructure.
- Legitimacy: Ensuring that farmers are involved in the shaping, designing and delivering of the climate information services and thus owning the services.
- Equity: Ensuring that the socially marginalized groups like the poor and women can access and use climate services; and
- Integration: Providing climate information as part of a broader agricultural and development support package to enable farmers to work on the information received.

Success is recognized if climate information can have all these attributes and are correctly used by the targeted communities. This study was concerned with the qualities of access (the quality and frequency of climate information the users can get), equity (bringing in women who have been marginalized from economic activities) and salience (urgency and currency or lead time of the climate information), which determine the adaptation of climate information to the prevailing local conditions, in this case tailoring content in the Kikamba language of the region. All other qualities remain relevant, nonetheless, even though on different scales. These are also held together by the SLF, which informed the overarching interpretative tool in this study. This is also because the sustainable livelihood approach provides a view that brings community/household-specific and contextual issues to the forefront when considering the application of climate information (Ziervogel and Calder, 2003).

2.5 The Role of ICTs in Dissemination of Climate Information

Chapman and Slaymaker (2002) point out that ICTs can facilitate the generation of information required by the rural poor, allowing them to make better-informed decisions affecting their

livelihoods strategies and ultimately their livelihoods. However, these ICTs must be linked to institutions and external stakeholders that may affect the livelihood of the rural poor. Most importantly, they must be demand-driven to address the specific needs of the rural poor.

There are emerging experiences that suggest that rural agricultural communities use some ICTs, such as, rural community radios and mobile phones to disseminate climate change information to the population (Ospina and Heeks, 2012). In Section 2.3 above, there was evidence that advances in technology also open up new ways in which the same technology may be used. Indeed, as the World Bank IEG (2011) notes ICT fosters innovation and can trigger major economic transformation. This is primarily in the case where human capital and creativity is shown through access to global knowledge. A direct example is how ICT is applied in climate and weather information systems by providing a level of localization and temporal specificity among vulnerable groups in rural areas (Karanasios, 2011). This coheres with Bhavnani *et al*.'s (2008) idea that mobile phones can drive everything from improvements in social capital creation, improved flows of market information and productivity.

According to Karanasios (2011), new and emergent technologies allow for diffusion of mobile broadband, which opens a range of possibilities for climate change adaptation, such as monitoring, capacity building, and information dissemination. Chaudhury *et al.* (2012) support this by highlighting how mobile phones can be used in information exchange, which is more accessible in developing countries than computers and the television. Therefore, this increases access to the internet by the purchase of data bundles for mobile phones, which means better connectivity for all save for the cost implications (ITU, 2008). Mobile telephony is, therefore, an essential component in the broader ICT framework to link climate information in rural areas, for livelihood strategies and economic development.

The radio is also core for climate information dissemination because it is one of the most useful and widely diffused technologies for reaching the masses, notably, the poor (ITU, 2008). According to Chapman, Slaymaker and Young (2004), the radio is advantageous in its capability of reaching and providing illiterate farmers with agricultural production information in a language they understand. Furthermore, radio programs can facilitate communication between

farmers and researchers by providing climate information on what is happening at the local level (Manyozo, 2009).

Other global agencies such as the United Nations Development Programme (UNDP) and the World Bank have identified ICTs as useful tools in many areas, including expanding women's roles and mitigating social and environmental inequities (ITU, 2005; UNCTAD, 2011). Indeed, ICTs play a crucial role in environmental monitoring and providing information related to natural resource-based livelihood assets and climate-related hazards like drought (ITU, 2012; ITU, 2014). For example, in meteorology, ICTs are increasingly being employed in disaster prediction and early warning and to improve data collection. Relevant to the study on ICT and natural resources are agriculture decision-support projects such as the COMMONSense Net wireless network in drought-hit villages in Southern Karnataka (Panchard *et al*., 2007). The authors report how ICTs have helped village residents manage crop-risk by the efficient use of water and pest prevention. Evidence shows that the answer lies in letting farmers connect to and act on the constraints of their environment. This research has similar objectives to that of Panchard *et al*. (2007) because of the element of linking relevant climate information, using ICTs, with rural women in Kitui County, which is an area that experiences extreme forms of climatic conditions. The next section focuses on sustainable rural livelihoods that can be maintained if rural women can get the right climate information to be successful.

2.6 Sustainable Rural Livelihoods

Chambers and Conway (1992: 6) define livelihoods as "the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living" while adding that a sustainable livelihood is where people can recover and cope with shocks and stress while also maintaining and enhancing their capabilities and livelihood assets for future generations. Sustainable livelihood rose to prominence in the early 1990s, after the challenges associated with famine and food insecurity during the 1980s (Haidar, 2009). Different researchers have since adopted the livelihoods concept and used it in development discourse. For instance, Chapman *et al.* (2001) demonstrated how sustainable rural livelihoods approach provides a useful framework for situating the rural poor in the context of issues that affect their lives. This is mainly in terms of policy formulation and implementation with regards to access and ownership of resources. In all

these, ICTs have been central in packaging and delivering relevant information for both the poor whose lives need to be changed and for the policymakers who should lead in making the desired changes. In this regard, the sustainable livelihood approach has gone beyond being a concept to become an analytical framework.

There are previous studies that informed this research like that of Burrel (2008) in Uganda who demonstrated that mobile phones were used in rural areas to reduce the money spent on transport and other transactional costs of subsistence farming. Mittal *et al.* (2010) and De Silva (2008) concur with this view, adding that reduced transport costs translate into benefits for the farmers who make net gains on other livelihood assets. Overall, farmers who are equipped with ICT-mediated information are more empowered to bargain in an increasingly competitive and technology-driven market.

The embrace of ICTs, accordingly, may not necessarily be beneficial to all farmers, but only to the market-driven ones. For instance, Bhavnan *et al.'s* (2008) study were based on the common perception by some subsistence smallholder farmers who produced food crops for household consumption only, and who suggested that they did not gain any benefits by using mobile phones to access and use agricultural information. The view is that all farmers do gain somewhat by using ICTs in general and mobile phones in particular, given that even those farmers who do not wish to sell their agricultural produce may still need to know which market sells inputs at the best prices, and thereby make savings on farm inputs expenditure. It is possible that Bhavnan *et al.* (2008) got their responses that way because of how the initial question had been framed. McNamara (2003) and May (2010) also suggest that too much experimentation with ICTs has demonstrated the possible advantages in the fight against and the promotion of sustainable development, but also the risks and challenges associated with the same ICTs. Accordingly, there is a tendency to exaggerate the successes associated with ICTs, without paying due regard to the broader contextual influence on the outcomes, for instance, the fact that the initial acquisition of mobile phones is an indicator of improving livelihoods in the first place. This has posed a danger to the sustainability of many ICT-for-Development initiatives because the planners and executors of such initiatives are blinded by their enthusiasm to the broader scope of underlying realities. This study considered this fact and was modest in evaluating the cause and effect relationships

that exist linking climate information, ICTs and the livelihood strategies adopted by rural women small-scale farmers. This section reviewed the concept of sustainable rural livelihoods but it is imperative to delve into components that constitute sustainable livelihoods. This includes livelihood assets, which include social, physical, human, financial and natural; – and how they relate to climate information, transforming structures and processes livelihood strategies and vulnerability contexts.

2.6.1 Transforming Structures and Processes

The concept of transforming structures and processes incorporates both social and cultural factors that can shape livelihoods, besides the institutions and policies that may influence (either directly or indirectly) the increase or depletion of one or more assets. The SLF at this point links the micro- and macro factors. The processes and structures can be accessible to incorporate into peoples' strategies, but they can also shape and constrain possibilities of individuals (Parkinson and Ramirez 2006). Culture, a part of processes, accounts for other 'unexplained' differences in how power dynamics affect access to ICT tools (DFID, 1999).

2.6.2 Vulnerability Context

Vulnerability in the context of climate change is defined as "a high degree of exposure to risk, shocks, and stress; and proneness to food insecurity" (Ellis, 2000: 62). De Haan (2000) further expounds on how it is caused by events and situations that are beyond the control of the concerned individuals or households. Climate variability contributes to both shocks and stress, depending on the nature and extent of the impact. Drought, which is prevalent in Kitui County, for instance, is considered stress when it occurs over several years, contributing to the accumulative effect on food and nutritional security. Vulnerability to short-term shocks is often a result of poverty induced by long-term stresses (Swift *et al.*, 2001). What is vital in all this is the fact that information flows through ICTs with the ultimate intention of insulating people against vulnerability to ensure sustainable livelihoods.

2.6.3 Livelihood Strategies

In two decades, the definition of livelihood strategies has not changed a lot with Chambers and Conway (1991) saying it is as a set of activities and choices people embark on to achieve their livelihood goals. On the other hand, Duncombe (2012) views livelihood strategies as the range of

activities and decisions undertaken by individuals to address their vulnerability. People adopt different livelihood strategies using their available assets to secure adequate income and welfare to protect themselves from vulnerabilities and achieve other goals, such as adequate food, education for their children, adequate shelter, and medicine (DfID, 2005). Livelihood strategies depend on assets status and transforming structures and processes. For this reason, people keep changing them depending on institutional policies and structural changes. Kollmair and St. Gamper (2002) argue that depending on the policies and institutions at work, a changing asset status may further hinder other strategies.

Livelihoods strategies are context specific as they respond to local conditions. Thus, Scoones (2009) identifies three broad clusters of livelihood strategies in rural areas: intensification/extensification of agriculture; diversification of livelihoods; and migration or seeking an alternative livelihood. These cover broadly the range of options available to rural people, who may make such choices and act on them with information channeled through ICTs. All these approaches and arguments demonstrate the fact that the policy and institutional environments primarily shape livelihood strategies that may be available to rural folks. Successful livelihood strategies can lead to further improvement or increase in assets or reduced vulnerability to eventually create favorable livelihood outcomes (DfID, 2009).

2.6.4 Climate Information, Livelihood Assets and Livelihood Strategies Nexus

According to DFID (1999), the shape of the Pentagon (Figure 2.2), schematically shows the variation in access to livelihood assets for individuals. The five types of assets pictured at the corners of the Pentagon are natural, human, financial, social, and physical and emphasize their interrelatedness. These assets are also referred to as capital, and the terms “asset” and “capital” are roughly interchangeable.

The Pentagon's center point is where the lines meet and represent zero access to assets while the outer perimeter represents maximum access to the same assets. For instance, different households have different access to livelihood assets and the livelihood strategies they adopt depends on the diversity, amount and balance between assets. On this basis, differently shaped pentagons are drawn for different communities or social groups within communities. Multiple

benefits can be generated by owning a single livelihood asset. For instance, if one has access to secure land (natural capital), he or she may also be well equipped with financial capital, as they cannot only use the land for direct productive activities but also use the land as collateral for loans, therefore, accessing more than two assets. Equally, livestock ownership can generate owners' social capital (prestige and community connectivity) while being used as productive physical capital and remaining, in itself, as natural capital (Chapman *et al*., 2004), accessing three sets of livelihood assets.

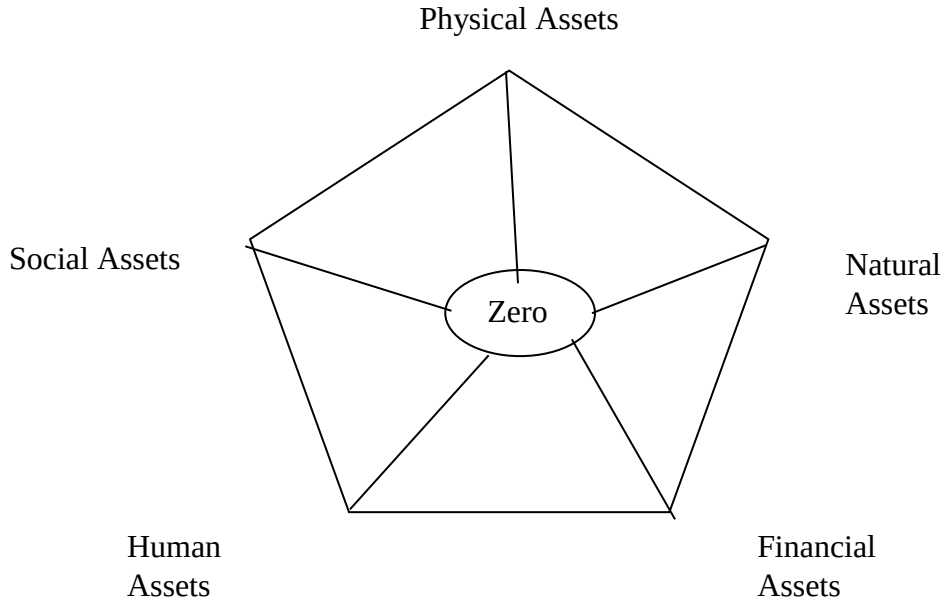


Figure 2.2: Livelihood Assets Pentagon
(**Source**: DfiD 1999)

As discussed by Duncombe (2006), ICTs can support livelihoods by providing access to information needed by the poor to pursue their livelihood strategies and by providing information to inform policies, institutions, and processes affecting their livelihood strategies. It is in this context that one can show how ICTs play a vital role in the livelihood of poor people by maximizing their access to different assets, as demonstrated in Table 2.2.

Table 2.2: Perceived ICT Impacts on Livelihood Assets

Livelihood Asset	Link with Livelihood Improvement
Natural Capital (Natural resource stocks from which resources flows are derived that are useful for livelihoods)	• Improving access to information on natural resource availability and management of natural resource, or by reinforcing market access for agricultural products • ICTs can reduce risk and vulnerability to natural disasters and food shortages by supporting early warning systems
Human Capital (knowledge, skills, good health, ability to work, that allow people to pursue diverse livelihood strategies)	• Learning through and with ICTs • Access to climate information services • Providing access to knowledge through agricultural and meteorological agents • New networking skills –learning basic computer and phone operating skills • Community, government, and organizational capacity building
Financial Capital (Available financial resources that provide livelihood options such as savings, loans, remittances, and pension)	• Increased access to financial services • The increase in profit margins resulting from improved access to information • Increased remittances from migrant workers
Social Capital (The social networks and resources people draw on to pursue their livelihoods, such as trust and reciprocity in membership groups and membership of networks)	• Strengthened connectivity and contact for households and social networks with geographical disparities • Communications make it possible for migrant workers to stay in touch with families and to transfer funds/remit finances • Access to climate information and related agro-advisories by SHG or community groups • Linkages between farmers in different villages and facilitating learning from one another
Physical Capital (Basic infrastructure for the supply of communications, energy, transport, shelter, water and production equipment)	• Access to ICT • Reducing transport needs and costs by using ICTS • Access to improved production equipment by expanding product research through ICTs • Supporting service providers in monitoring access to local services

Source: Batchelor and Scott (2001)

Similarly, Chapman *et al.* (2001) have shown that ICTs' maximization of livelihood assets depends on the local context where they are introduced. Within the context of the Sustainable Livelihood Framework (SLF), ICT interventions facilitate the provision of information to the rural poor to improve their decision-making abilities. However, core to information is the fact that the information needs are directly related to the five livelihood assets and are represented by the livelihood information wheel best illustrated in Figure 2.3.

A represents the core information which leads to building long-term decision-making capacity for appropriate livelihood strategies, via education and training, as well as technical support, and problem-solving assistance. **B** represents the information that relates to local context and needs

to be updated regularly to allow people to make short-term decisions about their livelihood activities. It can also contribute to diversification and livelihood strategies in the medium term.

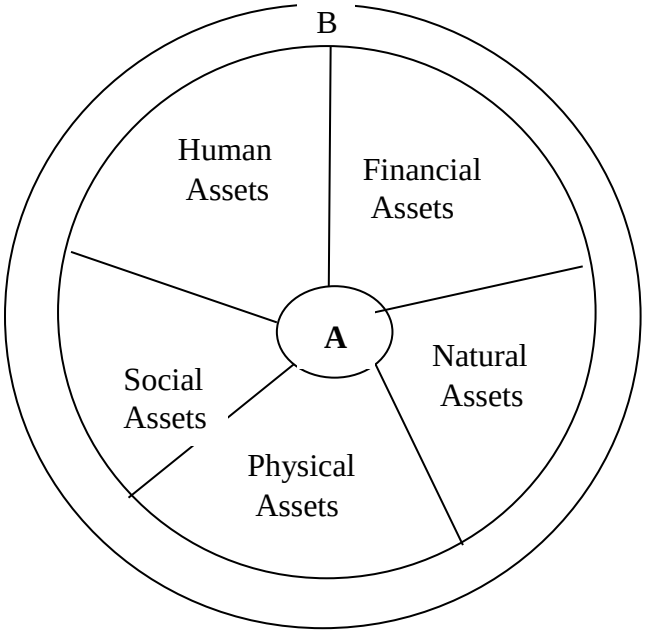


Figure 2.3: Livelihoods Information Wheel
(**Source:** Chapman and Slaymaker, 2001)

Chapman and Slaymaker (2002) devised the information wheel model to differentiate between information that affects short-term livelihood strategies and those that affect long-term ones. More informed farmers and rural people can use relevant ICT-enabled information to make relevant and timely decisions about their livelihood strategies, thus reducing their vulnerabilities and increasing diversification of livelihood assets.

For instance, in **A**, institutions and government may use ICT tools such as mobile phones and to alert and update farmers about pest pandemic or famine. While in **B**, Greenberg (2005) shows that the provision of simple information such as weather forecasts and crop information itself has provided livelihood benefits. Rural farmers use this type of information to make relevant decisions about livelihood strategies, thus reducing the impact of disasters (floods, diseases, droughts warning, and mitigation), protecting their natural assets, and thus increasing their income diversification, which is closely tied to our study, the provision of local climate information mediated through ICTs.

2.7 Theoretical Frameworks

A theory is a statement of concepts and their interrelationships showing how or why phenomena occur (Gioia and Pitre, 1990). Hence, theories are generalized observations propounded on the topic by earlier researchers. A theoretical framework, therefore, emerges from an inductive integration of prior literature, theories, and other related information. Miles and Huberman (1994) state that for any researchable topic, there are certain theories associated with it. The theories form the basis for reframing the research questions and making informal predictions of possible study results as they help explain the relationship between the research variables. This can be either from a narrative or graphical perspective, the primary study areas, the key factors, constructs or variables and the relationships between them (Miles and Huberman, 1994). They inform the rest of the research design to help assess and refine goals. It is from such theories that one can develop relevant research questions, select methods, and identify potential threats in validation of the research conclusion (Maxwell, 2012). Hence, theory guides all aspects of academic research, from the formulation of the research question through operationalization and discussion (Gioia and Pitter, 1990).

A theoretical framework leads to the formulation of a paradigm that makes it possible for a researcher to imagine the outcome of the research. It summarizes the primary dependent and independent variables, the relationship between them in the study and helps to justify the research (Maxwell, 2004). The theories that we employed in the current study included those targeting ICTs, climate information, gender, and cultural aspects of the research. Specifically, employed in research are the Gender and Development (GAD) Theor, together with Pierre Bourdieu's ideas on cultural capital to address the gender and socio-cultural dimensions. This study also used the Information Need Analysis Model (INAM) to address the information needs of individual rural women. All these theories and models were applied in a complementary manner towards building the conceptual framework that was in turn understood within the larger SLF. These theories are discussed in the next section to lead to the conceptual framework in this study

2.7.1 Gender and Development (GAD) Theory

The study employed the theory of gender and development to understand the motive in using ICTs and Climate Information to achieve incremental and sustainable development for people.

At the same time, considered were the concept and process of development, which are gendered due to different dynamics, such as, cultural and sociological realities that frame the experiences of men and women in society. Hence, data were analyzed with particular regard to how men and women view the same phenomena, given their different forms of socialization that have sustained forms of gender inequality in society generally. This state of gender inequality has led to a situation where the roles, experiences, and achievements of women in the domains of development are generally under-acknowledged, under-reported and under-valued (Parpart *et al.*, 2000; Momsen, 2004; UN Women, 2014).

Boserup (1970) highlighted the gender dimension inherent in development processes. Observations that had broad political implications and gender awareness were adopted in the UN Decade for the Advancement of Women's World Course of action (Moser, 1989). In GAD, gender is defined as the socially acquired (rather than biologically determined) notions of masculinity and femininity that identify women and men. These socially acquired identities are flexible, as are gender roles. While GAD does not view socially acquired gender identities and roles as implacably fixed, neither are they homogenous. This is mainly in the case where gender roles are defined as the "tasks and types" of employment that are socially assigned to men and women (Momsen, 2004). Gender roles become more flexible in response to changes brought about by development, as those processes cause shifts in socially constructed definitions of divisions of labor and power relations, opportunities for women change as labor markets shift and development processes expand women's access to power altering tasks and types of employment (Parker, Lozano and Messner, 1995). It is on this basis that GAD also recognizes that everywhere, gender is crosscut by differences in class, race, ethnicity, religion, and age (Momsen, 2004).

For instance, in a household setting, Moser (1989; 2012) postulates that three generalized assumptions tend to be made. First, households are considered a nuclear family of a husband, wife, and children but ignores the non-nuclear family structure of the extended family. Moser (1989) builds on this argument by pointing out that the extended family does not disappear with 'urbanization,' instead, it continues to be a survival strategy for households with low-income. Another important type of household structure is the 'female-headed households' (FHHs) where

women are the "key decision-makers and economic managers" (Moser 1989; UN Women, 2014). The 2009 population census in Kenya supports Moser's study, with FHHs at 33.90%. The survey showed that female-headed households in urban areas were below the national average, but rose above 33% in rural areas, driven mainly by the migration of capable men to towns. The relevance of this data lies in the positive correlation between FHHs and poverty, and a higher vulnerability to climatic conditions (UN Women, 2014).

Second, Momsen (2004) suggests that a household is a socio-economic unit where women and men equally control resources and equally make decisions. The assumption ignores intra-household relations and idealizes the household as a harmonious institution. However, the intra-household relations have gender inequalities where the male controls resources and is the primary decision-maker. Also, male and female partner preferences are often incompatible, and thus, comprehending household structures is fundamental to the success of developmental efforts (Moser, 1983).

Third, that within the household, there is a clear division of labor, which implies that the husband is involved in productive work as the 'breadwinner,' and the housewife assumes responsibility as a 'homemaker' (Moser, 1989). Instead, Moser (1993) draws attention to the 'triple role of women' whose concept consists of their productive, and community management roles in addition to the reproductive role. Despite these reservations, the categorization of Moser is useful because it makes the work of women more visible and emphasizes their diversity in their domestic, commercial and community responsibilities. These three household assumptions give a wrong picture of what household is all about because it tends to oversimplify a complex issue and overlook some crucial aspects.

Therefore, under the GAD framework predicates, household dynamics is on the awareness that development processes have differential effects on women and men, with women often faring worse because of gender-based discrimination and power differentials. In order to expose barriers to women's full participation in development –whether economic, social or gender-based – GAD calls on researchers and practitioners to conduct a gender analysis to find the best strategies to address women's and men's different needs in developing communities (Parpart *et al.*, 2000; Marchand and Parpart, 2003; Momsen, 2004).

To discern the differences in how development affects men and women, GAD encourages reflections on the different "roles, responsibilities, access to resources, constraints, and opportunities" between women and men (Moser, 2012) and is grounded in the realities of women's lives and rooted in an analysis of gender inequalities. GAD provides a systematic way to examine gender issues, providing GAD Tools that are designed to help understand gender roles and responsibilities among stakeholders.

GAD was a useful, practical and theoretical approach to understand how use of ICTs marries with gender dynamics in rural villages of Kitui County, especially regarding their uptake in harnessing natural resource-based livelihood assets. The research implemented the GAD Tools analysis in the household survey questionnaire, focus group discussions, and key informant interviews. Using these GAD tools, the identified ICT and the attendant climate information explicitly considered women to be agents of change rather than passive or compliant development recipients (Momsen, 2004; Grigsby, 2013). Furthermore, GAD provided a useful lens to observe current use of ICTs by women in Kitui and how the same may be used to load climate information in their livelihood activities. These can be innovatively employed in terms that complement notions of class and how classes are formed, which is part of the main concerns in Pierre Bourdieu's theory discussed next. GAD theory is operationalized in the eight Tools of GAD Analysis (Parpart *et al.*, 2000), a system to operationalize the interconnection between gender, class, and race. Table 2.3 summarizes the GAD tools:

Table 2.3: GAD Tools

Tool	Key Concern	Critical Related Questions		
1	Gender Divisions in Labor	• What work do women and girls do (paid and unpaid)? • What are the implications of the division of labor for achieving livelihood outcomes?		
2	Types of work	• **Productive** (Paid or unpaid, employed or self-employed)	• **Reproductive** (Care and maintenance of the household and its members; bearing and caring for children. While critical, it is commonly not considered 'real work,' and are assigned to women and girls)	• **Community** (elective organization of social events and services, ceremonies and celebrations, local political activities, social activities, etc.)
3	Access and Control of Resources / Benefits	• The ability by women to access or control available resources such as land, equipment, cash, education, or training and what benefits may accrue to men and women through the facilitation of outside ownership, asset ownership, education, basic needs, and political power.		
4	Condition and Position	• **Conditions** refer to material elements of women's day-to-day life, such as daily needs for clean water and food.	• **Position** refers to women's social and economic status. Parpart *et al*. (2000) distinguish between women's conditions and their positions relative to men.	
5	Practical and Strategic Gender Needs	These relate to immediate needs • **Practical Needs** o Water provision o Income earning for household provisions o Housing and basic services o Family food provision	• **Strategic Needs** o Reducing the burden of childcare and domestic work o Removal of discrimination o Access to credit and resources	
6	Influencing Factors	• Community conditions (poverty, income distribution, inflation) • Legal framework • Demography factors • Training and education	• Community attitude to development (cultural issues) • External and internal political development • Generation and dissemination of knowledge on technology and skills	
7	Levels of Participation	• Women's participation in development initiatives benefits both women and the programs. It enables women to benefit by gaining decision-making skills and management experience and encouraging them to organize and plan solutions. Moreover, programs or projects benefit from consultation with women who are agents of change and are very familiar with issues affecting their livelihood.		
8	Potential for Transformation	• Focuses on the transformation of unequal power dynamics that disadvantage or marginalize women with the goal of intervening to disrupt or address unequal gender-based power dynamics that prevent women from fully participating in development.		

(**Source**:Moser,1989:1999)

2.7.2 Bourdieu's Theory of Class and Social Capital

Pierre Bourdieu (1986), in his theory of class distinction, argues that status differences may be viewed as indications of differences in social class. In advancing this idea, Bourdieu employs an explanatory discourse that proposes a causal link between class location and what he refers to as 'habitus.' Second, he establishes a relation of 'expression' between the habitus and some practices that are situated in different domains of consumption (lifestyles). Accordingly, these practices construct social collectivities (status groups) by creating symbolic borders between individuals occupying various locations within the class constructs. According to Bourdieu, the construction of status groups is contentious and involves "classificatory struggles."

Bourdieu's notion of class structure is based on the entirety of the occupational division of labor. It follows that locations within the division of labor are different based on various factors. For Bourdieu, these factors arise from the distribution of capital (the set of actual usable resources and powers). His concept of habitus is an establishment of an indirect causal link between positions in social spaces and practices. The habitus is differentially formed based on each individual's position in social space. As such, the process constituting the habitus is not situated at the point of production, as shown in Figure 2.4.

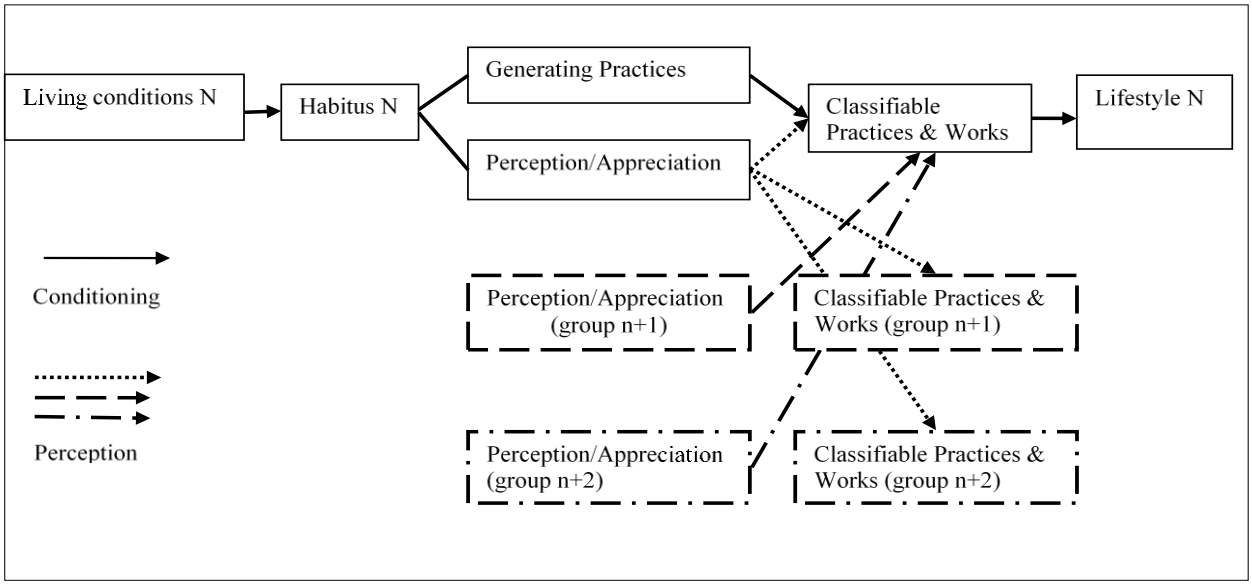


Figure 2.4: Bourdieu's Conception of Class-Based Structure &Agency
(**Source:** Adapted from Bourdieu's *Distinction* in Bourdieu, 1986)

The habitus provides an interface between the living conditions, the process of conditioning and the attendant perceptions on the one hand, and the emerging or generating practices and emerging perceptions on the other. Ultimately, the emerging classifiable practices and works lead to a lifestyle transformation that draws on Bourdieu's notion of social capital, among others. According to Bourdieu (1986), social capital entails the aggregate of the actual or potential resources which are linked to possession of a long-lasting network of more or less institutionalized relationships of mutual acquaintance or recognition. This notion of social capital works is commonly understood as social obligations that can be converted to economic capital under certain conditions. This concept of social capital, as used by Bourdieu was relevant to the selection of the research topic in this study. This can be explained in the sense that the rural communities in Kitui, by virtue of shared cultures and socio-economic experiences, have certain obligations to each other in terms of social support mechanisms that are put in place to mitigate against the harsh climatic and economic conditions.

Bourdieu's concept of social capital, furthermore, was relevant to this research because the use of ICTs by the target population constituted a simultaneous creation and utilization of social capital to negotiate their daily lives and mitigate against the common weaknesses associated with the SLF adopted in the study. Importantly, the concept of social capital fits in the SLF at the point where it was viewed as a central part of livelihood assets that go a long way in transforming communities through cultural dynamics.

2.7.3 Information Needs Assessment Model

ICTs in rural areas will not have a significant impact unless they meet the basic financial and social information needs of individuals, where climate information cuts across both information needs, although this information is of limited use unless properly packaged (Rathgeber, 2000). It confirms the requirement for an information needs assessment to identify needs gaps between current and desired results (Kaufman, 1998). Dhingra and Misra (2004) formulated the Information Needs Assessment Model (INAM) that was adapted by Kaufman's (1998) needs assessment. The INAM model's primary goal is to identify the information needs of the rural communities so that the information providers can address the actual needs of the rural poor and not the ones they perceive.

This approach is appropriate for ICT4D as it focuses on information delivery capacities through ICTs. The model is sensitive to the individual communities' specific information needs against the impacts of ICT4D information, which ensures that the information needs emerging are based on the realities on the ground. They include analyses of theme, existing community information systems, profile, and prioritization of information needs' (Dhingra and Misra, 2004). Figure 2.5 is a depiction of this:

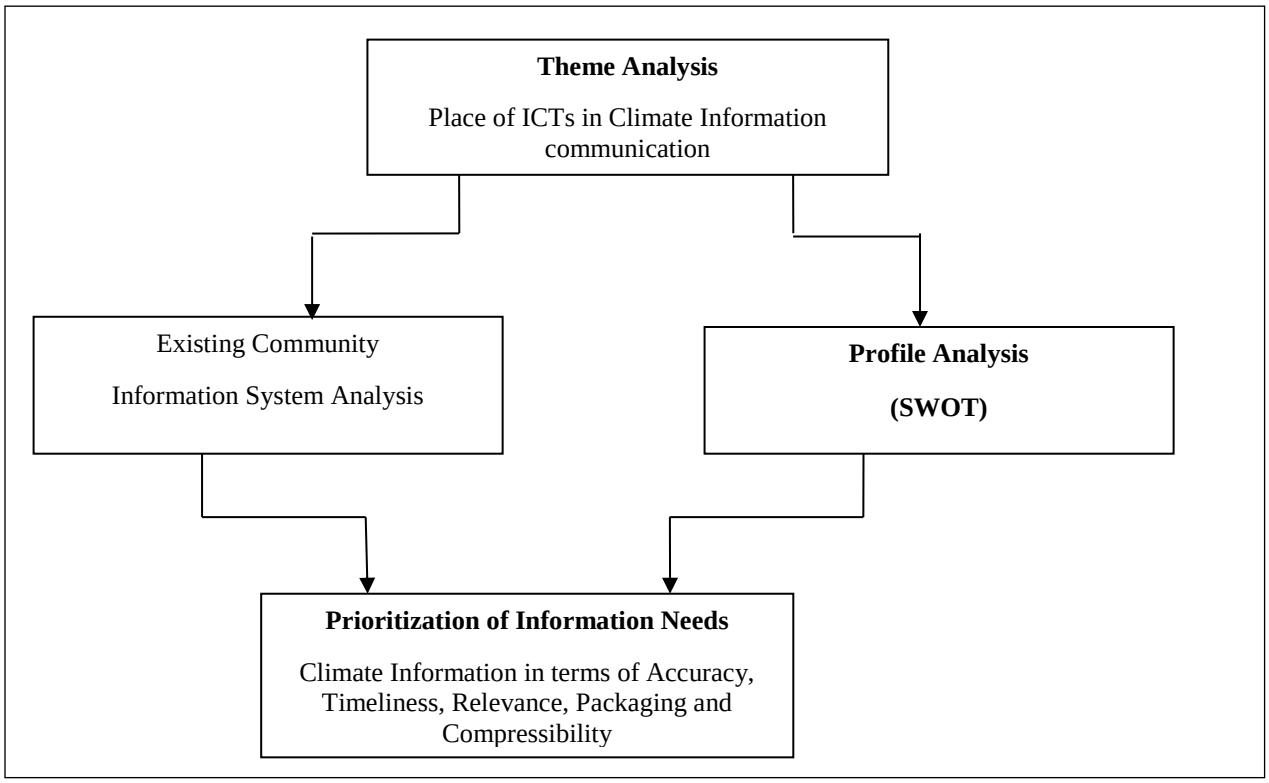


Figure 2.5: Information Needs Assessment Model
(**Source**: Dhingra and Misra, 2004)

An explanation of Figure 2.5 shows:

i. Theme analysis contextualizes the research problem.
ii. Profile Analysis Activity is a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis charts the life activities of the rural people and highlights the areas that need intervention in the targeted community to achieve enhanced livelihood outcomes.
iii. Existing Information Systems Activity Analysis checks for other community information systems, which may already be operational in the targeted area or other areas with a similar profile to uncover success stories and lessons, learned.

iv. Prioritization of Information Needs Analysis addresses which critical information should be of priority during delivery (Dhingra and Misra, 2004).

The INAM is a fundamental model in this study because it harnessed relevant climate information through ICT tools as part of the independent variables of livelihood strategies. This is very useful for the respondents from Kitui as accessibility to ICTs cans transform their lives. Specifically, INAM was helpful because it identified packaged and disseminated information on climate change and climate-resilient farming methods and practices in the research area. Such information is central in making crucial decisions regarding farming in the region. INAM then helps in harmonizing the information needs and packages that are relevant to different stakeholders in rural Kitui. In this regard, Chapman, *et al.* (2003: 4) note, "different stakeholder groups each have specific information needs and delivery preferences," suggesting a need for harmonization of such information. For this reason, "information must be communicated throughout the framework to inform decision making at every level". Hence, the model guided the study in determining the most effective way of linking the use of ICTs for climate information by women in rural Kitui County. It is also supported where climate information is incorporated in the analytical conceptual framework in Section 2.8.

2.7.4 Sustainable Livelihood Framework Model

According to Parkinson and Ramirez (2006), the Sustainable Livelihoods Framework (SLF) helps in understanding ICT-related issues from the "bottom-up" perspective. As Price, Janky and Latsenia (2004) illustrate in Figure 2.6, livelihood assets (natural, social, human, financial, and physical) mitigate the shocks that exist in the vulnerable context. Different structures and processes transform these into livelihood strategies that ultimately lead to better livelihood outcomes (DfID, 1999; Heeks and Molla, 2009). As Ellis (2000) suggests, SLF leads to a view of improved livelihood as a state made possible by a blend of capabilities, resources, and activities. Such improved livelihood, Chambers, and Conway (1991) indicate, is considered to be sustainable when it can outlive a certain period of time and overcome reasonable hardships.

Historically, SLF was deployed in development disciplines to analyze different contexts of poverty. The multifaceted SLF incorporates complex views of livelihood from the perspective of

the poor and considers their livelihood strategies and decisions. In order to increase and protect their livelihood assets, these strategies and decisions are formulated and implemented by the poor. The SLF's core principles are: (a) People-centered; (b) Multi-level with macro and micro views; (c) Participatory and responsive with the poor; (d) In partnership with private and public sectors; (e) Sustainable and; (f) Dynamic – mirroring the fluid nature of livelihoods. Therefore, the SLF can be used for planning future development, and assessing how ongoing activities and factors facilitate and contribute towards sustainable livelihoods (Chambers and Conway, 1991; Carney, 1999; DFID, 1999).

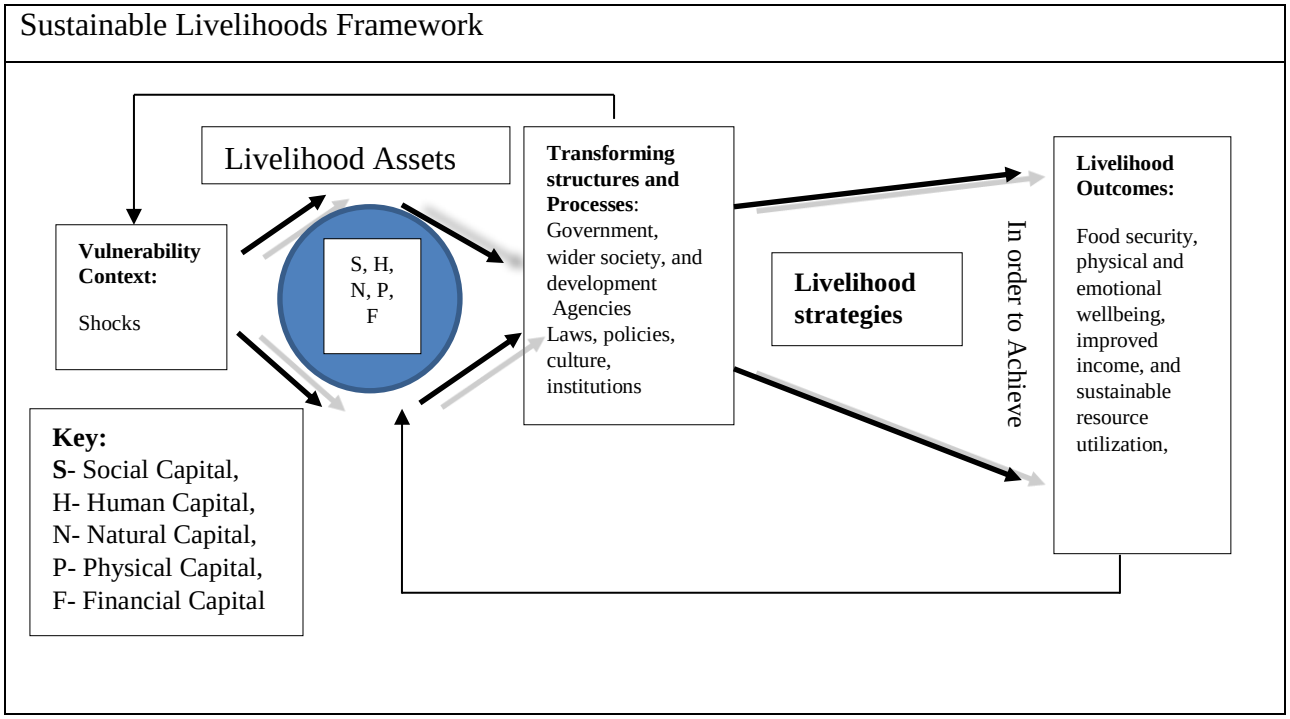


Figure 2.6: Sustainable Livelihood Framework.
(**Source**: Price, Janky and Latsenia, 2004)

This study adopted the SLF model, guided by Duncombe (2006), in trying to understand how ICTs can be used to mediate vulnerability contexts like climate variability and climate change; especially in the context of challenges faced by women of rural Kitui. The end goal is to improve their livelihoods. In particular, Figure 2.7 illustrates the role of ICTs on the model and how these interact with other elements.

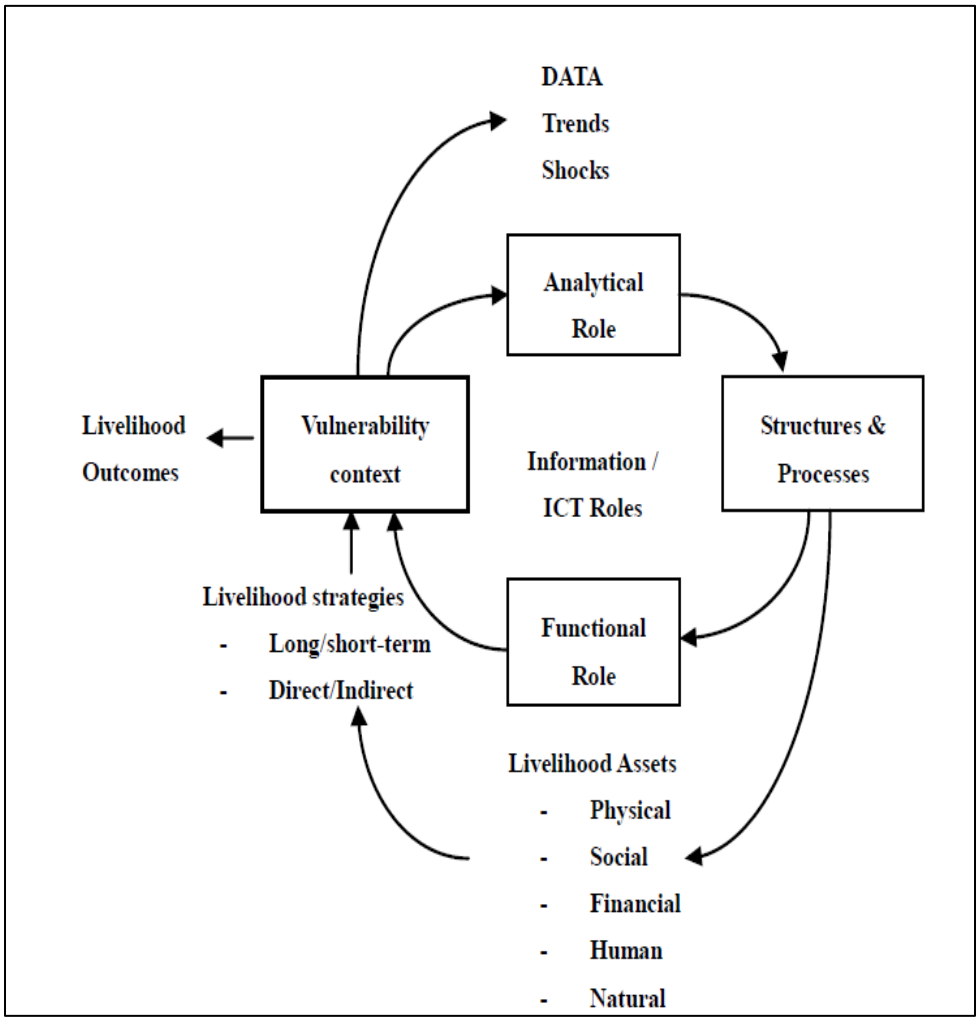


Figure 2.7: Model for the role of information and ICT in livelihoods
(**Source**: Duncombe, 2006)

The SLF emphasizes the dual roles of information and ICTs in livelihoods: analytical and functional roles (Duncombe, 2006). Thus, in the analytical role, ICTs and information are used to assess and determine the extent of vulnerabilities, measure assets and investigate structures and processes to understand the context of a livelihood. Duncombe also argued that in the functional role, ICTs and information is applied to support the strategies for households and institutions to create favorable outcomes in a livelihood. This study focused specifically on climate information, to ensure it is well packaged for the sample population in bettering their livelihoods.

2.7.5 The Sustainable Livelihood Framework in the Study Context

Some studies in Information Systems (IS), for instance, have employed the SLF to evaluate livelihood outcomes associated with the use of ICTs. Specifically, Duncombe (2006) analyzed the application of ICTs in poverty reduction among women's enterprises in Botswana, while Soriano (2007) assessed the impact of ICTs use on poverty reduction among communities in Wu'an, China, and Sife *et al.* (2010) in Tanzania analyzed the contribution of mobile phones to rural livelihoods. Adera *et al.* (2014) present the SLF as a conceptual framework to analyze how poverty dynamics change over time and highlight how various forms of ICTs affect different aspects of poverty and livelihood outcomes. This was based on research in Rwanda, Kenya, Namibia, and Tanzania. Similarly, other studies by Perkinson and Ramirez (2006) and Singh *et al.* (2008) show that ICTs have positive influences on the livelihood strategies of communities.

From all these, it emerges that different researchers adapt the SLF to suit their objectives and research problem. For this study, therefore, the appropriate use of SLF began with an analysis of vulnerabilities contexts, particularly challenges of climate variability and socio-cultural impediments experienced by the women in rural Kitui County. The scoping study (Yohannis *et al*., 2016) already established that challenges exist of gendered access to resources, where men have more access than women, and the patriarchy-driven exclusion of women from decision-making processes involving livelihood assets.

In understanding the extent of the vulnerabilities and their impact on the community under study, considered were data on climate variability and change to grasp the livelihood and coping mechanisms that the people have deployed (DFID, 1999). The study also focused on societal structures, which mean institutions and organizations that support the community's livelihoods. Hence, for analysis, the author used government departments, NGOs and private sector organizations operating in the study area. Their selection was based on their role in packaging and disseminating climate information using ICTs.

Further, this study focused on processes, which are the actions that institutions or households undertake using a range of assets that take the forms of capital. The capital that supports livelihoods includes human (skills, education, and health); social (relationships and networks in a

community); natural (land, water); financial (money, income and credit facilities); and physical (ICT infrastructure, farming equipment, transportation infrastructure).

Improving livelihoods entails adopting progressive livelihood strategies, which are those actions that communities, institutions, or households take in order to deal with common vulnerabilities in a livelihood (Carney, 1999). As Figure 2.7 showed, livelihood strategies can be short-term or long-term, depending on the specific vulnerabilities (Duncombe, 2006). They should ideally lead to increased income, reduced vulnerability, improved well-being and empowerment of the women, among other positive outcomes (DFID, 1999; Duncombe, 2006).

While the SLF has been versatile and handy in many situations since the 1990s, it has certain weaknesses especially concerning the broader spectrum of what forms of capital exist (Heffernan *et al*., 2012). For instance, Ospina, Heeks and Adera (2012) observe that SLF, with all its strengths, does not recognize the role of digital capital as part of the asset base of livelihood systems, while other scholars note its inability to recognize the gender dimension in power relations in a household, communities or organizations. Digital capital is the "*availability* of ICT supply infrastructure, *affordability* of ICT service and *accessibility* in skills of access and use of ICT tools" (May *et al.*, 2011).

Despite these misgivings, the SLF was found to be useful and was employed in this research while taking care to address the weaknesses identified. Digital capital plays a crucial role in rendering livelihood strategies more useful in situations similar to those recommended in this study. It is an essential component in understanding how women in Kitui mitigate the challenges of climate change. Thus, it was factored into the research design.

2.8 Conceptual Framework

The conceptual framework in Figure 2.8 draws on the SLF in analyzing the relationship between ICTs and climate information and livelihood strategies among rural women. The SLF is appropriate for this study and particularly relevant to understanding vulnerability to climate change since it provides a framework for analyzing both the key components that relate to people's livelihoods and the contextual factors that influence them (DfID, 2000).

When viewed from the livelihood approach perspective, significant benefits can be achieved from ICTs if they are employed to strengthen a range of social and political assets and if they can be utilized to build efficient structures and processes that support the marginalized poor. Therefore, the livelihoods approach can identify ICTs and information as only one part of a much broader development picture, and it avoids the overemphasis on technology that can beset some development /ICT for development (ICT4D) research. Mainstream application of livelihoods ideas tend not to engage explicitly with either ICT or information issues, but the framework developed in this study shows how the engagement of both can occur. It identifies both an analytical role for ICTs and information that helps understand livelihoods of the poor, and a functional role that uses these assets within livelihood strategies.

The ICT system that comprises of digital capital and ICT tools is at the center of the studies conceptual framework in order to gain a broader perspective on the research area. Ashley and Carney (1999) point out that the SLA may overlook some critical issues, such as, power imbalance of gender particularly at a household level that are not directly analyzed. It follows that SLF would be more effective when used complementarily with other frameworks like the GAD theory, as we do in our study. In this regard, the use of the Gender and Development (GAD) theory helped in overcoming the challenge of the absence of intra-household-level gender and power considerations in SLF, while the use of Bourdieu's theory of class and social capital helped in understanding the dynamics of power relations along socio-economic planes in the study area. Besides, the advantages of using the INAM and ICTs within the livelihoods framework is that it does not dwell on constraints but instead focuses on existing strengths and assets (Chapman and Slaymaker, 2001). These theories as discussed in Section 2.7, under Theoretical Frameworks, including the Sustainable Livelihoods Framework (SLF); they were also used in data analysis and interpretation.

Excluded from the conceptual framework were measurements of change in livelihood outcomes because this requires a more extended period to determine parameters like increased purchasing power and disposable income. Further given that the study is a cross-sectional study, a concern with livelihood outcomes falls beyond our ambit and can only be a subject for further study.

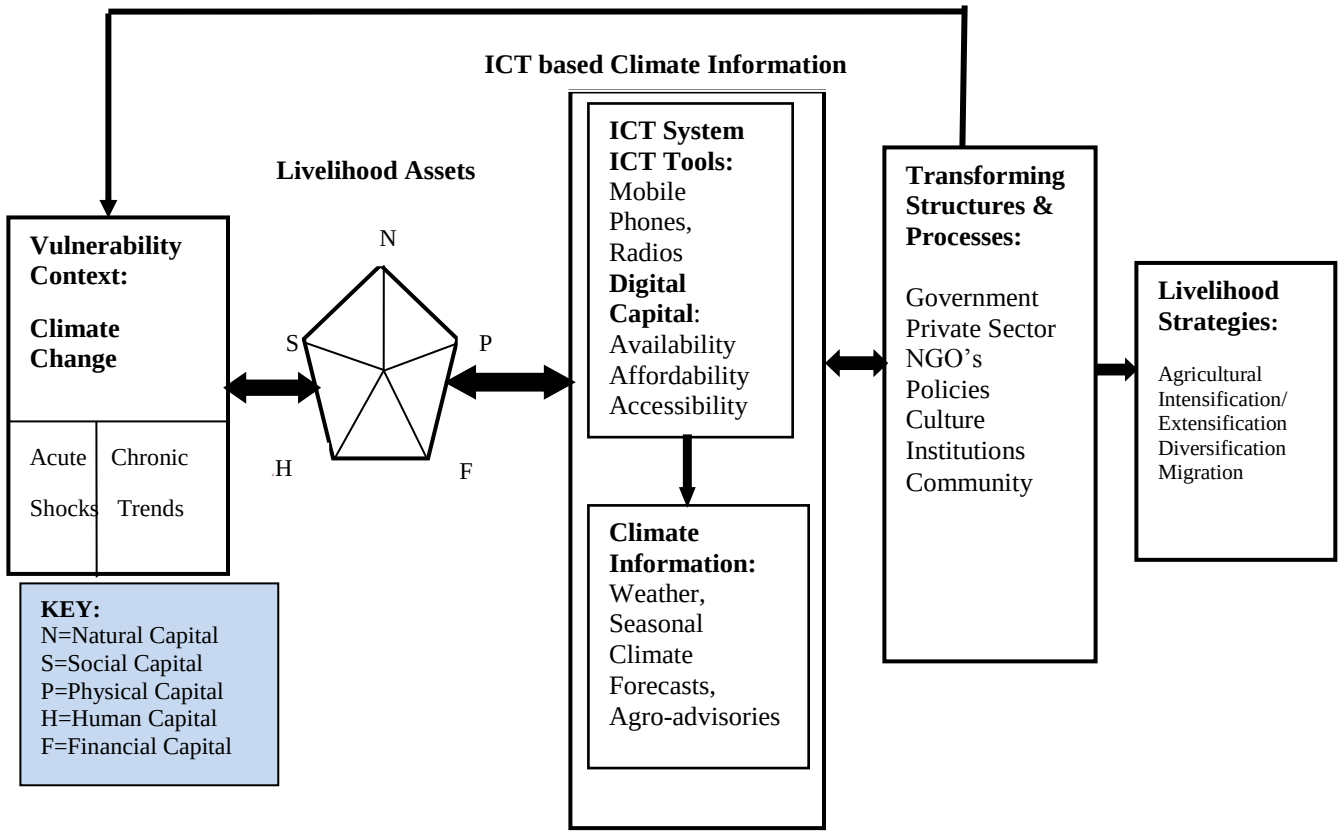


Figure 2.8: Analytical Conceptual Framework
(**Source:** Adapted from Carney, 1999; Duncombe, 2007)

The Conceptual Framework (Figure 2.8) shows the different linkages between vulnerability context, livelihood assets, ICT system (ICT tools and digital capital), climate information, transforming structures and processes, and livelihood strategies.

All these components are understood with the help of theories that generally overlap, but which find resonance more strongly in some aspects compared to others. Hence, the GAD theory, Bourdieu's Social Class Theory and Information Needs Analysis Model were used in answering each question. For example, the first question that sought to establish how rural communities use ICT tools to access climate information found relevance in GAD theory because of the gendered nature of climate information and ICTs. The question was also relevant to Bourdieu's Social Class Theory because both men and women are calibrated in different social classes. INAM also applied to the first question of the study because it prioritizes information in terms of relevance, timeliness, accuracy and packaging format. The same logic applied in responding to the second

and third questions. For instance, because of the patriarchal nature of society, where women may not have the same rights in accessing livelihood assets, it was necessary to invoke the GAD theory for the second question. Even then, women among themselves belong to different social classes', which made Bourdieu's Theory of Social Class applicable.

The Conceptual Framework approach emphasizes the importance of the livelihood assets that people have access to or draws on, and the context within which they devise livelihood strategies (Messer and Townsley, 2003). Due to its flexibility in understanding people's livelihoods in rural development, the SLF was extended and used to analyze how the rural community use ICT systems (ICT tools + Digital Capital) to access climate information (**Question 1**) and if this climate information accessed through ICTs can maximize their utilization of livelihood assets (**Question 2**). Access to these assets was then analyzed in relation to the context of that livelihood in this case the vulnerability context (acute and chronic climate shocks) transforming structures in terms of policies (ICT and Climate change Policy), institutions (Local Government, NGOs CBOs) and processes (land tenure) that then translated to the livelihood strategies **(Question 3**). The livelihood strategies are livelihood diversification, alternative non-agricultural activities, intensification, extensification, and migration.

In essence, ICTs can act as facilitating factors linking climate information to livelihood strategies. As part of the context, policies, regulations, and institutions influence people's livelihood strategies (Messer and Townsley, 2003). For instance, at the macro-level, ICT and climate change policies enacted may have the potential to favor or disfavor rural communities through the provision of ICT (Duncombe, 2006). Policies and institutions may ease or harden the likelihood of people to achieve viable livelihood strategies (Messer and Townsely, 2003). It is on this basis, this study looked at access to climate information through ICT tools and digital capital in improving the livelihood strategies of the rural community**.**

2.9 Chapter Summary

This chapter reviewed the literature on ICTs along with the variables of gender and ICTs use in relaying climate information. The chapter has shown that although there is some literature on ICTs in Africa, and on socio-cultural variables like gender and demographics generally, very

little literature touches on the interface between ICTs, socio-cultural variables and climate change in the Kenyan context. This exposes a gap that the current study sought to fill. The chapter has also discussed the theoretical and the conceptual framework that was applied to the research where GAD and Bourdieu's Theory addressed the humanist aspects of the research, and INAM model that focused on the communication technologies and their use in transmitting climate information as a precursor to enhancing human livelihoods.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The research philosophy portrays the researcher's philosophical worldview orientation. The research strategy adopted is based on the defined philosophical paradigm. The strategy outlined includes the research design, research location, sampling procedure, target population, sample size, research instruments, and data collection procedure. Finally, the data analysis approaches used in this study are to ensure data trustworthiness and ethical standards. In determining validity, reliability and model fit of the conceptual model, Structural Equation Modeling (SEM) was used for quantitative data analysis. This ensured the studies conceptual model was grounded on the theoretical background.

3.2 Research Philosophical Paradigms

Paradigms are systems of beliefs and practices that influence how researchers select both the questions they are investigating and methods used to study them. These are essential as part of a strategy the researcher deploys in their work (Morgan, 2007; Saunders *et al.,* 2009).

Generally, there are three main philosophical worldviews. One is positivism that refers to a research design that relies on factual and quantifiable information in a value-free manner as a natural scientist would. The second is interpretivism, which aims to interpret human attitudes and actions besides their consequences. Last, the pragmatic philosophical worldview presumes that neither positivism nor interpretivism is adequate on its own and that a researcher must choose aspects of each while guided by specific questions from their research. Hence, pragmatism involves the adoption of the two, positivism and interpretivism (Creswell, 2009).

Saunders *et al.* (2009) indicates that the key questions that determine whether to use pragmatic philosophical paradigm or not are whether the researcher aims at building theory or testing it. Building theory entails an inductive qualitative approach, while testing theory uses deductive approaches that are primarily quantitative. The study adopted the pragmatic philosophical paradigm because the research problem accompanying the research questions and related research objectives are multifaceted, which cannot be explained by positivism or interpretivism alone. The focus of the research was to gain a deeper understanding of the power dynamics in the

household, the societal structures and processes that support the community's livelihoods and the need to explain the causal relationships. Therefore, this requires the adoption of a research approach that achieves both purposes of inductive and deductive aspects of the study.

3.3 Research Design

This study is interdisciplinary covering ICTs, climate change, gender and livelihoods. This required a conceptual framework where various elements are interrelated. The development of the research design was influenced by the research questions and in this study. They covered four areas: the questions informing the study, relevant anticipated data, collection of data tied to the research questions and anticipated data analysis approaches (Creswell, 2003). Consequently, the research design used the mixed-method approach of both qualitative and quantitative method rather than the quantitative and qualitative approaches independently (Crotty, 2003; Bryman, 2004; Anfara and Mertz, 2006).

The implementation of a mixed-method research design enabled the researcher to explore various ways in which ICT based climate information can be relayed to households in rural parts of Kitui County. Sife *et al*. (2010), support the use of the mixed-methods design in these types of studies when they argue that the method can harness different strengths of quantitative and qualitative methods while offsetting the weaknesses of every method.

The research is a case study and cross-sectional in timescale. The researcher used a concurrent mixed-method approach based on a triangulation strategy. The quantitative and qualitative data collected was different yet complementary. It built on a similar approach by Creswell and Plano Clark (2011), as it was analyzed and integrated on the same topic around the same time. Morse's (2003) notation system "QUAN+QUAL" was used where the plus sign signifies the two approaches used concurrently, and the capitalization means that the priority was of equal importance between the two approaches, as shown in Figure 3.1.

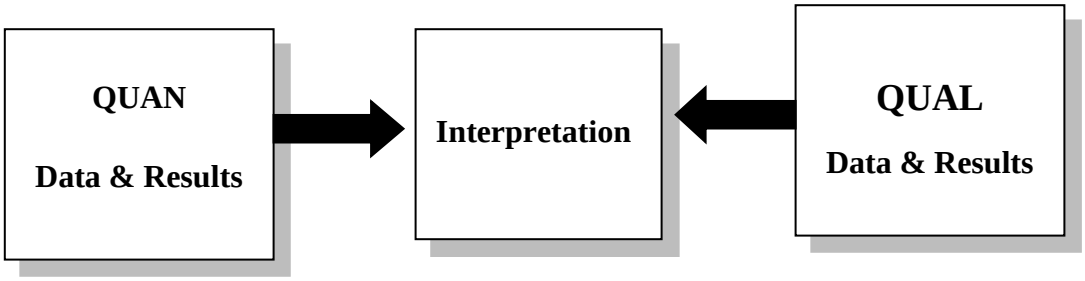


Figure 3.1: Concurrent Mixed Method: Triangulation Design
(**Source**: Creswell, 2008)

This mixed-method approach was used to evaluate the effectiveness of ICT mediated approaches in communicating localized climate information and how these influence utilization of livelihood assets as a strategy of ensuring sustainable livelihoods. Specifically, a household survey was conducted using a semi-structured questionnaire and face-to-face interviews to test the hypotheses derived from the conceptual framework, where the central hypothesis predicts that ICT-based climate information will positively influence the livelihood strategies for rural communities in Kitui County. To test the various theories in-depth, FGDs and key informant interviews (KIIs) were also used to explore the same phenomena from key participants. In order to provide a comprehensive analysis of the research problem, this strategy resulted in a shorter data collection time compared to the other mixed method strategies like the sequential strategies (Creswell and Plano Clark, 2007).

3.3.1 Operationalization of the Research Variables

Operationalizing a variable means finding a quantifiable, measurable, and valid index for the variable (both independent and dependent variables) (Creswell and Plano Clark, 2008). On the other hand, when one variable precedes another in time, it is considered a temporal order and because of this order in timing, one variable probably causes another (Chapman and Slaymaker, 2002). Thus, independent variables influence outcomes; conversely, dependent variables rely on the independent variables. Moderating variables stand between the independent and dependent variables and they moderate the effects of the independent variable on the dependent variable.

As the conceptual framework specifies, some of these variables have interrelations, direct and indirect relations. For this study, the key independent variable selected (from the analytical, conceptual framework) is the ICT-based climate information. In this instance, the encoded

variables are the ICT tools, digital capital and climate information. This is because of the centrality of ICT in our lives, achieved via a level of relevance in the information age (Carr *et al*., 2016a), and is a key independent variable for studying diverse social phenomena. For example, climate information has always been there, from the meteorological department, but access to this information may vary among individuals. This depends on a number of factors including, cultural considerations and whether or not the individual has access to digital capital or any of the other livelihood assets (Adera and Waema, 2014; Duncombe, 2006; Messer and Townsely, 2003; Ospina and Heeks, 2012; Sife *et al*., 2010; Soriano, 2007). Therefore, the government and private sector, policies and culture, institutions, and community were considered. Included were personal variables such as, gender, age and educational level, which are associated with human capital, as moderating variables because they all influence whether the independent variables can alter the dependent ones to yield and influence the desired livelihood strategies which are the dependent variable. Overall, livelihood strategies were considered as a dependent variable whose significance and possible changes were pegged on both the independent and moderating ones.

Excluded from Figure 3.2 are the livelihood outcomes, the justifications were discussed in section 2.8 and the vulnerability context that are uncontrollable external factors that influence people's assets and livelihood strategies. Nevertheless, there is a discussion of the vulnerability context of Kitui throughout the study concerning the climatic impacts. Details on the various constructs of the study are operationalized as indicated in Figure 3.2, and a summary of the constructs and coding strategy are shown in Table 3.1.

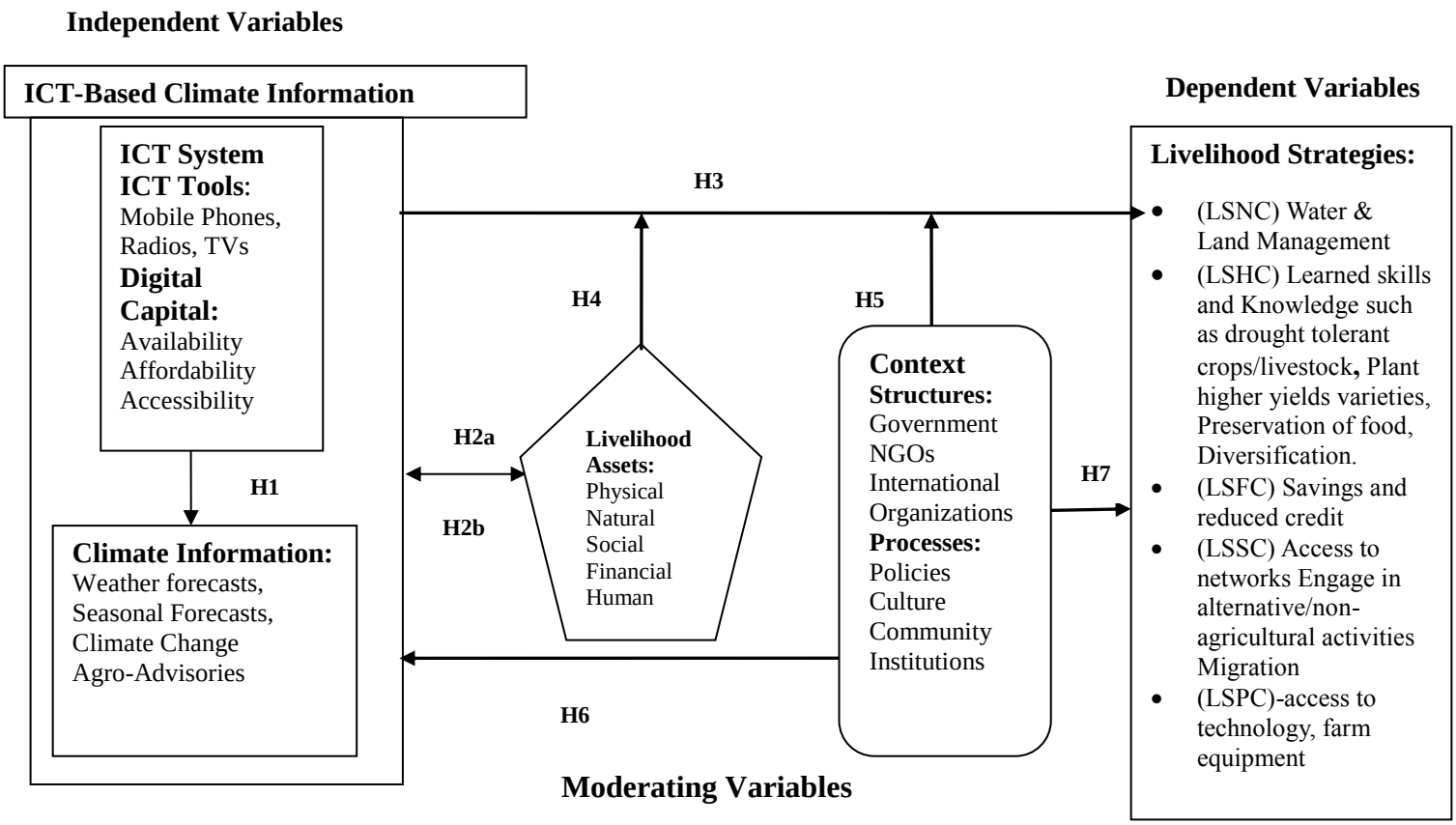


Figure 3.2: Hypothesized Variables

Table 3.1: Operationalization of Key Variables and Coding

Variable	Definition	Operational Indicators	Codes
ICT Tools	ICTs play a crucial role in supporting Livelihood Assets, Transforming Structures and Processes and Livelihood Strategies	**ICT Tools** Radio Mobile Television Computer	**ICTs** R M T C
Digital Capital	The "*availability* of ICT supply infrastructure, *affordability* of ICT service and *accessibility* in skills of access and use of ICT tools	**Digital Capital** Availability Affordability Accessibility	**DC** AV AF AC (KS &TU)
ICT System	A combination of ICT Tools and Digital Capital	**ICT System**	ICTS
Climate Information	CI encompasses weather and seasonal forecasts and related Agro-Advisories that are increasingly being demanded by the rural farming community to cope with climate variability and extreme events such as droughts and floods more efficiently	**Climate Information (CI)** Awareness Frequency Relevance Timeliness Reliability &Accuracy	**CI** AW FR RV TM RA

Livelihood Assets	These are capital assets owned, controlled, claimed, or by some other means accessed by the household	**Livelihood Assets** Natural Capital Human Capital Financial Capital Social Capital Physical Capital	**LA** LANC LAHC LAFC LASC LAPC
Natural Capital	These are natural resource stocks from which resources that are useful for livelihoods are derived (land, water, wildlife, biodiversity, and environmental resources)	**Natural Capital** Land, Water	**LANC** LANC-L, LANC-W
Human Capital	These are the skills, gender, age, education level, knowledge, and ability to labor that enable households to pursue different livelihood strategies	**Human Capital** Education Climate Information knowledge ICT skills Age, Gender Labor	**LAHC** LAHC-E LAHC-K LAHC-S, LAHC_A, LAHC-G LAHC-L
Financial Capital	These are financial resources that are available to people (whether savings, supplies of credit or regular remittances or pensions) to provide them with different livelihood options.	**Financial Capital** Savings Credit Income Remittance	**LAFC** LAFC-S LAFC-C LAFC-I LAFC-R
Social Capital	These are social resources (networks, membership in groups, relationships of trust, access to more extensive institutions of society) upon which people draw strength in pursuit of livelihoods	**Social Capital** Networks Membership groups Trust	**LASC** LASC-N LASC- MG LASC-T
Physical Capital	These are basic infrastructure (transport, shelter, water, energy, and communications), the production equipment and means that enable people to pursue livelihoods	**Physical Capital** Livestock Farm Tools Digital Capital	**LAPC** LAPC-L LAPC-FT DC
Livelihood Strategies	These refer to the various initiatives and combination of activities that household adopts in order to achieve livelihood goals to support their livelihoods. This includes productive activities, investment strategies, and reproductive choices.	**Livelihood Strategies** Human Capital Livelihood strategies Social Capital Livelihood strategies Natural Capital Livelihood strategies Financial Capital Livelihood strategies Physical Capital Livelihood strategies	LS LSHC LSSC LSNC LSFC LSPC
Transforming Structures and Processes	These are various external factors that affect households' access to different forms of capital. They also include the various returns associated with the exchange between the capitals	**Structures and Processes (STPR)** National Govt. extension Agents NGO's, County Govt. Institutions County-Based Org. Policies (PC) Decision-Making (DM) Culture Practices and Beliefs(PB)	**STPR** ST1 ST2 ST3 ST4 PC DM PB

(Source: **Researcher, 2019**)

3.3.2 Hypothesized Relationships

The alternative hypothesized relationships emerging from the conceptual framework, literature review, research questions, and constructs drawn from Figure 3.2 and Table 3.1 proposes that if a statistically significant relationship exists between two variables, then the hypothesis is accepted.

RQ1: To what extent do rural women access and use ICT tools in the utilization of climate information?

The researcher investigated how women in rural communities access and use ICT tools in the utilization of climate information; and hypothesized that:

> **H1**: *Rural women use ICT tools – such as, mobile phones and community radios in the utilization of climate information (seasonal forecasts, weather, and agro-advisories).*

RQ2: To what extent does the use of ICT-based climate information by rural women influence their maximize access and utilization of livelihood assets?

The researcher posed some questions, including, what combination of livelihood assets does a small-scale farmer require in order to access and utilize ICT based climate information? What forms of assets does the farmer already have, such as land and water for them to need climate information? Do they have the knowledge and skills necessary to understand the climate information that is disseminated to them? Are there members of formalized groups, such as farmer field schools or women Self Help Groups (SHG) that need to access climate information in preparation for agriculture production? What combination of livelihood assets does a small-scale farmer need in order to access and utilize ICT tools? What skills and knowledge are required to utilize the ICT tools in accessing ICT-based climate information? We hypothesized that:

> **H2a**: *Rural women use ICT-based climate information to maximize access and utilization of their livelihood assets*
>
> **H2b**: *The access and use of various livelihood assets by rural women increase their use of ICT based climate information.*

RQ3: What are the effects of using ICT-based climate information in the adoption of livelihood strategies by rural women?

Does access to ICT based climate information influence the livelihood strategies adapted? The researcher hypothesized that:

H3: *Livelihood strategies of rural women positively change with the increasing availability and use of ICT-based climate information*.

The researcher addressed hypotheses ***H4*** that moderate the relationship between accesses to ICT based climate information and livelihood strategies. For instance, is access and use of various livelihood assets such as to access natural capital, human capital, social capital and physical capital moderate the relationship between use of ICT based climate information and livelihood strategies implemented?

H4: Do access to various livelihood assets by rural women increase the relationship between ICT-based climate information and livelihood strategies. The researcher hypothesized that:

H4: *Access to various livelihood assets increases the relationship between the use of ICT-based climate information and livelihood strategies.*

The researcher addressed hypotheses ***H5*** that moderate the relationship between accesses to ICT based climate information and livelihood strategies. Do institutions, such as, national government extension agents, NGOs, county government institutions, community-based organizations, and Agro-Vets facilitate the access and use of ICT based climate information for the rural farmer? Does this influence the livelihood strategies the farmer implements? Do climate change policies, ICT policy and gender policy moderate the effect of ICT based climate information on livelihood strategies? What is the role of cultural beliefs and decision-making in households in moderating the said relationship?

H5: Do structures and processes increase the relationship between ICT-based climate information and livelihood strategies. The researcher hypothesized that:

H5*: Structures and processes increase the relationship between the use of ICT-based climate information and livelihood strategies.*

Addressed were other intervening hypothesis **H6** and **H7** within the SLF. Access to institutions, policies, and processes can either enhance or constrain ICT based climate forecast information flow and uptake. This could be the changes in the local institution's culture and norms to education and training for rural women. Furthermore, access to the same can enable access to digital capital (affordability, accessibility, availability). For instance, policies that affect returns to different livelihood strategies, such as, reduction on taxes for digital capital that in turn

reduces the cost of ICT tools create physical capital (ICT basic infrastructure or technology generation), yielding human capital.

H6: Do structures and processes influence the uptake of ICT-based climate information? The researcher hypothesized that:

H6*: Structures and processes increase the uptake of ICT-based climate information*

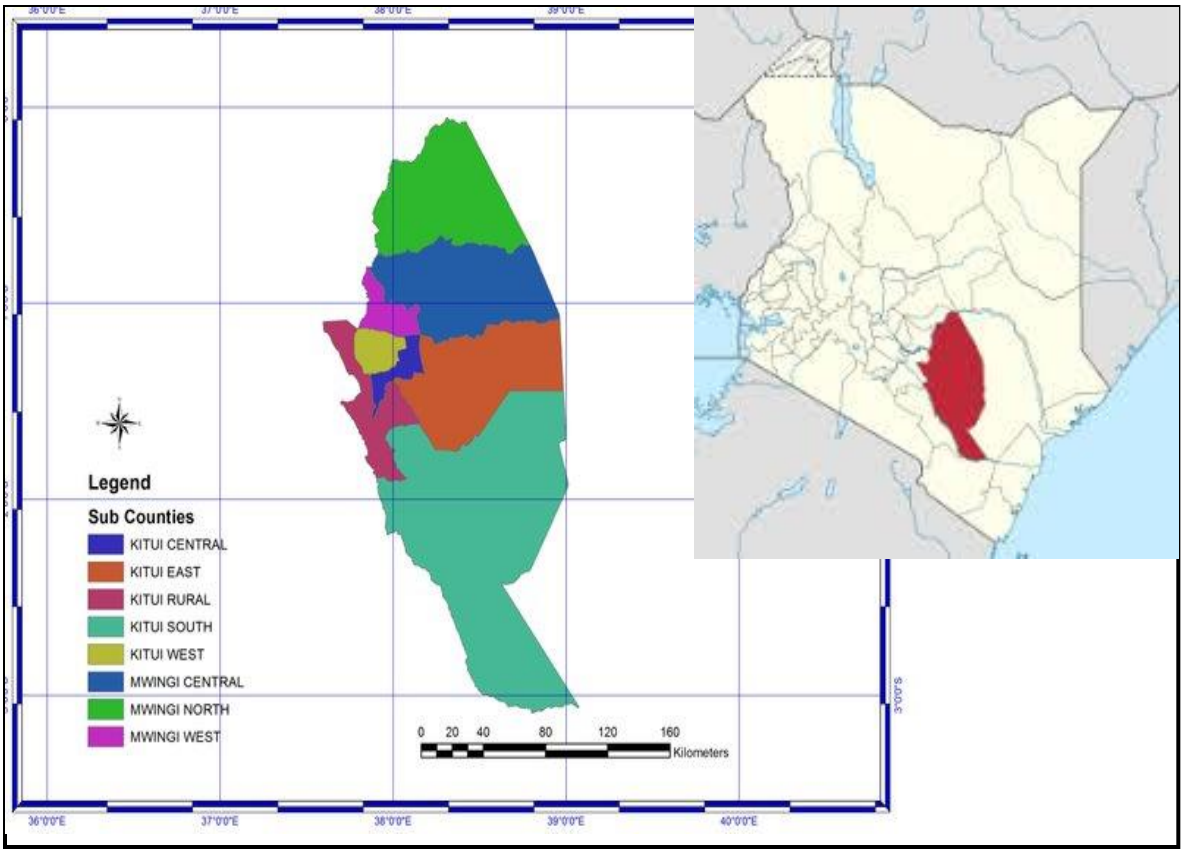
H7: Do structures and processes directly influence the adoption of livelihood strategies? The researcher hypothesized that:

H7: *Structures and Processes increases the adoption of livelihood strategies*

3.4 Description of Study Area

Kitui is located in eastern Kenya and is composed of eight sub-counties with forty wards, and covers an area of 30,496.5 Km^2. It had a population of 1,000,012 million people, representing 2.6% of the total population in Kenya with an annual growth of 2.2% according to the population and census report of 2009. According to the same report, there are 205,491 households with 63.5% living below the poverty line. Kitui and Mwingi Town are the two main urban centers. The Kamba people, who speak Kikamba followed by the Tharaka, are the principal inhabitants of Kitui. There is also a sizable Swahili and Somali population (KNBS, 2010; CGoK, 2014).

Map 3.1 shows the position of Kitui County on the map of Kenya bordered by seven counties. These are Machakos and Makueni to the west; Tana River to the east, Taita Taveta to the south, Embu to the north-west, and Tharaka-Nithi and Meru to the north. It falls between latitudes 0°10’ and 3°0’ south and longitudes 37°50’ and 39°0’east. Kitui lies between the altitude of 400m and 1,800m above sea-level. It has 14 different minerals, but coal is the most prominent located in Mui basin, as well as gypsum in Mwingi area (CGoK, 2014).



Map 3.1: Map showing location of Kitui County
(**Source**: KNBS, 2014)

Over 85% of the county's population live in rural areas and reside in arid and semi-arid conditions highly susceptible to frequent droughts and reliance is high on rain-fed agriculture and settled pastorals. The climatic condition of the county is classified as arid and semi-arid characterized by variable and unpredictable rainfall and temperature patterns. The county experiences high annual temperatures ranging from 14^0 C to 34^0 with the hot months from mid-July to September and from January to February when droughts are frequent. The rainfall patterns are bi-modal and range from 500 mm to 1050 mm per year in various parts of the county with long rains falling between March and May. These are usually very unpredictable and unreliable, while the short rains between October and December are usually more reliable, leading to two growing seasons. (Kitui County CIDP, 2018-2022).

These climatic patterns put pressure on food security and water resources (Behnke and Muthami, 2011; PDNA, 2012; Oremo, 2013; CGoK, 2014) frequently causing circulatory migration, poor well being and compounded poverty (Ngigi, 2009; Mutimba *et al*., 2010). The majority of

residents (87.3%) derive their livelihoods from agriculture. The primary economic activity is subsistence farming of maize, pigeon peas, cassava beans, sorghum, millet, and cassava; coupled with livestock rearing of goats and cattle. These economic activities, therefore, plays a crucial role in poverty reduction, food security and creation of employment opportunities in the county (Kitui County CIDP, 2018-2022).

3.5 Study Population

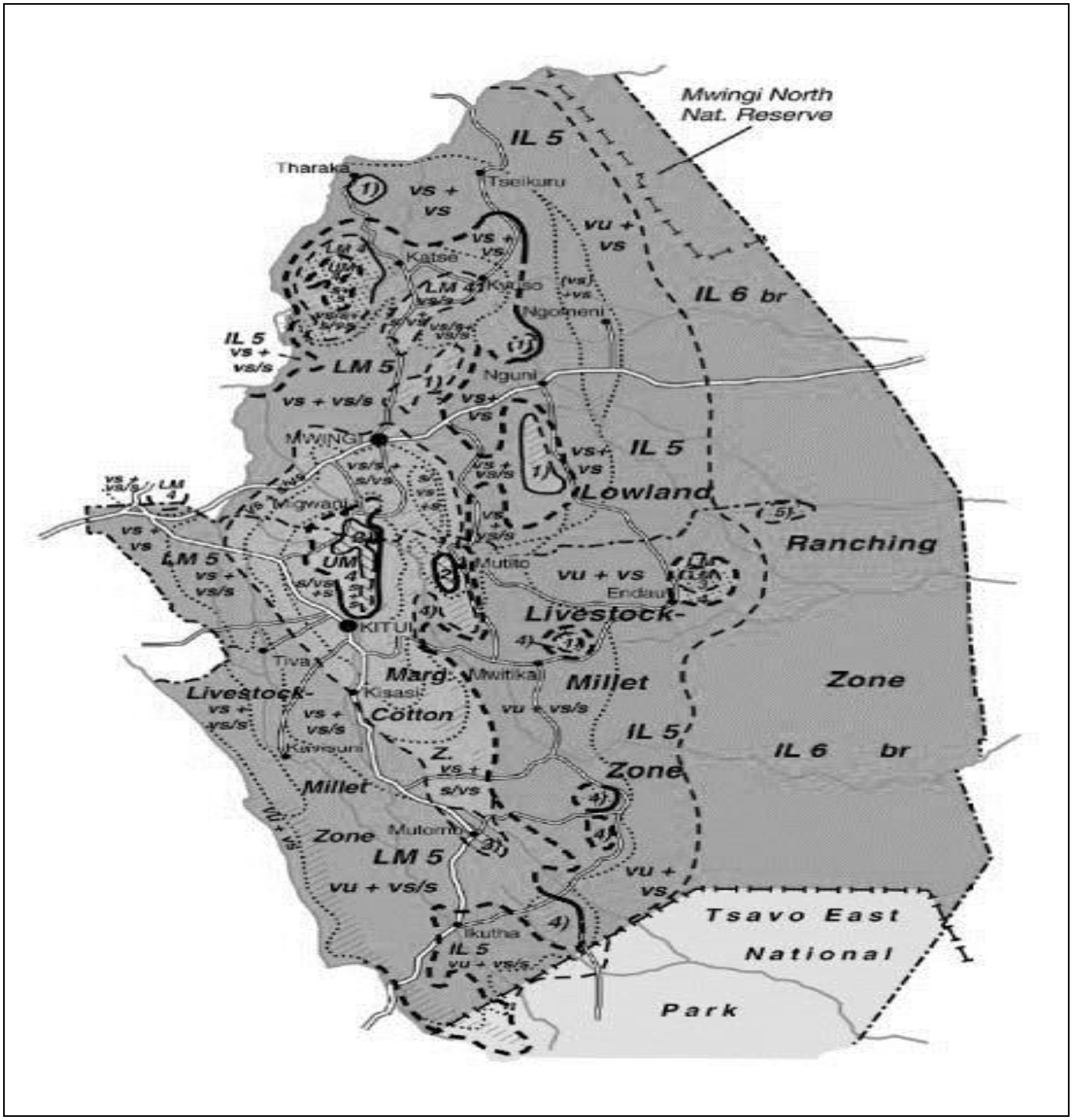
The 2009 population and housing census of Kitui's population stood at 1,012,709 where males constituted 48% (481,282), while females at 52% (531,427). The county has a large children's population with 47% of the total population between 0-14 years. Households with 4-6 members were the highest percentage at 42%. The population of women from the ages of 15-85 years was 298,378 (KNBS, 2009). This was the last major census and the data may be a little old data but is still generally representative in terms of the categorizations discussed, for example, the percentage of women to men.

3.5.1 Sampling Strategy

The sampling strategy entailed the use of multi-level sampling procedures to select the required respondents for the household survey; key informant interviews (KIIs) and focus group discussions (FGDs) in order to obtain information about the entire population (Tashakkori and Teddlie, 2010; Teddlie and Tashakkori, 2009).

Kitui County was purposively selected out of forty-seven counties in Kenya because over 85% of the county's population lives in rural and ASAL regions where it experiences frequent droughts conditions. This condition affects food security and water supply in the area (Behnke and Muthami, 2011). The research focused on the county to obtain as much information as possible on how to link climate information with livelihood strategies through ICTs. This approach can be generalized to other ASAL counties in Kenya. The reference period was from September 2014 to December 2017.

To maximize the representativeness of the sample, stratified sampling of livelihood zones in the study area were identified first based on agro-ecological zones (AEZs) in Kitui County as shown on Map. 3.2.



Map 3.2: Kitui Agro-Ecological Zones.
(**Source**: Jaetzold *et al*., 2007)

Stratified sampling maximizes the inclusion of different production methods and livelihood types, ensuring the representation of livelihood variation and minimizing the possibility of bias relating to the impact of weather and climate information on particular livelihoods. Included in

this AEZs are: *Upper Midland Zone* (UM4) which has sub-humid climate and is regarded as the sunflower, maize and pigeon pea growing zone; *Lower Midland Zone* (LM4) a marginal cotton growing zone; while (LM5) and *Inner Lowland* (IL) have arid climates; and IL5 are the main livestock-millet zones (Kitui County CIDP, 2018-2022).

Second, the selection of wards within the AEZ's was purposively selected guided by various NGOs and county government offices located in Kitui that worked with villages or Women Self-help Groups (SHGs) that had projects related to climate information dissemination and food security. These were Caritas, National Drought Management Authority (NDMA), FAO and government agencies such as the Ministry of Agriculture and Kenya Meteorological Department (KFSSG, 2015).

The ten wards selected were Miambani, Matinyani, Kaui, Kwa-Mutonga/Kithumula, Kyome-Thaana, KwaVonza/Yatta, Nguutani, Nguni, Tseikuru, and Zombe/Mwitika as shown in Table 3.2.

Table 3.2: Wards in Livelihood Zones

AEZ	UM4	LM4	LM5	IL5
Wards	Kyangwithya east, **Miambani** **Matinyani** Township	Chuluni **Kaui** **Kwamutonga/Kithumula** Kisasi Kyanguithia west, **Kyome-Thaana** Migwani Mbitini Mulango, Mumoni Nzambani	Kanyangi Kiomo/Kyethani Kivou Kyuso **KwaVonza/Yatta** Mutitu/Kaliku Mutonguni Mwingi Central **Nguutani** Tharaka Waita	Endau/Malalani Ikanga/Kyatune Mui Mutomo Ngomeni **Nguni** Nuu **Tseikuru** Voo/Kyamatu **Zombe/Mwitika**

The target populations were the 205,491 households in Kitui County based on the 2009 population and housing census (KNBS, 2009), and the sampling unit in the study was the rural household. This study defined household per FAO (2005) as "a collection of people who live together, eat from a common pot, and share a common stake in perpetuating and improving their socio-economic status from one generation to the next and report to the same head". The choice

of households as the units of analysis were: it can be easily identified and defined; permits appreciation of household coping and survival strategies such as asset, income, consumption and labor pooling. It also permits appreciation linking individuals, households and communities, and portraying links between well-being and household life cycle.

Tashakkori and Teddlie (2003) suggest that the best decision about choosing who will be a respondent depends on the kind of information that is gathered and if the information is general, then any household member can be a respondent. Although the household is considered our unit of analysis and provides the essential context within the community at large, rural women as individuals were our central unit of observation (respondents). Women's self-perception and their objective and subjective interpretations of the different actions that they undertake throughout their lives are critical to understand the dynamic interplay between women's agency and the structure of power relations. In essence, the main reason for choosing the household is that most decisions about agriculture, among other livelihood activities, is made within the household.

3.5.2 Determination of Sample Size

Three criteria were used in this study to determine the appropriate sample size. These include the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured (Miaoulis and Michener, 1976). For the level of precision, in its sampling, this study applied a plus or minus 5% sampling error, a 95% confidence level. In the sampling the maximum variability of the population, the study used a more conservative sample of 50%.

The study drew on Fischer *et al.* (1984) exact statistical significance test to develop a formula to determine the sample size of households surveyed, where they argue that the ideal sample size for any population above 10,000 is 384 (Mugenda and Mugenda, 2003). The 205,491 households of Kitui County were the target population in this formula.

The general formula is

i. $$ME = z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$ Equation 1

(a) Which also translates to:

ii. $$n = \frac{\hat{p}(1-\hat{p})z^2}{ME^2} \mathrm{n} = \frac{\hat{\mathrm{p}}(1\text{-}\hat{\mathrm{p}})\mathrm{z}^2}{\mathrm{ME}^2}$$ Equation 2

Where: n is the sample size, ME is the desired sampling error (5%), z is the z-score, 1.96 for a 95% confidence level, $\hat{p}$ is percentage of picking a choice, the convention is to assume $\hat{p}$ = 0.5.

With ME = 0:05; $\hat{p}$ = 0.5; z = 1:96 we get

$$384.16 = \frac{0.5(1-0.5)1.96^2}{0.05^2}$$

The formula arrives at the sample size of 384 households. The actual sample size of 450 HH used is slightly larger than the minimum requirement to compensate for persons the researcher was unable to reach and for a non-response rate suggested by Fischer *et al*. (1984).

While non-probability sampling was geared towards representing only a particular group, it was used in qualitative data design for purposive sampling (Mugenda and Mugenda, 2003). Purposive sampling strategies were undertaken to increase inference quality and to address household power dynamics. This employed by using Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) to get rich data and to support the quantitative analysis.

3.5.3 Determination of the Key Informants

Glasser and Strauser (1967) and Mason (2010) state that there is no exact formula for determining sample sizes for key informants but cautions that the sample size must be large enough to ensure that most or all of the perceptions that might be important are uncovered. Yet it should not be too large that the data becomes repetitive and eventually, superfluous. Kumar (1989) slightly differs with this and argues that Key informant interviews (KII's) entailed interviewing a select group of people to share information and idea of interest to the researcher.

This study combined Kumar's (1989), Mason's (2010), Glasser and Strauser's (1967) and Miles and Huberman's (1994) perspectives in determining the key informant's sample size. The characteristics of the informants provided an overview of their suitability for the study and represented the diversity of the different actors in the problem area. Understanding the background, expertise and experiences of the respondents shed light on the selection of informants. Fourteen individuals were selected for the KIIs due to their diverse experiences and knowledge on ICTs, gender issues and climate information in relation to Kitui County, especially

in the selected AEZs. The informants were drawn from a range of institutions, among them agricultural extension officers, officers from the Kenya Meteorological Department, mobile service providers and activators and anchors from different community FM radio stations that broadcast in Kikamba.

3.5.4 Determination of the Focus Group Discussions

In the determination of the Focus Group Discussions (FGDs), some factors were considered, including the group size and composition (Cohen *et al*., 2007). When selecting the participants, a balance was achieved by selecting enough people that can generate a discussion and understand the research purpose versus many people to form a crowd, which is a concern that Morgan and Scannell had (1998). Most scholars hold that FGDs should have between six and twelve members. For this study, the researcher purposely selected seven women and seven men for the two FGDs representing the different AEZ locations (at least one ward per sub-county) or from neighboring wards. They consisted of Chairpersons or leaders from SHGs, Farmers Groups or any social network groups that facilitate access to climate information mediated through ICT tools. The men were included so as not to leave them out of the joint intra-household decision making consultations.

3.6 Data Collection

The study used two types of research instruments: interview guides and household survey questionnaires that were based on research questions and the conceptual framework themes and concepts (appendix 1, 2 and 3). The purpose of the interview guides was to collect qualitative data, while the purpose of the household survey questionnaires was to collect quantitative data, and its structure contained demographical information (age, gender, language(s) spoken, education level and assets ownership) questions, closed-ended questions, and attitude/perception (Likert scale) questions.

3.6.1 Qualitative Data

i. Key Informant Interviews (KIIs)

Interviewed were fourteen key informants representing government agencies, FM Radio stations, and Non-Governmental Organizations (NGO). The NGOs had six representatives from Kitui-Caritas, Bio-Vision Africa Trust (BvAT) and Food Agriculture Organization (FAO). Three

participants represented the local radio stations, which are Radio Thome, County FM and Syokimau FM. Senior managers from seven government agencies were selected; represented by four members from the Ministry of Agriculture (County Government of Kitui) and one member each from the Agricultural Sector Development Support Programme (ASDSP), Kenya Meteorological Department (KMD), and National Drought Management Authority (NDMA).

The key informants were interviewed to explore the context for the use of ICTs and the challenges experienced to access, share and disseminate climate information in rural areas. The interviews were 30-45 minutes face-to-face using an interview guide between the researcher and the informant, for the specific purpose of obtaining research-relevant information (Kothari, 2004). According to Patton (2002), the purpose of interviews was to find out what was on someone's mind and to discover what could not be directly observed through a questionnaire.

ii. Focus Group Discussions

In the preliminary scoping study of Yohannis *et al.* (2016), it was found that men tended to dominate the FGDs when women attended. Therefore, the study separated men and women to enable full participation in all issues pertaining to specific gender categories. Men and women were able to share information without any fear or intimidation. Therefore, two FGDs of seven participants each were conducted for two to three hours. Open-ended questions were asked. Focus group participants were encouraged to talk to one another, ask questions, exchange anecdotes and give feedback on their experiences and points of view on the research focus. The researcher together with assistants moderated the group to ensure equity in discussions and avoid dominance of specific individuals. The discussions helped gather supplementary data, besides verifying some points that emanated from responses from the individual key informant interviews

3.6.2 Quantitative Data

A household survey questionnaire was administered to gather primary data from the respondents to answer the research questions for quantitative data collection. The survey questionnaires consisted of printed lists of close-ended questions in the Likert format. Close-ended questions are easier to analyze and code data. The first part of the questionnaire gathered demographic information while the second section collected data that was essential for examining and

validating the conceptual framework. The whole process was interviewer-administered (face-to-face) where the researcher and research assistants asked respondents questions and recorded the answers. The research assistants were conversant with the Kamba/Kiswahili language and translated the questions for respondents not conversant with English. The questionnaires were categorized and mapped along four Agricultural Ecological Zones (AEZ) IL5, LM4, LM5, and UM4 and assigned a numerical number for easier identification. Targeted were SHGs that were located in the AEZs and represented randomly selected households. The advantages of using survey questionnaires are that they provide data that can be amended to quantification via content analysis of written responses or simple counting of boxes (Denzin and Lincoln, 2011). This is an ideal method for the study because it provides for example percentages for the extent of use of ICTs to disseminate and access specific local climate information in rural areas. It can also derive percentages of the respondents who have the same information needs and the number of respondents who agree that the use of ICTs has significantly influenced their livelihoods if at all.

3.6.3 Data Collection Instruments Design

The study linked the quantitative (survey questionnaire) and qualitative (KIIs and FGDs interviews) data collection instruments to the study's research questions, alternative hypotheses, and the conceptual framework themes and relevant theories (Creswell, 2007; Onwuegbuzie and Leech, 2006), as indicated in Table 3.3:

Table 3.3: Linking Data Collection Tools to Research Questions

Research questions	Alternative Hypothesis	Key Pts. Conceptual Framework (SLF) and Relevant Theories	QUANT Questions	QUAL Questions (KIIs)	QUAL Questions (FGDs)
1. To what extent do rural women access and use **ICT tools** in the utilization of CI	**H1**: Rural women ' use **ICT tools** such as **mobile phones** & **community radios** in the utilization of **CI** (seasonal forecasts, weather & agro-advisories	**Access to ICT System** (ICT tools &Digital System GAD and Bourdieu Social Capital	**ICT System (ICTS)** Ownership, access & use of ICT tools **ICT Tools (Var8.1)** **Specific variables** Radio (Var8.1-R), Mobile (Var8.1-M), TV (Var8.1-T), C (Var8.1-C) **Digital Capital: DC** Accessibility (Var8.2a -Var8.2c) Availability (Var8.2d) Affordability (Var8.2e)	Access and Use of ICT Tools Do you own any of the ICT tools mentioned (Q2a) What is your view on **DC** (Q2b)	Access and Use of ICT Tools (Q2a) What is your view on **DC** (Q2b)
		Awareness and use of CI Climate Information accessed through ICTs GAD, Bourdieu Social Capital and INAM	Awareness & use of **CI** (Var9a) ICT medium to access CI (Var9b-h)	Awareness & use of CI (Q3) What ICT mode does the Org use to share CI you /group Q4a-c) What is your success rate in CI dissemination (Q8)	Awareness & use of CI (Q3) What ICT tool do you use to access CI (Q4) What is your view on the following in regards to the CI that you receive through ICT tools (Q5)
2. To what extent does the use of **ICTBCI** influence rural women to **maximize access and utilization** of their **livelihood assets (LA)**?	**H2a***:* Rural women use **ICTBCI** to **maximize access** and **utilization** of **LA.**	Livelihood Asset ownership Maximization and Utilization of Livelihood assets GAD, Bourdieu Social Capital and INAM	Livelihood assets LA (var10) **Specific Assets Variables** Var10a-LANC, Var10b-LAPC, Var10c-LAHC, Var10d-LAFC, Var10e-LASC Access and Maximize utilization of LA (Var11-LAa-e)	What changes in livelihood assets have been experienced in the community (Q6)	What changes have you experienced in your livelihood assets (Q7)
3. What are the effects of using **ICTBCI** in the adaptation of **livelihood strategies (LS)** by	**H3**: **Livelihood strategies** of rural women positively change with the increasing	ICT based climate information influence on Livelihood strategies GAD, Bourdieu Social Capital, and INAM	I use ICTBCI to implement the following Livelihood strategies (Var12), Var12a_12c)	Have you witnessed changes in agricultural and subsequent crop yields since disseminating ICTBCI (Q10) What is your evaluation on the	Have you witnessed changes in agricultural and subsequent crop yields since you started receiving ICTBCI (Q11) What is your evaluation of

rural women	availability and use of **ICTBCI**			communities livelihood since you started disseminating ICTBCI(Q11)	livelihood since you started receiving ICTBCI (Q12)
Moderating Factors	**H4**: **LA moderates** the relationship between **ICTBCI** and **LS**	Livelihood assets moderates the relationship between ICT-based CI and LS	Maximize utilization of LA (VarD11-LAa-d)	Which social network groups do you target (Q4d-e)	What social groups do you belong too (Q6)
Moderating Factors	**H5**: Structures & processes moderate the relationship between ICTBCI & LS	Structures & processes moderate the relationship between ICTBCI & LS	Structures (ST) Var13_ST1-ST5) Processes (PR) Var14_ PC, DM, CB)	Whom do you partner with (Q5) Are there cultural challenges in the use of ICTBCI (Q7) What can the organization do differently in sharing ICTBBCI (Q9)	What organizations facilitate the process of receiving ICTBCI (Q8) Are there inter-HH DM dynamics that affect access to ICTBCI (Q9) Are there cultural challenges to the access and use of ICTBCI (Q10)
Intervening Variables	**H6**: **Structures & processes** (STPR) influence the uptake of **ICTBCI.**	Structures & processes influence the uptake of ICT based climate information	Structures (ST) Var13_ST1-ST5) Processes (PR) Var14_ PC, DM, CB)	Whom do you partner with (Q5) Are there cultural challenges in the use of ICTBCI (Q7) What can the organization do differently in sharing ICTBBCI (Q9)	What organizations facilitate the process of receiving ICTBCI (Q8) Are there inter-HH DM dynamics that affect access to ICTBCI (Q9) Are there cultural challenges to the access and use of ICTBCI (Q10)
Intervening Variables	**H7**: **Structures & processes** (STPR) influence the uptake of **LS.**	Structures & processes influence the uptake of livelihood strategies	Structures (ST) Var13_ST1-ST5) Processes (PR) Var14_ PC, DM, CB)	Whom do you partner with (Q5) Are there cultural challenges in the use of ICTBCI (Q7) What can the organization do differently in influencing the uptake of LS (Q9)	What organizations facilitate the process of Livelihood strategies (LS) (Q8) Are there inter-HH DM dynamics that affect access to LS (Q9)

(Source: Researcher)

3.7 The Scoping Study

The pre-research preparation involved a scoping study that focused on a small cross-section of rural women and rural men in Kangwithia East and Township wards in Kitui County (Yohannis *et al*., 2016),. Importantly, 95% of the interviewed rural women relied on small-scale farming as their primary source of income and were aware of climate information. Thus, research on the link between climate information relayed through ICTs for such a vast population is necessary because it can inform policy decisions. Indeed, from the scoping study, it emerged that using mobile phones and radio to access information on how to adapt to climate change has helped the respondents to plan better, diversify their crops and in turn get better yields. Based on the responses from the scoping study, changes were made to the FGDs Guides, KII Guides and survey questionnaire.

3.8 Data Analysis

The data collected was processed and analyzed following the concurrent mixed method. The process of data analysis and presentation involves editing, classification, coding, and tabulation of collected data so that they are amenable to analysis (Kothari, 2004). Therefore, the closely related operations were undertaken in order to summarize the data and organize it in such a manner that answers the research questions.

3.8.1 Qualitative Data Analysis

In analyzing qualitative data for this study, theory-driven thematic analysis was employed, where analytical deductive techniques guided the process. The deductive approach implies that the research used existing theories as opposed to the inductive approach that seeks to build up a theory based on collected data (Saunders *et al*., 2011). Therefore, the reliance on deductive theory was on testing existing theories rather than building up new ones. The thematic analysis consists of several steps, including familiarization of data collected, data transcription, and coding (Howitt, 2010). Familiarization of data involved collection of KIIs, FGDs field notes, and observation logs, which were typed, and imported for preliminary analysis, as the data collection process got underway in order to obtain a deeper understanding of the data gathered. Transcription of data involved transforming data that was recorded on paper for subsequent analysis. Coding of data entailed assigning particular codes for every line of text or more lines of

the transformed text (Howitt, 2010). The data categories and codes employed to analyze the data (see Table 3.1 above, in the operationalization of the research variables) followed a predetermined analytical framework around the themes; namely, the use of ICT tools to access climate information, digital capital and maximization of livelihood assets and livelihood strategies.

Display of analyzed qualitative data used scripts and tables, established systematic patterns and interrelationships between the variable and concepts to enable conclusions and verifications (Saunders *et al*., 2011).

3.8.2 Quantitative Data Analysis

The data collected was cleaned to take care of missing data and outliers. The study used SPSS 23 and SPSS (Analysis of Moment Structures) AMOS 23 in the analysis, interpretation, and presentation of the quantitative data. A codebook was developed to convert themes and concepts from the respondents' answers into numbers that enable keying into the SPSS program.

Second, descriptive statistics used tabulation methods to summarize the data into frequency and cross-tabulation, besides the automatic generation of statistical tables with the SPSS program. Last, the researcher used the Structural Equation Modeling (SEM) method using the AMOS program to guide the data collection and analysis process as discussed in Section 3.9.

3.8.3 Integration of Qualitative and Quantitative data

The study employed the concurrent mixed methods where findings from qualitative and quantitative data were analyzed at the same time and integrated at the interpretation and discussion stage. The data was integrated following Caracelli and Greene's (1993) recommendations that in mixed methods studies, each data set was analyzed separately using the techniques used with the data; that is, qualitative methods used to analyze qualitative data, and quantitative techniques used to analyze quantitative data. Therefore, the conclusion and verification of quantitative and qualitative data analyses were integrated at the interpretation level and the discussion stage of research, but each data set remaining analytically separate from the other as per the concurrent mixed-method design.

3.9 Structural Equation Modeling

Structural Equation Modeling (SEM was used for testing hypotheses on relationships between construct variables and indicator variables (Hoyle, 1995). Indicator variables are observed variables, while construct variables are unobserved variables that correspond to hypothetical constructs that are presumed to reflect a continuum that is not directly observable or measurable (Kline, 2011). The Study's Structural Equation Models comprised of a measurement model and a structural model (Lei and Wu, 2007; Hair *et al*., 2010; In'nami and Koizumi, 2013). A measurement model indicates the relationships among observed indicators and construct variables, while the structural model specifies the relations among construct variables and the regression of construct variables on observed variables.

The study used a two-step approach emphasized by Bryne (2016) in the analysis of SEM, where the measurement model and structural models were considered as two conceptually distinct models. The approach using Confirmatory Factor Analysis (CFA) assesses the fit of the observed variables to the construct variables (measurement model) first before assessing the fit of the structural equation model among construct variables (structural model). Jöreskog and Sörbom (2003) gives the rationale for the two-step approach and argue that unless the measurement model holds first, it will be useless testing the initially specified structural model. The reason is that if the chosen observed indicator variables for a construct do not measure the construct, the specified measurement model should be modified prior to testing the structural relationships.

3.9.1 Aspects of Using SEM

SEM has grown to be an essential analytical method for testing and developing theories and is considered a more powerful technique than other conventional multivariate procedures (Byrne, 2016). Byrne (2016), In'nami and Koizumi (2013), and Teo *et al.* (2013) lists several aspects that set SEM apart from the traditional multivariate statistical method. In contrast, (Hox and Bechger 1998; Nachtigall *et al*., 2003) compared the shortcomings of SEM versus other traditional statistical methods.

3.9.1.1 *Pros of Using SEM*

(i) SEM is a methodology that is very flexible and comprehensive.

(ii) In the SEM technique, multiple interrelated equations are solved simultaneously to

determine parameter estimates.

(iii) SEM considers measurement errors explicitly, while traditional methods assume that measurement takes place without errors.

(iv) SEM is capable of modeling complex multivariate relations and establishing direct and indirect relationships of variables under study that is not easily implementable in other models.

(v) SEM is a multivariate technique integrating measured and unobserved variables (construct variables) while traditional techniques analyze only observed measured variables.

(vi) SEM takes a confirmatory hypothesis testing (Confirmatory Factor Analysis) approach to data analysis by specifying relationships between variables and constructs priori. By contrast the traditional multivariate statistics approach is descriptive by nature (Exploratory Factor Analysis), making hypothesis testing difficult.

(vii) SEM resolves problems of multicollinearity. Multiple measures are required to describe a construct variable (unobserved variable) preventing occurrence of multicollinearity because unobserved variables act as distinct construct variables.

(viii) Finally, the pictorial representation of the SEM model provides a convenient and powerful way to present complex relationships.

3.9.1.2 *Cons of Using SEM*

(i) SEM assumes that researchers have excellent statistical skills and expertise.

(ii) SEM provides evidence of a poor model and not proof of a good one.

(iii) Proof of model fit in SEM can become empirical rather than theory-driven.

(iv) SEM requires a considerable sample size of at least 200 and least three indicators per latent construct for a model to be identified and

(v) SEM assumes that the multivariate distribution of the data is normal and that the proposed model is identified correctly.

The study followed six necessary steps in structural equation modeling as established by most authors in model testing. In addition to data collection, the steps used were model specification, identification, estimation, evaluation, and modification (Hair *et al.*, 2010; Kline, 2011).

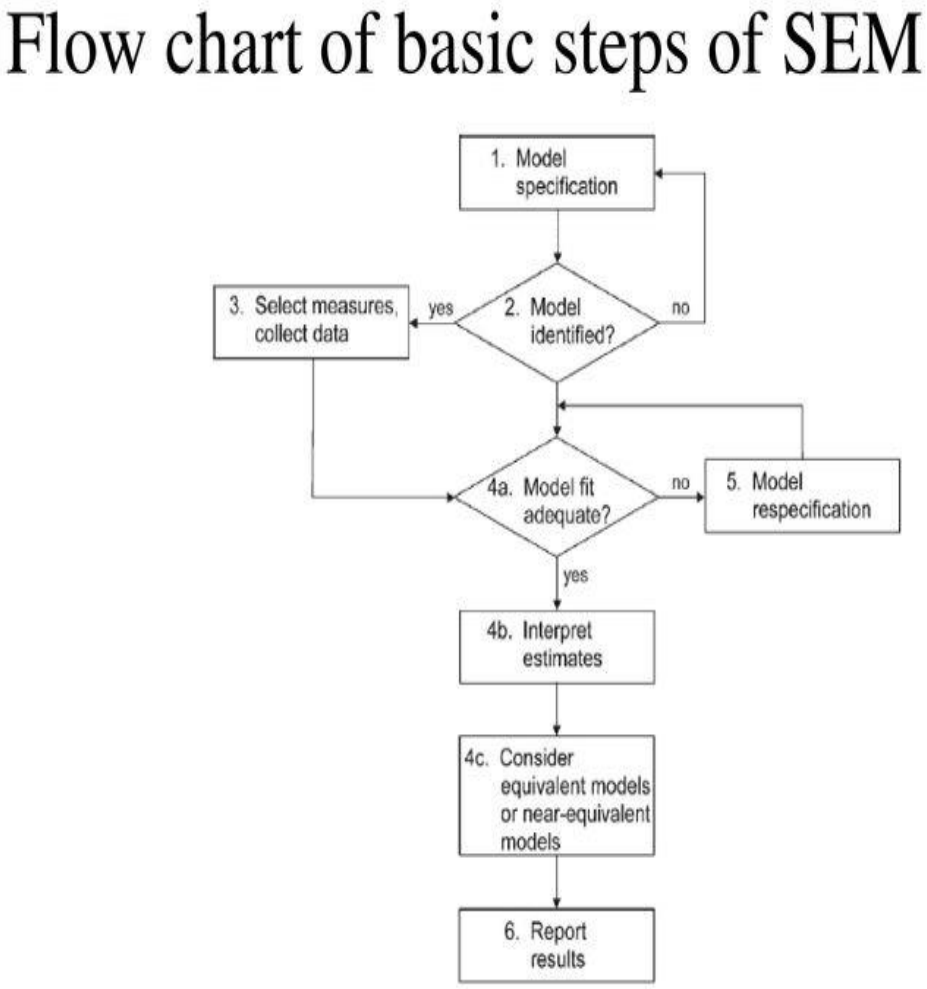


Figure 3.3: Basic steps of SEM
(**Source**: Kline, 2011)

3.9.2 Model Specification

The researcher first specified a model that reflects the study's hypotheses and in total, makes up the model to be analyzed based on theory. Model specification consists of formulating statements about a set of variables where a model's pictorial representation is transformed into a set of interrelated equations (path diagram) that are simultaneously solved to test the model fit and estimate parameters (Bryne, 2016; Kline, 2011). Per SEM's requirement, specified were all relationships a *priori* before the model estimation. Figure 3.4 displays a *path diagram* that depicts the dependence and correlation relationships between the *independent*, *moderator* and *dependent* variables and expressed in terms of measurement and structural model.

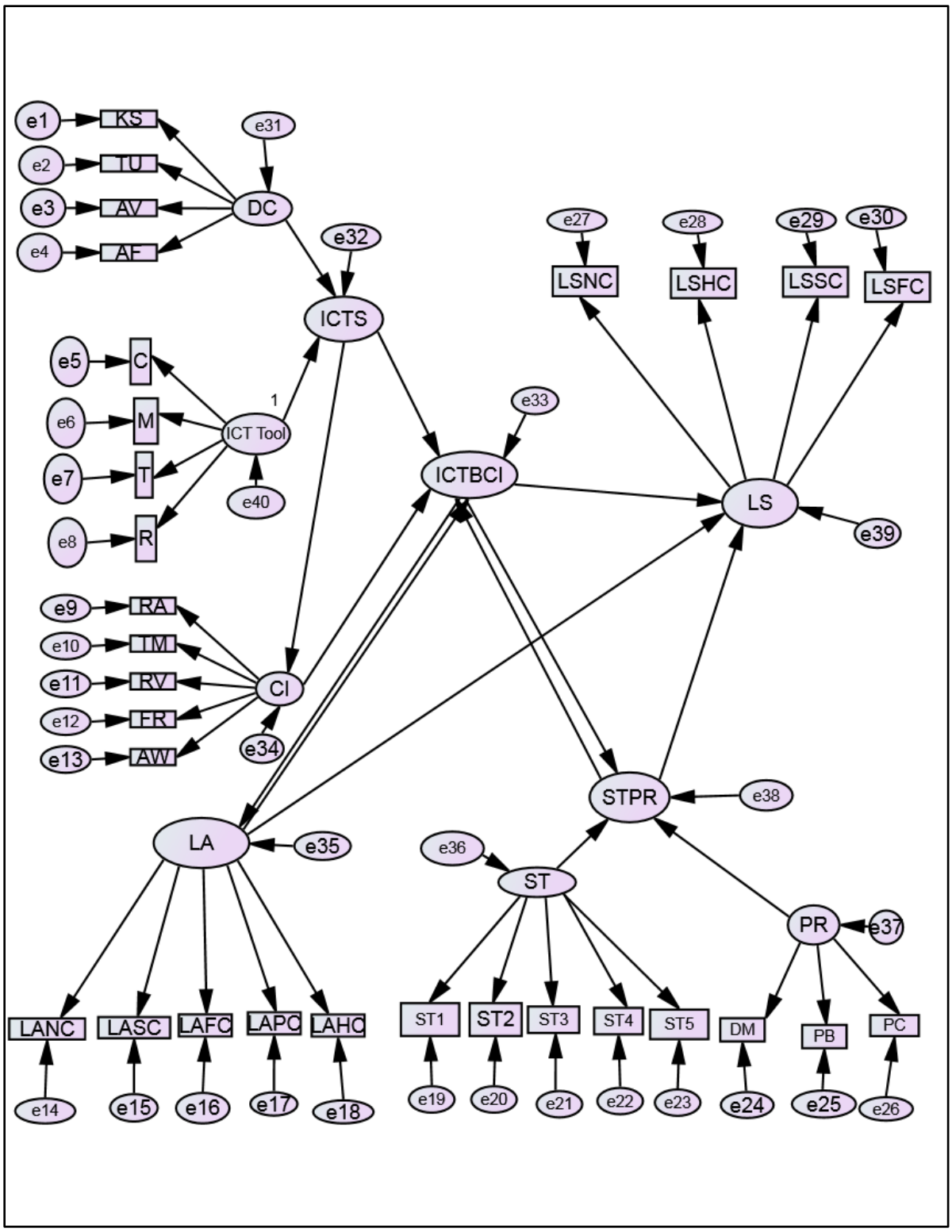


Figure 3.4: Specified Structural Model Path Diagram

The relationships among the variables in the path diagram are fixed, free, or constrained. Fixed

paths are assigned a specific value such as the value of one, the AMOS computer program calculates free paths, and constrained paths and must meet certain specified conditions or criteria. Directional effects involve dependence relationships between observed indicators and construct variables and relationships between construct variables and other construct variables. It is recommended to have a minimum of three indicators per construct and preferably four to provide adequate identification and a good fit for the model (Hair *et al.*, 2010; Kline, 2011). A minimum of three indicators per construct was modeled. Table 3.4 illustrates the Constructs and Indicator variables used for the studies specified model.

Table 3.4: Constructs and Indicator Variables

Construct Variables	Indicator Variables		Code
ICT Tools (Tool)	Radio, Mobile, Television, Computer		R, M, T, C
Digital capital (DC)	Accessibility	• Knowledge & Skills (KS) • Technical understanding of CI (TU)	KS TU
	Availability		AV
	Affordability		AF
Climate Information (CI)	Awareness		AW
	Frequency		FR
	Relevance		RV
	Timeliness		TM
	Reliability/Accuracy		RA
Livelihood Assets (LA)	Natural Capital		LANC
	Physical Capital		LAPC
	Human Capital		LAHC
	Financial Capital		LAFC
	Social Capital		LASC
Structures & Processes (STPR)	Structures		ST
	Policy		PC
	Decision Making		DM
	Cultural Practices & Beliefs		PB
Livelihood Strategies (LS)	Livelihood Strategy Natural Capital		LSNC
	Livelihood Strategy Human Capital		LSHC
	Livelihood Strategy Physical Capital		LSPC
	Livelihood Strategy Financial Capital		LSFC
	Livelihood Strategy Social Capital		LCSC

3.9.3 Model Identification

The basic principle of an "identified" model is when the estimated parameters have a unique solution and are determined by comparing the number of data points to the parameters being estimated. There are three forms of model identification (Hair *et al.*, 2010; Kline, 2011; Byrne, 2016). A model is considered "under-identified" when the of number data points are fewer than the parameters to be estimated and therefore the parameters cannot be estimated, requiring the reduction of the number of parameters by deleting or fixing some of them. If the data points equals the parameters to be estimated, it is considered "just identified". Such a model fits the data perfectly and but is not practical. The study's measurement model was "over-identified," when the number of data points was greater than the number of parameters to be estimated, then the analysis in AMOS could proceed to the next stage, model estimation (results in 4.7.2).

3.9.4 Model Estimation

In model estimation, the unknown parameter values and the errors of the estimates are determined. A properly specified equation model has some free parameters to be estimated and some fixed parameters, where the scale of a construct variable is standardized by fixing a variance to one (Kline, 2011; Byrne, 2016). Once the model passed the identification stage, the research adopted the most common estimation technique Maximum Likelihood Estimation (MLE) (Section 4.7.3), guided by sample size and the multivariate normality of the data (Boomsma, 1987).

3.9.5 Model Evaluation

Once the model parameters were estimated, the next step was to make decisions on whether to retain or reject the proposed model. The central purpose of model evaluation or fit is to determine the degree to which data fit the proposed model. The study compared the estimated model covariance with the sample covariance matrix obtained from the data and reported on various fit indices used in the research. The three types of Fit indices used to investigate model fit were: *absolute, incremental* and *parsimonious* fit. Absolute fit indices indicate the extent to which the observed data matrix and the hypothesized model data matrix are the same; the less similar they are, the worse the fit (Kline, 2011; Byrne, 2016). The incremental fit indices compare the improvement in fit of the proposed model to a baseline model in which the co-variances among all variables are hypothesized to be zero. The more the proposed model is

improved as compared to the baseline model, the better the fit. The Parsimonious fit indices assess the discrepancies between observed and proposed covariance matrix and considers the complexity of a model. Hair *et al.* (2010) and Teo *et al.* (2013) recommend the following fit indices, as exhibited in Table 3.5 that we apply later in the specified model in section 4.7.4.

Table 3.5: Model Fit Indices

Measure	Fit Index	Expected	Source
Absolute Fit	The Goodness of Fit (GFI)	> 0.9	Jöreskog and Sörbom 1989
	Root Mean Squared Error of Approximation (RMSEA)	0.03 < x < 0.08	Steiger and Lind 1980
	Root Mean Residual (RMR)	-4 < x < 4	Bentler, 1995
	Normed Chi-square (χ^2 :df)	< 1:3 (ratio)	Wheaton et al.'s (1977)
Incremental Fit Indices	Comparative Fit Index (CFI)	> 0.95	Bentler, 1989, 1990
	Tucker-Lewis Index (TLI)	> 0.95	Tucker and Lewis, 1973
Parsimony Fit Indices	Adjusted Goodness of Fit (AGFI)	Varies between 0 & 1 with higher values signifying a better parsimonious fit	Jöreskog and Sörbom 1989
	Parsimony Normed Fit Index (PNFI)		James, Mulaik and Brett, 1982

3.9.6 Model Modification

The research process required model modification (re-specification) to improve on the overall model-data fit by adding and deleting non-significant paths. However, the modification process did not go beyond the allowed fourth modification so as to not over-fit the model and lose on theory (Bryne, 2016).

3.9.7 Report the Results

The final stage is the report of the results in which the researcher accurately and elaborately reports the SEM analysis process. The researcher documented the assumptions, processes, and results of all steps mentioned above in Chapter 4, sections 4.7 to 4.8.

3.10 Data Management in Structural Equation Modeling

Before conducting data modeling and analyses, the dataset was checked for errors, missing data, outliers, normality, reliability, and validity as discussed by Byrne (2016).

3.10.1 Data Validation and Missing Data

The study investigated the reasons for the missing data to select the most appropriate course of action before proceeding with data analysis in structural equation modeling (SEM). Missing data was due to various reasons, human errors in data collection or data entry, and one or more invalid variables values not available for analysis or the respondents purposively ignoring or mistakenly not filling out some parts of the questionnaire. The extent of missing data and the randomness of their occurrence determines the type of remedy applied to address the issue of missing data. By doing so, it was possible to identify patterns and relationship underlying the missing data and apply remedies that would not lose much of the original distribution of values, assuming the data was not missing (Kline, 2011). Hair *et al*. (2010) assert that in SEM, missing data minimizes the capacity of the statistical test that implies an association in the dataset, a bias of results towards estimated parameters, skewed research findings and the reduction of sample available for analysis. Hair *et al.* (2010) and Kline (2011) recommend ignoring an individual case of missing data that has a small percentage (5-10%) unless it occurs in a non-random fashion.

The study adopted the automatic imputation method in SPSS in order to ensure continuities between available data and solving the challenge of missing data. Before proceeding with the imputation analysis, Missing Completely at Random (MCAR) test was conducted to establish the randomness of the missing values as a safety measure for carrying out the imputation process without affecting the results. The MCAR test results were not significant, showing a p-value of 0.779. It was deemed safe to proceed with the imputation process using Multiple Imputation methods. Further, the SPSS automatic imputation used linear regression to solve the problem of missing data.

Table 3.6: Summary of Missing Data

	Missing		**Valid N**	**Mean**	**SD**
	N	%			
AF	10	2.4%	409	2.915	1.202
RA	9	2.1%	410	3.159	0.917
TM	9	2.1%	410	3.240	0.884

After an investigation of the data, Table 3.6 displays the occurrence and the proportion of

missing data. It reveals that affordability, accuracy, and timeliness of climate information disseminated through ICT tools had missing data of not more than 2.5 %. The overall summary of missing values in variables and cases are 5.20% and 9.31%, respectively, while the overall incomplete values consisted of 0.37% as exhibited in Figure 3.5 below. The missing value percentages fall below (5-10%) and therefore considered acceptable for data analysis.

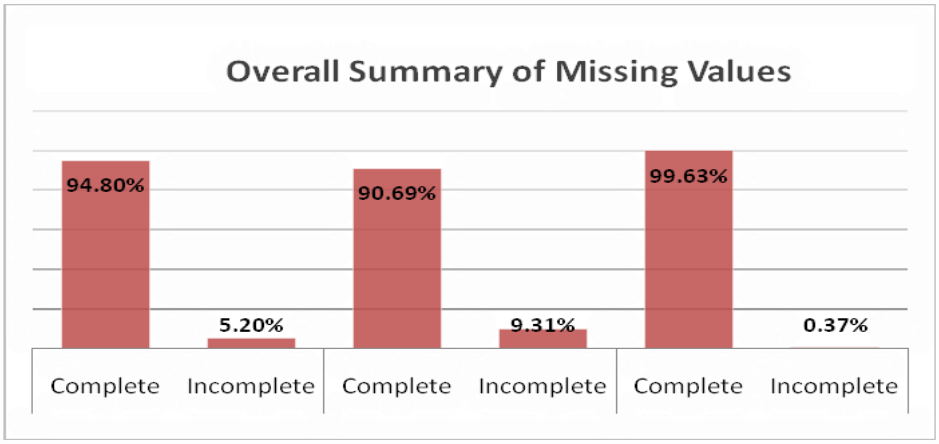


Figure 3.5: Graphic Representation of Missing Data

3.10.2 Outliers

In the context of research data, outliers are cases with extreme values well above or below the majority of other cases. They affect the data presentation of the analysis and hypothesis testing hence altering the conclusion since they skew towards the wrong direction correlation coefficients and lines of best fit (Kline, 2011). There are two forms of classification of outliers; first is univariate, whereby an extreme score on one variable is very different from the others and, second, multivariate whereby there is a combination of unusual scores on at least two or more variables (Tabachnick and Fidell, 2007).

This study used a standardized method to check the dataset for outliers. Furthermore, the bases for outlier analysis were the independent, dependent, and the moderating variables of the study. Univariate outliers for the continuous variables were analyzed through the standardized Z-Score values with absolute values of -3.29 or +3.29. Results show that education level had two outlier values of 3.43 and 3.44, which were not too far off the cut-off Z-scores and therefore were retained (Pallant, 2013). The multivariate outliers were analyzed through the Mahalanobis method, which measures the distance of a case from the centroid (Hair *et al.*, 2010; Kline, 2011).

The distances are interpreted using the value p less than 0.001 and the corresponding $\chi 2$ value with the degrees of freedom equal to the number of variables. Cases of p greater than 1.00 are likely to be outliers. In this study, the values computed by SPSS were within the acceptable range, and so the conclusion was that there were no outliers in the data.

3.10.3 Data Normality

Structural equation modeling assumes that the univariate and multivariate distribution of the data is normal and the joint distribution of any variable pair is normal and bivariate (Kline, 2011). Any infraction of normality may affect the estimation procedure or the interpretations of findings. Normal data distribution can be visually verified using histograms or assessed based on skewness and kurtosis statistical tests. Figure 3.6 shows histograms and normal curves for two of the variables: Livelihood Strategy Financial Capital (LSFC) and Livelihood Strategy Human Capital (LSHC).

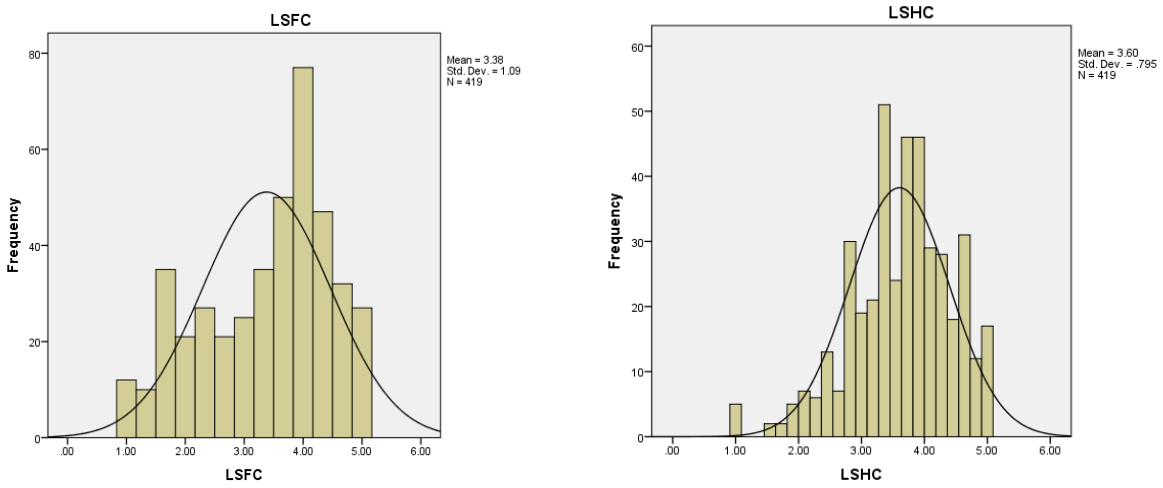


Figure 3.6: Normality Curves

The measures of construct '*ICT Tool*' were dichotomous (they possess both categorical and metric properties), and therefore, it was not necessary to measure the normality distribution test for the ICT tools. Details of the univariate normality measurement are captured in Appendix 4, and it displays the normality analysis distribution results of all variables, which are continuous or categorical as normal univariate distribution. The skewness and kurtosis values are all within the guidelines set by Kline (2011), which are below the absolute value of three and the absolute value of 10, respectively.

3.10.4 Validity and Reliability of the Study

The validity and reliability address the data quality and the appropriateness of the methods used in carrying out the study were. Validity is the degree to which the data is plausible, credible and trustworthy, and can be replicated by researchers when the observation is conducted using the same method(s) and procedure(s) (Bryne, 2016). Whereas, Hair *et al.* (2010) describe reliability as the degree to which measures do not contain any errors, thus yielding high consistency and is commonly used to measure internal reliability. This study's validity and reliability were ensured through the selection of the study area, a sampling of the respondents and the piloting of the research instruments.

3.10.5 Composite Reliability

Composite Reliability (CR) was used in the study due to its ability to draw on the standardized regression weights and measurement correlation errors for each item. Composite reliability refers to the internal consistency of indicators measuring the underlying constructs by using CFA. As a rule of thumb, CR of 0.7 or higher suggests a good reliability (Hair *et al.*, 2010). The constructs variables were measured by more than four or five indicator variables as recommended by Malo (2016). Table 3.7 shows the CR results, the indicators measuring the underlying constructs show internal consistency with CR values of higher than 0.8. The CR value for the indicators measuring structure and processes is 0.583, below 0.7 criterions. This is because the factor loading value for cultural practices and beliefs (PB) variables is 0.318 below the acceptable 0.5 estimates. Although the factor loading for cultural practices and beliefs were below the acceptable estimated value they were not rejected at this point but were further investigated during model modification and causal relationship of hypothesis testing in Chapter 4, section 4.7.5.

Table 3.7: Construct Reliability

Indicator	Path	Factor	Factor Loadings	Error	(SUM (F. Loadings)^2)	CR
TM	<---	CI	0.940	0.131	13.184	0.875
RV	<---		0.608	0.499		
FR	<---		0.547	0.525		
AW	<---		0.587	0.607		
RA	<---		0.949	0.127		

Indicator	Path	Factor	Factor Loadings	Error	(SUM (F. Loadings)^2)	CR
LSFC	<---	LS	0.751	0.774	10.956	0.852
LSNC	<---		0.896	0.186		
LSSC	<---		0.764	0.706		
LSHC	<---		0.899	0.232		
PC	<---	STPR	0.695	1.069	4.635	0.583
PB	<---		0.318	1.043		
DM	<---		0.448	0.472		
ST	<---		0.692	0.731		
AF	<---	DC	0.670	1.227	11.411	0.832
AV	<---		0.770	0.708		
TU	<---		0.958	0.25		
KS	<---		0.980	0.112		
LANC	<---	LA	0.834	0.439	11.717	0.868
LAFC	<---		0.869	0.451		
LAPC	<---		0.862	0.442		
LAHC	<---		0.858	0.446		
LASC	<---		0.653	0.024		
R	<---	ICT Tool	0.912	0.203	8.638	0.9542
C	<---		0.750	0.089		
M	<---		0.804	0.105		
T	<---		0.473	0.018		

C.R= (Sum (Loadings)^2)/ (Sum (Loadings)^2) + Sum (Item variables for each construct)

3.10.6 Construct Validity

Construct validity tests how well an experiment measures up to its claims. The study used convergent validity because the validity can also be tested using CFA, and two or more options can corroborate the results.

3.10.7 Convergent Validity

The study used convergent validity because the validity can also be tested using CFA, and two or more options to corroborate the results and tests whether the instruments designed to measure the same construct are related to each other (Bryne, 2016). There are three ways of testing convergent validity in CFA:

i. The use of standardized factor loadings, whereby factor loadings of 0.7 or higher indicate good validity and values of 0.5 or higher are acceptable,

ii. Using the Average Variance Extract (AVE) method as introduced by Hair *et al.*, (2010), where AVE= Average (item variable for each construct), A good AVE should have values of 0.5 and above for the construct validity to hold,

iii. The use of Construct Reliability (CR) for testing internal consistency. CR of 0.7 and above shows good internal consistency hence good convergent validity.

Table 3.8: Convergent Validity

Indicator	Relation	Factor	Factor Loadings	AVE
R	<---	ICT Tool	0.912	0.566
C	<---		0.750	
M	<---		0.804	
T	<---		0.473	
AF	<---	DC	0.670	0.730
AV	<---		0.770	
TU	<---		0.958	
KS	<---		0.980	
TM	<---	CI	0.940	0.560
RV	<---		0.608	
FR	<---		0.547	
AW	<---		0.587	
RA	<---		0.949	
LSFC	<---	LS	0.751	0.690
LSNC	<---		0.896	
LSSC	<---		0.764	
LSHC	<---		0.899	
PC	<---	STPR	0.695	0.538
PB	<---		0.318	
DM	<---		0.448	
ST	<---		0.692	
LANC	<---	LA	0.834	0.671
LAFC	<---		0.869	
LAPC	<---		0.862	
LAHC	<---		0.858	
LASC	<---		0.653	

Table 3.8 shows the results for the measurement model convergent validity for the standardized factor loadings and the average variance extract methods. Most of the standardized factor loading values for the indicator variables were above 0.7, and a few above 0.5 indicating good convergent validity except for indicator variable for cultural practices and beliefs (PB which had

a value of 0.318. However, because the AVE value was within an acceptable range, the convergent validity holds.

3.11 Ethical Considerations

Ethical considerations help researchers observe morals associated with researching to achieve high professional standards and also respect and protect participants (Payne and Payne, 2004). Busha and Harter (1980) highlighted that professional ethical standards need to be observed in all research phases. Cohen *et al*. (2000), Babbie and Mouton (2001), Leedy, and Ormrod (2001) highlight similar ethical considerations in any research, which include:

i. Protecting the confidentiality of human subjects
ii. Giving credit to research associates who provided direct evidence and placing a high value on intellectual honesty
iii. Reporting procedures and findings as accurately as possible
iv. Following proper procedures to gain access and acceptance to instructions and organization where research is to be conducted; and
v. Obtaining informed consent from the respondents.

The study adhered to research ethics and professional guidelines by obtaining an authorization letter from the University of Nairobi. The researcher explained the purpose of the study to respondents to obtain their consent. The research assistants were trained on how to manage the questionnaires and how to record the responses. The collected information was treated confidentially for academic purposes only. The survey questionnaire avoided personal questions that could have embarrassed and annoyed the respondents.

3.12 Summary

The research design of this study was first discussed. The sampling strategy was explained in detail, including the sample size determination for quantitative and qualitative data. Also outlined were the data collection methods and analysis that were used in this study. Specifically, the researcher utilized the statistical SPSS and AMOS 23 for descriptive statistics and AMOS for Structural Equation Modeling that addressed the studies hypothesis testing. Also discussed was the rationale for each research instrument and the ethical issues that could influence the research process.

CHAPTER 4: QUANTITATIVE DATA FINDINGS

4.1 Introduction

This chapter presents the results and findings of the quantitative data analysis. The data analysis plan followed three stages. First, the demographic information, which was followed by establishing how well the model fits the data for the measurement model. The final stage involved testing the alternative hypotheses using path coefficients and p-values for the structural model (Hair *et al*., 2010).

4.2 Response Rate

For the quantitative data, a team of interviewers administered face-to-face household survey questionnaires. Where 419 of 450 distributed questionnaires were returned, representing a response rate of 93.1%. As the minimum desirable sample size was 384; hence, the response rate for this study was adequate; this methodology was explained in Section 3.5.3.

4.3 Descriptive Statistics

The following section presents general information relating to demographic study findings.

4.3.1 Geographical Distribution of Respondents

Figure 4.1 and Table 4.1 presents data collected in the sub-counties and wards that fall within mentioned AEZs (Sampling Strategy 3.5.1).

The sub-counties that had the majority of the respondents were Kitui West at 40% and Kitui East at 35%. Mwingi West and Kitui Rural had the least number of respondents at 14% and 11% respectively. IL5 was the largest geographical AEZ and had the majority of the respondents constituting 35%, while LM4 and UM4 had 22% respondents, followed by LM5 with 21% respondents. The ten (10) wards selected using a stratified random sampling method were Nguuni, Tseikuru, Zombe/Mwitika, Kwa-Vonza, Kaui, Kwa-Mutonga/Kithumula, Kyome-Thana, Nguutani, Matinyani, and Miambani. Majority of the respondents were drawn from Zombe/Mwitika (62.1%), Matinyani, and Kwa-Vonza at 58.5%, and 52.3% respectively.

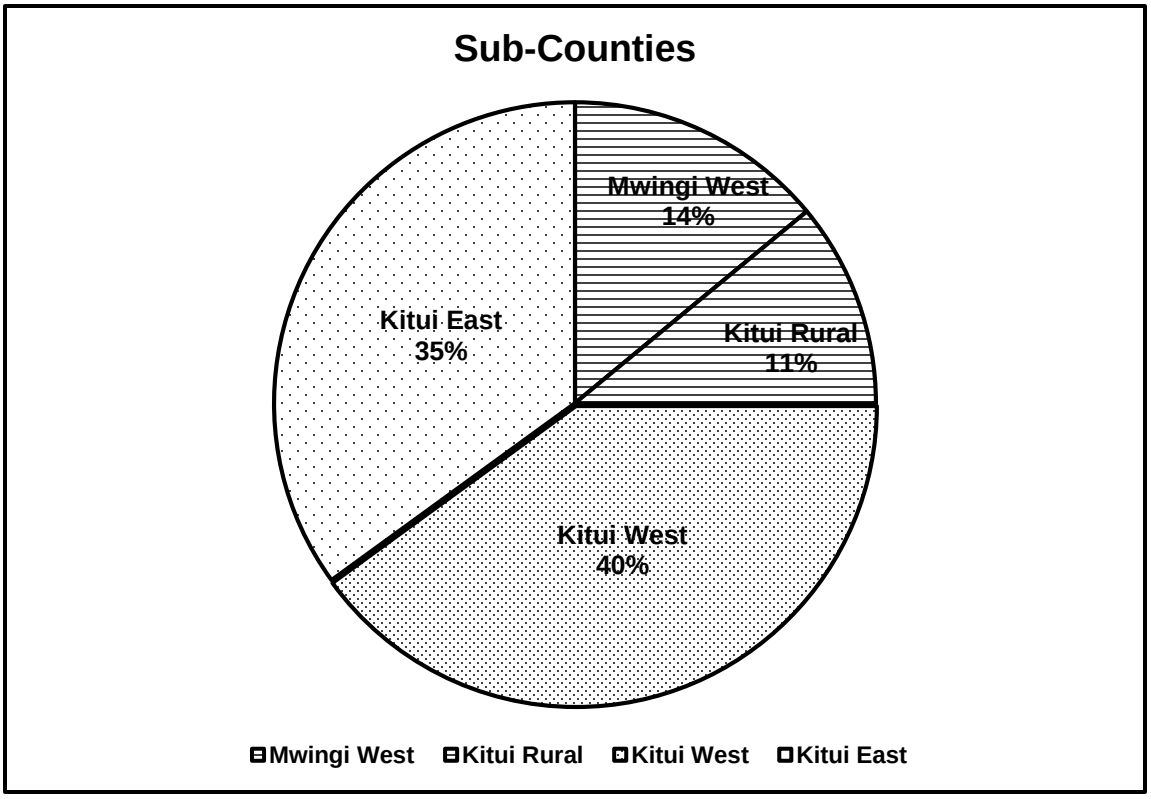


Figure 4.1: Distribution of Respondents by Sub-County

Table 4.1: Wards Distribution under AEZs

AEZ	Ward	Frequency	Percent
IL5	Nguuni	30	20.7
	Tseikuru	25	17.2
	Zombe/ Mwitika	90	62.1
	Total	**145**	**100**
LM4	Kaui	33	35.1
	Kwa Mutonga/ Kithumula	41	43.6
	Kyome-Thaana	20	21.3
	Total	**94**	**100**
LM5	Kwa-Vonza	45	52.3
	Nguutani	41	47.7
	Total	**86**	**100**
UM4	Matinyani	55	58.5
	Miambani	39	41.5
	Total	**94**	**100**

4.3.2 Demographic Characteristics of Respondents

Table 4.2 shows the demographic characteristics of the respondents derived from the survey.

Table 4.2: Demographic Characteristics of Respondents

Indicator Variable	Category	Frequency	Percent
Gender	Male	70	16.7
	Female	349	83.3
	Total	419	100
Age	18-30 years	73	17.4
	31-45 years	190	45.3
	46-60 years	94	22.4
	Above 60	62	14.8
	Total	**419**	**100**
Marital Status	Never married with no children	11	2.6
	Never married with children	28	6.7
	Married living together	268	64.0
	Married living apart	53	12.6
	Divorced/ separated/ widowed	59	14.1
	Total	**419**	**100**
Household Size	One member	9	2.1
	2-4 members	76	18.1
	5-7 members	206	49.2
	8-10 members	82	19.6
	More than 10 members	46	11.0
	Total	**419**	**100**
Able to read	Yes	322	76.8
	No	97	23.2
	Total	**419**	**100**
Able to write	Yes	326	77.8
	No	93	22.2
	Total	419	100
Education	None	73	17.4
	Primary	252	60.1
	Secondary	59	14.1
	College	30	7.2
	University	5	1.2
	Total	**419**	**100**

There were 349 females and 70 males, representing 83.3% and 16.7% respectively. The study targeted rural women hence the higher percentage of female respondents but the male respondents were useful for the primary purpose of joint intra-household decision-making consultation.

The highest number of respondents were aged between 31 and 45 years (45.3%), followed by those between 46 and 60 years at 22.4%. This meant that 67.7 % of respondents were between 31 and 60 years. Respondents who were in the age cohort of 18-30 years were 17.4 %. The lowest ratios of respondents were above 60 years.

The results show that the majority of the respondents (64%) are married and living together, while 14.1% were divorced/separated/widowed. There were also 12.6% respondents who were married but living apart. The study findings showed that women-headed households were 36%, while 74% are male-headed.

Table 4.2 also indicates that 49.2% of the respondents had a household size of 5 to 7 members, while 19.6 % of the respondents had 8 to 10 members. The majority (68.8%) of the respondents had a household size of between 5 and 10 members.

Regarding literacy and the highest education achieved, most of the respondents could read (76.8 %) and write (77.8 %). The majority (60.1 %) of the respondents indicated primary school as their highest level of education confirming the relevance of the KNBS 2009 census results, which indicated that 62% of Kitui residents had a primary level education. The Table also shows that 17.4 %) respondents did not have any level of education, while 8.4% were post-secondary graduates.

4.4 Use of ICTs to Access Climate Information by Rural Communities

The results in this section capture information on the ownership of ICT tools by the respondents and digital capital, namely, accessibility, availability, and affordability of the same ICT tools. The results on their awareness, access, and use of climate information, and links to ICT tools were then presented.

4.4.1 ICT Tools Owned by Respondents

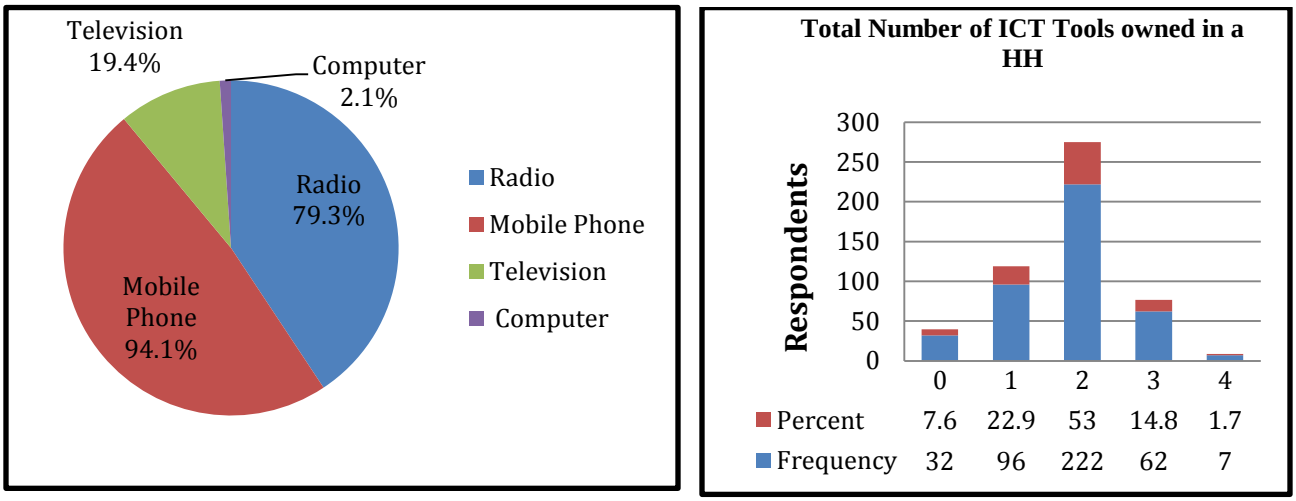


Figure 4.2: ICT Tools Ownership

Figure 4.2 displays the ICT tools owned by the respondents. Out of the 419 respondents, the majority (94.1%) owned mobile phones and (79.3%) owned radio sets. Only 19.4% of the respondents owned television sets a minimal 2.1% with computers. At least 53% owned both mobile phones and radios, while very few respondents (7.6%) owned no ICT tools.

4.4.2 Digital Capital

Table 4.3 on Digital Capital construct represents the response rates for accessibility, availability, and affordability

Table 4.3: Digital Capital

Digital Capital Construct	Indicator Variable	Radio	Mobile Phone	Television	Computer
Accessibility	Source of Access to ICT Tool	Neighbors/ Friends (n = 109)	Neighbors/ Friends (n = 60)	Neighbors/ Friends (n = 224)	Cyber Café (n = 225)
	ICT Tool Operation	n = 319	n = 324	n = 86	n = 22
	ICT Assistance	Child (n = 166)	Child (n = 205)	Child (n = 38)	Cyber Café (n = 101)
	Understanding Technical Information (CI)	n = 293	n = 278	n = 87	n = 30
	Format of Technical Information	Kikamba (n = 314); Kiswahili (n = 253); English (n = 144)			
Availability	Charging of ICT Tool	Battery (n =156)	Solar (n =224)	Solar (n= 46)	Electricity (n = 9)

Digital Capital Construct	Indicator Variable	Radio	Mobile Phone	Television	Computer
	The frequency of ICT tool use in accessing CI	n = 333	n = 377	n = 104	n = 18
Affordability	Sustaining use of ICT Tools	Battery (n = 179)	Solar (n =245); Airtime (n = 335); Internet/Bundles (n = 34)	TV Box (n = 62); TV Monthly Charges (n = 54)	Internet (n = 15); Printing & Photocopying (n = 19)

In Table 4.3, the respondents had several options in answering the questions on each row. The highest response rate was selected for each question. On the digital capital construct on accessibility to ICT tools, there were multiple sources of access to ICT tools. Some respondents went to neighbors and friends to access television (n=224), radio (n=109) and mobile phones (n=60), while others went to the cyber café to access computers (n=225).

In regards to ICT tool operation, the respondents' ability to operate the mobile phone (n=324), and the radio (n=319) were high, with very few capable of operating the television (n=86) and computers (n=22). The latter is expected, as depicted by the ownership of the various ICT tools in Figure 4.2. Most respondents sought assistance from their children when they were unable to operate the ICT tool (mobile n=205; radio n=166; and television, n=38). When it came to the computer, several respondents sought assistance from the cyber café (n=101). In understanding the climate information received via ICT tools, information relayed through the radio was understood the most (n=293), this was because on the radio climate information and the related agro-advisories were in the local dialect. The mobile phone (n=278) followed next, and this could be because of the preference in interactive voice response in Kikamba of the mobile phone. However, very few respondents could understand the climate information relayed through the television (n=87) and the computer (n=3), and the response rate could be because they were not interactive and expensive to own. A considerable number of respondents (n= 314) preferred to receive ICT based climate information in their vernacular language (Kikamba), followed by Kiswahili (n=253) and then English (n=144). This means to reach the widest audience any climate information must be packaged in the dominant local language in the catchment areas.

On the availability of power sources to support ICT tools, solar was the primary choice with 224 respondents using this to power their mobile phones and 46 respondents to power their televisions. A total of 156 respondents used batteries to power their radios, while nine respondents used electricity for their computers. On how frequently they used an ICT tool to access climate information, the majority at 377 respondents confirmed they relied on their mobile phone, followed closely by 333 on FM radios. Through neighbors, friends and cyber cafés, 104 respondents accessed climate information through television, and only 18 respondents accessed climate information through the computer.

Concerning perceived affordability of ICT services, 179 respondents were able to maintain the use of the FM radios with batteries, while 245 sustained their use of mobile phones with solar power. Most respondents (n=335) could afford to buy airtime, although very few (n=34) could afford to buy Internet bundles. Very few respondents (n=62) and (n=54), could afford to buy the modem and the monthly TV charges that go with it. Overall, the respondents that accessed use of the computer (internet access) at the cyber cafes were very few (n=15), and those who could afford to pay for printing and photocopying) services were also very few (n=19).

4.5 Awareness and Use of Climate Information

Table 4.4 contains information on the respondents' awareness and use of climate information. The source of climate information was from Kitui County Meteorological Department (KMD).

Table 4.4: Awareness and Use of Climate Information

Awareness and use of climate information *(5 = Very Important; 4 = Important; 3 = Neutral; 2 = Less Important; 1 = Not Important)*	**Median**	**Mean**	**SD**	**Skewness**	**CV**
Intensity of Rainy Season	4	4.24	0.91	-1.27	0.214
Daily Weather Forecast	4	4.25	0.94	-1.49	0.222
Length of Rainy Season	4	4.21	0.98	-1.43	0.232
Onset and cessation of rainy season	4	4.22	0.99	-1.53	0.235
Weekly Forecast	4	4.17	1.00	-1.36	0.239
Seasonal Forecast	4	4.15	1.03	-1.42	0.248
Early Warning of Extreme Weather (drought, floods, pests)	4	4.14	1.09	-1.42	0.264
Future Forecast	4	4.06	1.18	-1.34	0.291

From Table 4.4, the study results show that awareness of climate information level is very high, with a median of four for each indicator. There is also information concerning the distribution of scores on awareness and use of climate information by assessing skewness and Coefficient of Variation (CV) in normalization and ranking of the variables. The score of skewness is greater than -1, which implies that the distribution of dataset is highly skewed, where most of the responses are clustered around the median number of 4. The Coefficient of Variation was computed for each measured indicator, to differentiate between these similarities. It was then ranked in terms of climate information awareness. Since the values of CV are very close to each other and less than 0.5, it means there is a very low dispersion of respondents around the mean. It also indicates that over 80% of the respondents are aware of climate information and hence realize its importance in implementing their livelihood strategies and eventually attaining a sustainable livelihood.

4.5.1 ICT Tools Frequently Used to Access Climate Information in Kitui

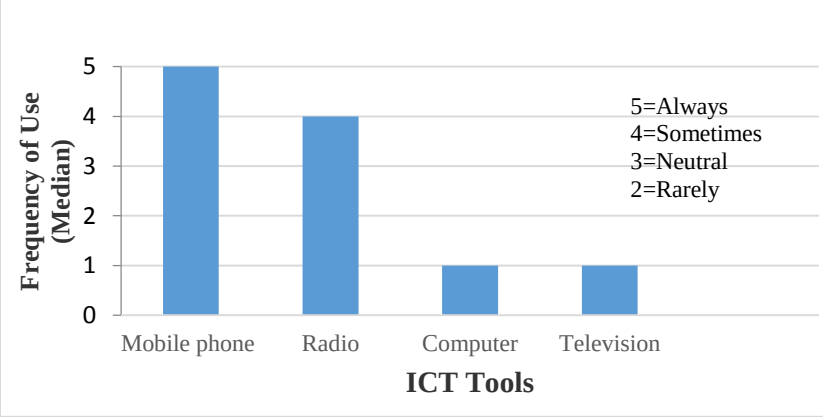


Figure 4.3: ICT tools frequently used to access climate information

Figure 4.3 indicates the results of ICT tools frequently used to access climate information. Considering the median value, the respondents use mobile phones always, the radio sometimes and rarely use the computer and television (mobile phone=5, Radio=4, Computer=1, and Television=1) in accessing climate information. The results continue to confirm a linkage between ownership and use with very few respondents using televisions and computers to access climate information. Access to these (Figure 4.2 and Table 4.3) may need one to physically move from their comfort zone to seek them from neighbors and cybercafés. The respondents found mobile phones and community radios to be affordable, available and easily accessible compared

to the television and computers and this is because almost all households in Kitui owned at least one mobile phone with some level of disparity based on gender, technological feasibility, and financial ability.

4.5.2 The Relevance of Climate Information Accessed through ICT Tools

Figure 4.4 displays results on the respondents who found climate information accessed through ICT tools to be relevant. The data was categorized into low, medium, and high. A majority (82%) of the respondents were in high category and find the relevance of climate information accessed through ICT tools while 13% in medium and 5% in low.

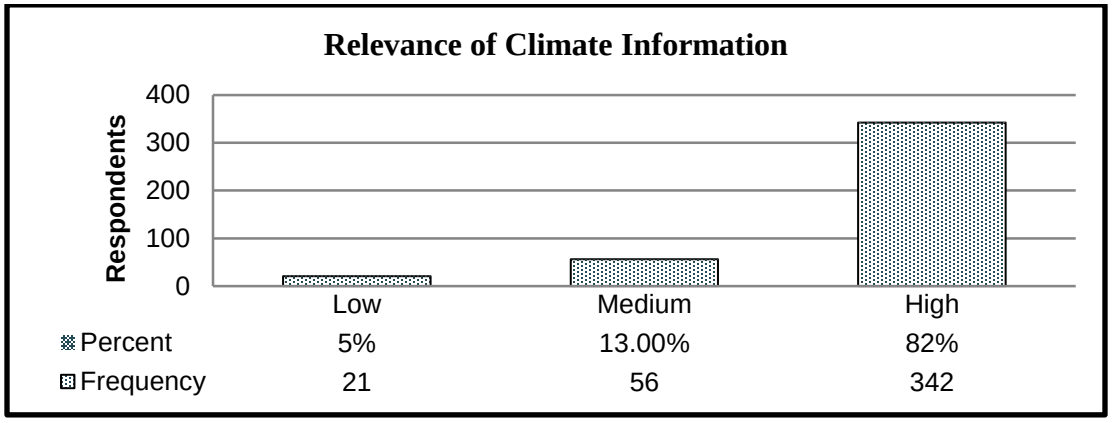


Figure 4.4: Relevance of Climate Information Relayed through ICT Tools

4.5.3 Timeliness and Accuracy of Climate Information Relayed through ICT Tools

In Table 4.5, median values indicates that the radio and mobile phones are timely and accurate in relaying climate information, at a median of 4, while only a few respondents find the television and computer timely and accurate in relaying climate information (at a median of 2 (disagree), and 1(strongly disagree)).

Table 4.5: Timeliness and Accuracy of Climate Information Relayed through ICT Tools

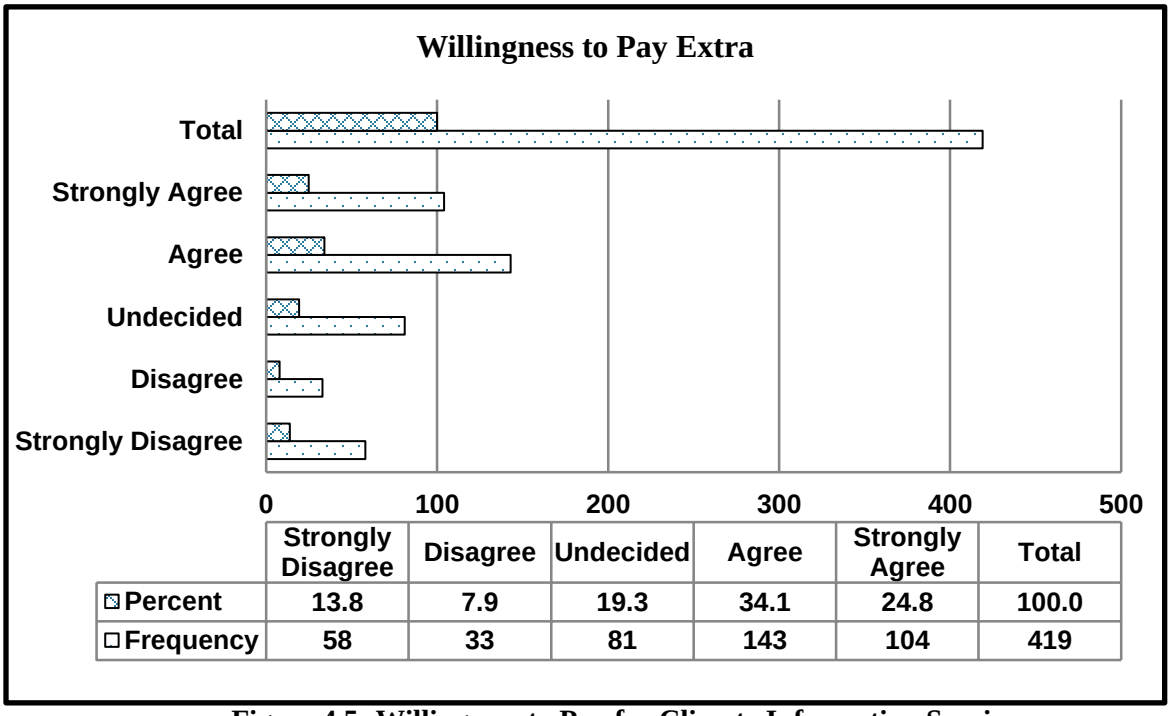
(5 = Strongly agree; 4 = Agree; 3 = undecided; 2 =Disagree; 1 = Strongly disagree) **Timeliness**	**Median**	**Mean**	**SD**	**Skewness**	**CV**
Radio	4	3.91	1.02	-0.94	0.261
Mobile Phone	4	3.71	1.14	-0.71	0.306
Television	2	2.46	1.39	0.46	0.565
Computer	1	1.55	1.13	1.97	0.728
Accuracy					
Radio	4	3.71	1.08	-0.73	0.291
Mobile phone	4	3.63	1.11	-0.55	0.306

Television	2	2.45	1.36	0.39	0.556
Computer	1	1.68	1.20	1.63	0.716

The responses were moderately distributed given the skewness at ±< 1, except for the computer skewness positive value of greater than 1. The CV aids in data distribution and computes the variables by ranking timeliness and accuracy of relaying climate information through ICT tools. The radio is ranked highest (CV= 0.261, 0.291), followed by the mobile phone (CV=0.306, CV=0.306) for timeliness and accuracy respectively. The least ranked are the television (CV = 0.261, 0.291) and the computer (CV= 0728, 0716).

4.5.4 Willingness to Pay for Climate Information Services

Figure 4.5 below indicates that 69.6 %, more than half the respondents (n=104, n=143) are willing to pay extra if the climate information relayed through the ICT tools is relevant, timely, and accurate.



	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Total
Percent	13.8	7.9	19.3	34.1	24.8	100.0
Frequency	58	33	81	143	104	419

Figure 4.5: Willingness to Pay for Climate Information Services

4.6 LIVELIHOOD ASSETS

This section reflects the results of the livelihood assets owned by the respondents.

4.6.1 Natural Capital

Table 4.6 shows the results of multiple response rates in establishing land ownership, and therefore, the results do not add up to 100%. Respondents who lease land for cultivation are the highest in number at 95.2% (n=399); those who use their parents land for cultivation were 87.6 % (n=367), while 81.1% (n=340) own the land jointly with their spouses. The results further show that 70.9% (n=297) of the land is owned by the respondents' spouses, mostly husbands but majority of the respondents were women. It is noteworthy that 54.2% (n=227) own the land they farm.

Table 4.6: Land Ownership and Land Acreage

Indicator Variable	Category	Frequency	Percent
Land Ownership	Self	227	54.2%
	Spouse	297	70.9%
	Jointly	340	81.1%
	Parents	367	87.6%
	Rented	399	95.2%
Land Acreage	<2	173	41.2
	3-5	191	45.5
	6-8	29	6.9
	9-10	14	3.3
	>11	13	3.1
	Total	**419**	**100**

For the acreage of land cultivated, the table results show that 41.2% of the respondents cultivate less than two acres of land while 45.5% between 2 and 5 acres. Very few respondents (13%) cultivate more than five acres.

Table 4.7: Water Source

Water Source *(5 = Always; 4 = Sometimes; 3 = Neutral; 2 = Rarely; 1 = Never)*	**Median**	**Mean**	**SD**	**Skewness**	**CV**
Rain-fed Water	4	4.08	0.74	-2.14	0.182
River Water	5	3.84	1.67	-0.99	0.435
Well/Dam Water	1	2.61	1.85	0.37	0.709
Piped Water	1	1.74	1.36	1.48	0.782
Kiosk Water	1	1.94	1.53	1.16	0.787
Borehole Water	1	2.02	1.62	1.06	0.802

Cultivation of land cannot be done without understanding the sources of water and the results of this are in Table 4.7 above. The median of 4 and 5 and the ranking of the variables by the CV

show that the respondents mostly depend on rain-fed water and river water, CV = 0.182 and CV = 0.435 respectively. Very few respondents have their primary water source from wells, dams, piped water, kiosk and boreholes as represented by the median value of 1=Never.

4.6.2 Human Capital

Human capital is reflected in the results of farm labor in Figure 4.6 below.

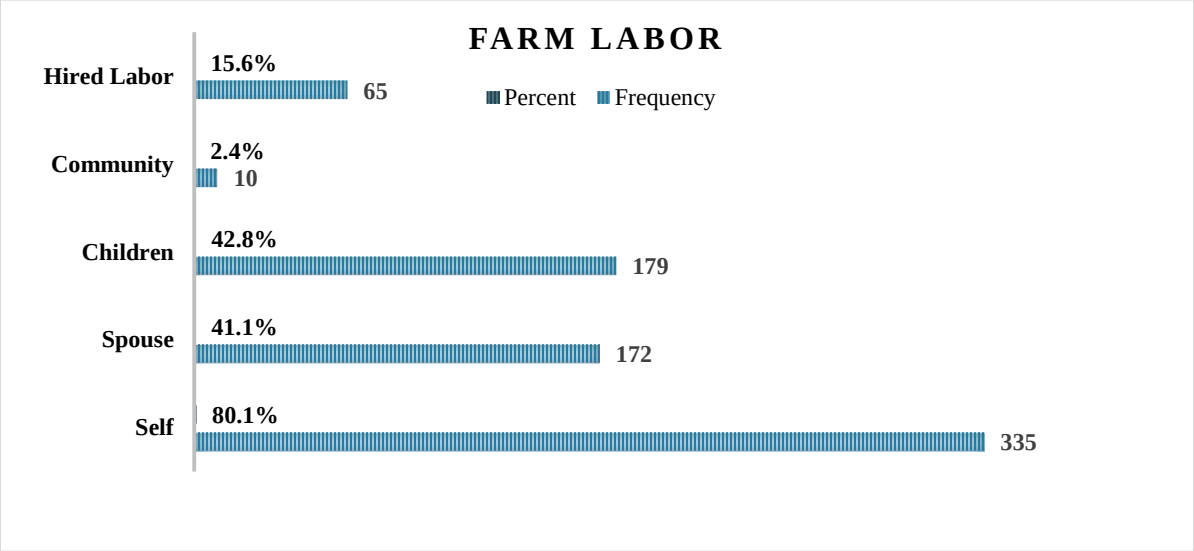


Figure 4.6: Farm Labor

The responses are multiple, with 80.1% who undertook farm labor themselves. At least 42.8% get help from their children and 41.1% from spouses. A few of the respondents (15.6%) can afford to hire farm labor and a negligible number of respondents (2.4%) rely on the community for farm labor.

4.6.3 Financial Capital

The respondent's financial capital results are displayed in Table 4.8. Around 59.7% of the respondents have some form of savings, and 53.9% can access credit facilities, while 34.1% receive remittances from outside sources.

Table 4.8: Financial Capital

Variable	Category	Frequency	Percent
Financial Resources	Savings	250	59.7
	Credit	226	53.9
	Remittances	143	34.1
	Livestock	**Total number of Livestock**	**Maximum # of Livestock in a HH**

	Cows	482	12
	Donkeys	268	3
	Sheep	83	10
	Chicken	3213	150
	Goats	1888	40

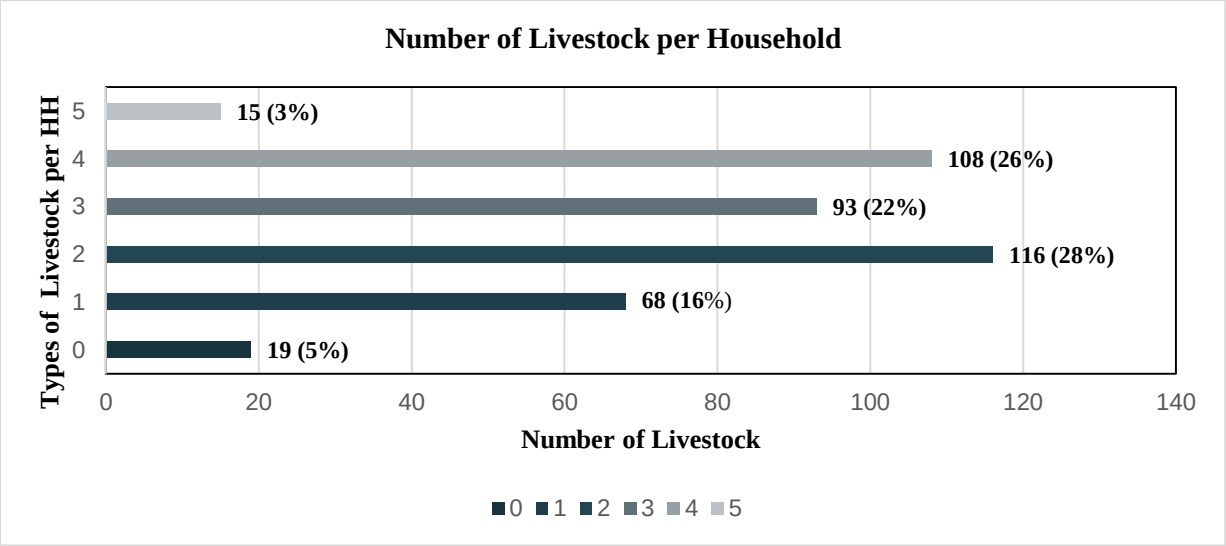


Figure 4.7: Number of livestock per Household

The results of Table 4.8 show the types of livestock owned in the community, which includes cattle, donkeys, sheep, chicken, and goats. Most households own chickens and goats with 150 chickens and 40 goats as the maximum in a household. In addition, Figure 4.7 shows the results of types of livestock owned in a household. Households that own two sets of livestock represent 28%, reflecting that chicken and goats were the highest numbers owned. Households that owned four of the livestock types were 26% with 3% of the households owning all five of the livestock types, while 22% own three livestock types. A notable 16 % own one type of livestock, while only 5% do not own any livestock at all.

4.6.4 Social Capital

The social network groups the respondents belong to are depicted in Table 4.9, where multiple responses were extracted. Respondents that belonged to savings groups were 23.6% and Self-help Groups at 22.8%. The self-help groups have the highest number of respondents who hold leadership positions. A total of 19.6% respondents belong to religious organizations, while 18.2% belong to farmers groups. Community-Based Organizations had 12.5% of respondents. Respondents that belonged to other organizations were 3.3%.

Table 4.9: Social Capital

Social Capital	Regular Member	Chairperson	Secretary	Treasurer	Governing Official	Total
Savings Groups	144	24	21	15	9	213 (23.6%)
Self Help Groups	109	42	26	21	8	206 (22.8%)
Religious Organizations	111	21	10	21	14	177 (19.6%)
Farmers Group	111	25	14	7	7	164 (18.2%)
CBO	81	6	8	5	13	113 (12.5%)
Other	15	4	3	3	5	30 (3.3%)

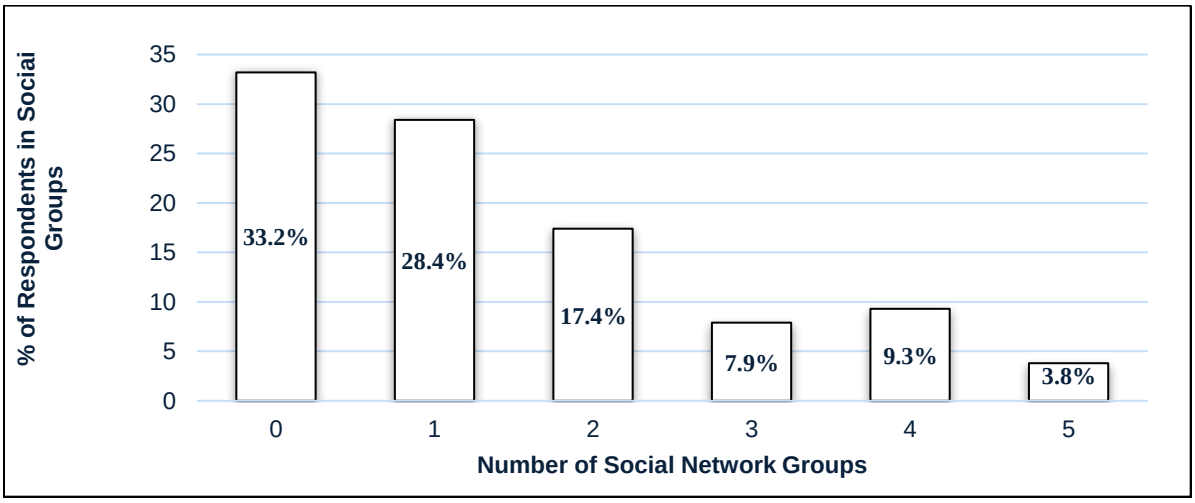


Figure 4.8: Respondents in Social Network Groups

The number of social network groups a respondent belongs to is represented in Figure 4.8. Around 28.4% of the respondents belong to at least one social network group, followed by 17.4% who belong to two social network groups and a few 7.9%, 9.3% and 3.8% belong to three, four and five social network groups, respectively. Respondents that do not belong to any social capital network are 33.2%.

Table 4.10 displays the results of the benefits the respondents have achieved by joining the social network groups. Networking and decision-making are benefits valued most by respondents. More

than 50% of the respondents reported that they gained respect when they joined religious organizations and savings groups. The number of respondents who are in leadership positions or who gained visibility by joining these social network groups is less than 40%.

Table 4.10: Utilization of Social Capital

Group	n and%	Leadership Position	Networking	Visibility	Decision-Making	Respect
Farmers Groups	f	48	109	42	118	62
	%	30.8%	**69.9%**	26.9%	**75.6%**	39.7%
Self Help Groups	f	79	159	79	144	90
	%	39.3%	**79.1%**	39.3%	**71.6%**	44.8%
Religious Org.	f	36	80	47	63	85
	%	23.4%	**51.9%**	30.5%	40.9%	**55.2%**
Savings Groups	f	62	155	70	153	107
	%	30.5%	**76.4%**	34.5%	**75.4%**	**52.7%**
CBOs	f	19	65	36	76	40
	%	17.6%	**60.2%**	33.3%	**70.4%**	37.0%
Other Groups	f	4	14	6	20	6
	%	14.8%	**51.9%**	22.2%	**74.1%**	22.2%

4.6.5 Physical Capital

Table 4.11: Physical capital

Variable ***(5 = Always; 4 = Sometimes; 3 = Neutral; 2 = Rarely; 1 = Never)***	**Category**	**Frequency**	**Percent**
Ownership of Physical Capital Facilities	Mechanized tools for farming	345	88.9
	Storage facilities for crops	324	83.5
	Shelter for animals	282	72.7
Distance Traveled to Local Market	1 - 5 KM	185	44.2
	Less than 1KM	125	29.8
	5-9 KM	86	20.5
	More than 9KM	46	11
Mode of Transport	Foot	255	60.9
	Motorbike	167	39.9
	Public Transport	135	32.2
	Animal Cart	43	10.3
	Bicycle	20	4.8
	Car	2	0.5
Type of House	Mud-walled hut	89	21.2%
	Brick walled house	332	79.2%
	Grass thatched roof	24	5.7%

Variable *(5 = Always; 4 = Sometimes; 3 = Neutral; 2 = Rarely; 1 = Never)*	**Category**	**Frequency**	**Percent**
	Iron sheet roof	395	94.3%

Multiple responses results apply in Table 4.11, which show that 88.9% (n=345) of the respondents own mechanized tools (tractor with ploughs) for their farming activities, while 83.5% (n=324) owned storage facilities for their crops and 72.7% (n=282) had shelters for their livestock

Concerning distance traveled to the local market, 44.2% of the respondents traveled on average between 1 to 5km. 29.8 % traveled less than 1km, while 32% traveled further than 5 Km.

Regarding the mode of transport, the three main modes of transport used were traveling by foot at 60.9 % and the use of motorbikes (‘*boda-boda’)* at 39.9%.

On housing, 79% of the respondents owned brick-walled houses (traditional red brick obtained locally) while 21% lived in mud-walled houses.

4.7 Structural Equation Modeling

This section outlines the second phase of analysis and discusses the testing, modification, and verification of the conceptual research model. The fit of the model to the data was very critical and explored by checking how the hypothesized model fits the data. The usefulness of the strategy for implementing SEM is outlined. The study followed the two steps for analysis recommended by key scholars in the area (Anderson and Gerbing, 1988; Hair *et al*., 2010; Kline, 2011; Teo *et al*., 2013; In’nami and Koizumi, 2013). The first step is to validate the measurement model by the use of Confirmatory Factor Analysis (CFA) and inspection of reliability and validity to reduce measurement error. The results are under the data management Section 3.10.4 above. The second step is the structural model analysis, which can only be carried out after the measurement model is successful. This examines the causal relationships that link the hypothesized model’s constructs, forming the basis of establishing if relationships exist between constructs and hence enables one to accept or reject a theory.

4.7.1 Measurement Model (Confirmatory Factor Analysis)

The study’s measurement model was based on the conceptual framework and specified the relations between the identified constructs (unobserved variables) and indicators (observed

variables). The error terms for the observed variables are shown below in Table 4.12 and Figure 4.9, respectively. The measurement model used the Confirmatory Factor Analysis (CFA) to validate the model before specifying and estimating the structural model (Malo, 2016). Further, this study relied on two universal central measurements to reduce measurement errors; reliability and construct validity, before evaluating the goodness of fit measures which ties in with Section 3.10.4 above. The model consists of six latent constructs: ICT tools, Digital Capital, Climate Information, Livelihood Assets, Structures and Processes, and Livelihood Strategies with five and four indicator variables.

Table 4.12: Constructs and Indicator Variables

Construct Variables	**Indicator Variables**	**Codes**
ICT Tools (Tool)	Radio, Mobile, Television, Computer	R, M, T, C
Digital capital (DC)	Accessibility (Knowledge and Skills, Technical Understanding of CI)	AC (KS and TU)
	Availability	AV
	Affordability	AF
Climate Information (CI)	Awareness	AW
	Frequency	FR
	Relevance	RV
	Timeliness	TM
	Reliability/Accuracy	RA
Livelihood Assets (LA)	Natural Capital	LANC
	Physical Capital	LAPC
	Human Capital	LAHC
	Financial Capital (LAFC)	LAFC
	Social Capital	LASC
Structures & Processes (STPR)	Structures	ST
	Policy	PC
	Decision Making	DM
	Cultural Practices & Beliefs	PB
Livelihood Strategies (LS)	Natural Capital	LSNC
	Human Capital	LSHC
	Financial Capital	LSFC
	Social Capital	LSSC

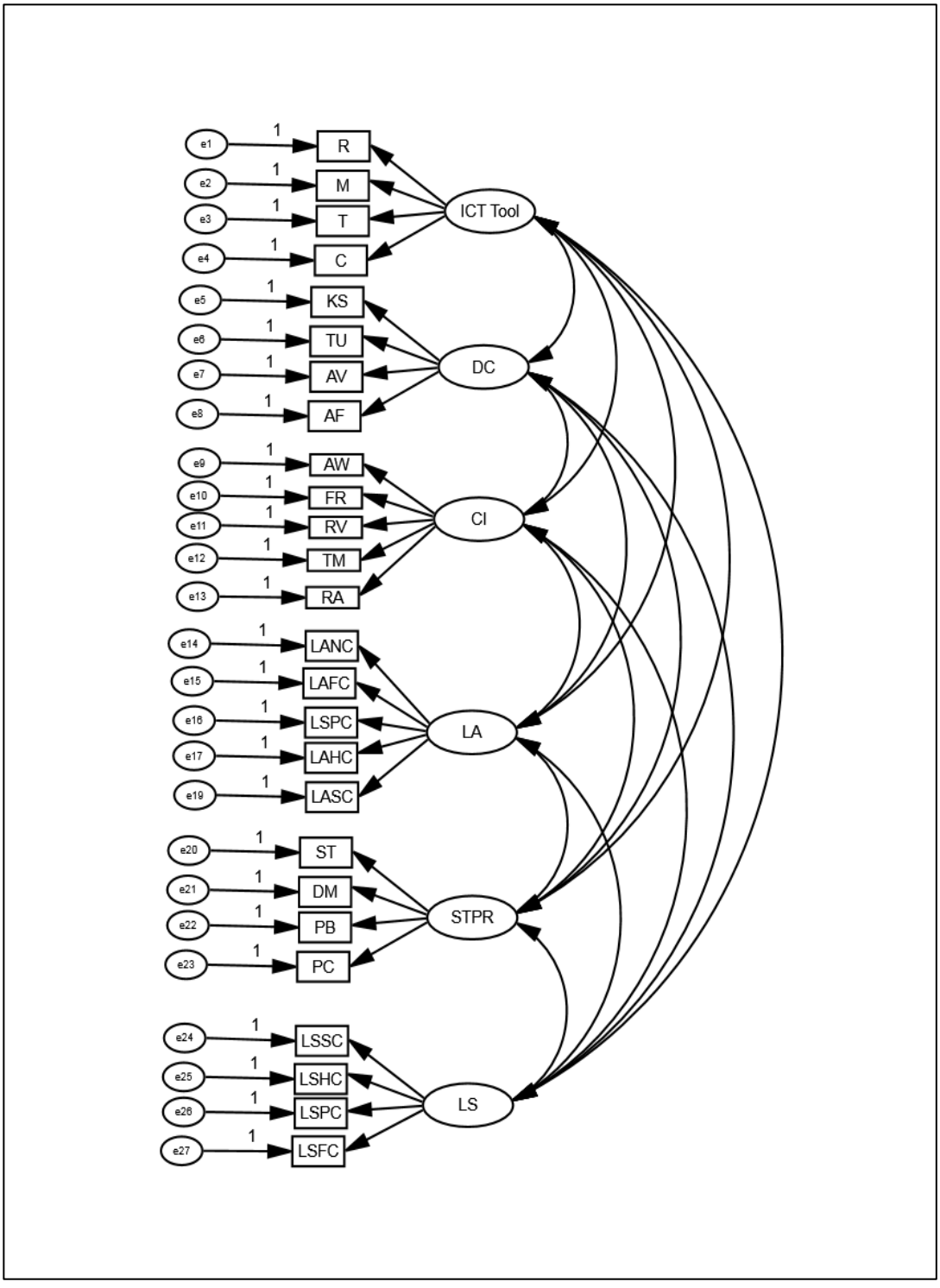


Figure 4.9: Initial Path Diagram Representing the Measurement Model

4.7.2 Model Identification

Model Identification refers to the idea that there is at least one unique solution for each parameter estimate in an SEM model (Kline, 2011). Subsequently, if there is only one possible solution for each parameter estimate, the model is *just-identified*. Models with an infinite number of possible parameter estimate values are *under-identified*. Finally, models with more than one possible solution for each parameter estimate is considered *over-identified.* The SPSS AMOS software used in the study for model identification cannot proceed with estimation if a model is not identified. The first step of the measurement model analysis did not lead to model identification, therefore, as suggested by Malo (2016) the researcher constrained more regression paths, and after two steps of constraining parameters, the model was *over-identified*, with the following results.

Table 4.13: Model Identification

Number of distinct sample moments	348
Number of distinct parameters to be estimated:	58
Degrees of freedom (348-58):	290

4.7.3 Model Estimation

Maximum Likelihood Estimator (MLE) attempts to find a parameter value that maximizes the given observations. To achieve the best estimate, MLE uses an iteration method that is a series of calculations until the best value is obtained. Figure 4.10 below shows the standardized estimate values using MLE in AMOS 23 (Arbuckle, 2006), whereby the measurement model was estimated at the 11^{th} iteration during the analysis. Also, the factor estimates from the constructs to the indicator variables should be at least 0.5, and ideally, 0.7 or higher to make a meaningful relationship. This is supported by SEM guidelines and researchers like Arbuckle (2006) and Kline (2011). A detailed Table with the results of the factor loading for the indicator variables is displayed in Appendix 5.

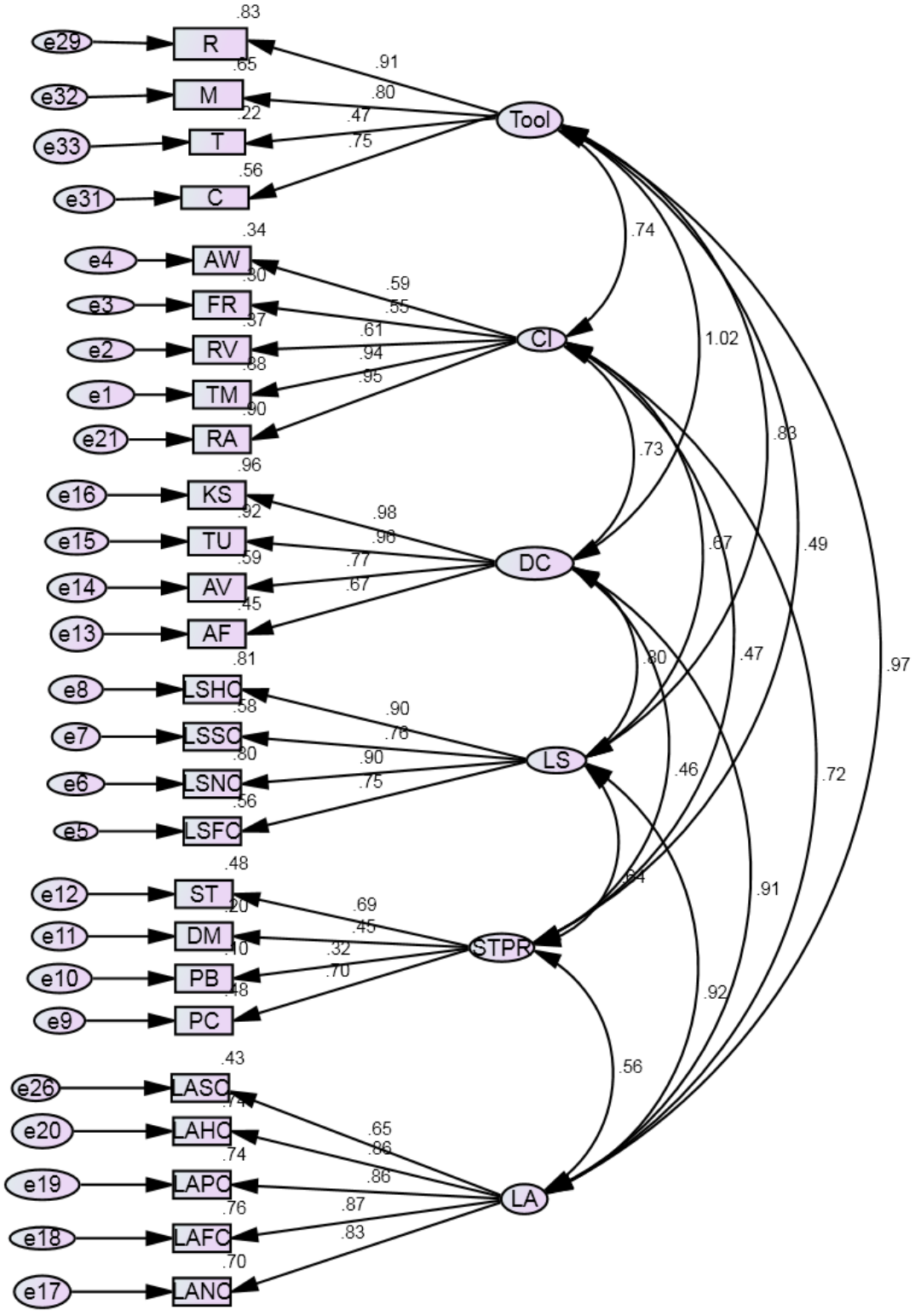


Figure 4.10: Standardized Estimates of Measurement Model Using Maximum Likelihood Estimator

4.7.4 Model Evaluation and Model Modification

It was critical to have a model re-specification and model modification based on model fit evaluation results; because the specified model did not fit the data the first time. The AMOS software provides Modification Indices (MI) to help with model re-specification. The researcher used the method, which would interfere least with the theory under study to improve the model fit. This was done through the correlation of error terms as supported by Jöreskog and Long (2003).

Kenny (2015) describes the model fit as the capability of a model in terms of reproducing the data, and this study employed the goodness of fit indices. The latter was categorized in three: absolute, incremental, and parsimonious (also explained in detail in Section 3.9.5 above under Model Evaluation). A first (MI 1), and a second (MI 2) was further implemented by correlating the measurement error terms, and the results of the Model Fitness are in Appendix 6. The Model modification index cannot go beyond the fourth iteration or it would compromise the integrity of the data (Jöreskog and Long, 1993; Kline, 2011). After running AMOS analysis, Table 4.14 below concluded the data as fit at the third modification model process, with a chi-square value of 714.5 and degrees of freedom =170. The researcher was then able to deduce that the questionnaire deployed captured the measurement indicators accurately and could proceed to the next phase of testing the structural model without any further adjustments to the measurement instrument.

Table 4.14: Third Modification Model Fitness

Chi-square = 714.5				
Degrees of Freedom = 170				
Measure	**Fit Index**	**Expected**	**Result**	**Comments**
Goodness of fit	Goodness of Fit (GFI)	> 0.9	0.977	Acceptable
	Root Mean Squared Error of Approximation (RMSEA)	0.03 < x < 0.08	0.06	Acceptable
	Root Mean Residual (RMR)	-4 < x D8< 4	3.71	Acceptable
Incremental Fit Indices	Comparative Fit Index (CFI)	> 0.95	0.983	Acceptable
	Tucker Lewis Index (TLI)	> 0.95	0.977	Acceptable
Parsimony Fit Indices	Adjusted Goodness of fit (AGFI)	0-1	0.561	Acceptable
	Parsimony Normed Fit Index (PNFI)	0-1	0.477	Acceptable

4.8 Structural Model Analysis

The next step is to evaluate the structural model to test this study's hypotheses. The emphasis is on the nature and magnitude of the constructs' relationship that is linked to the hypothesized model, forming the basis of establishing if relationships exist between the constructs (Hair *et al.*, 2006; Kline 2011).

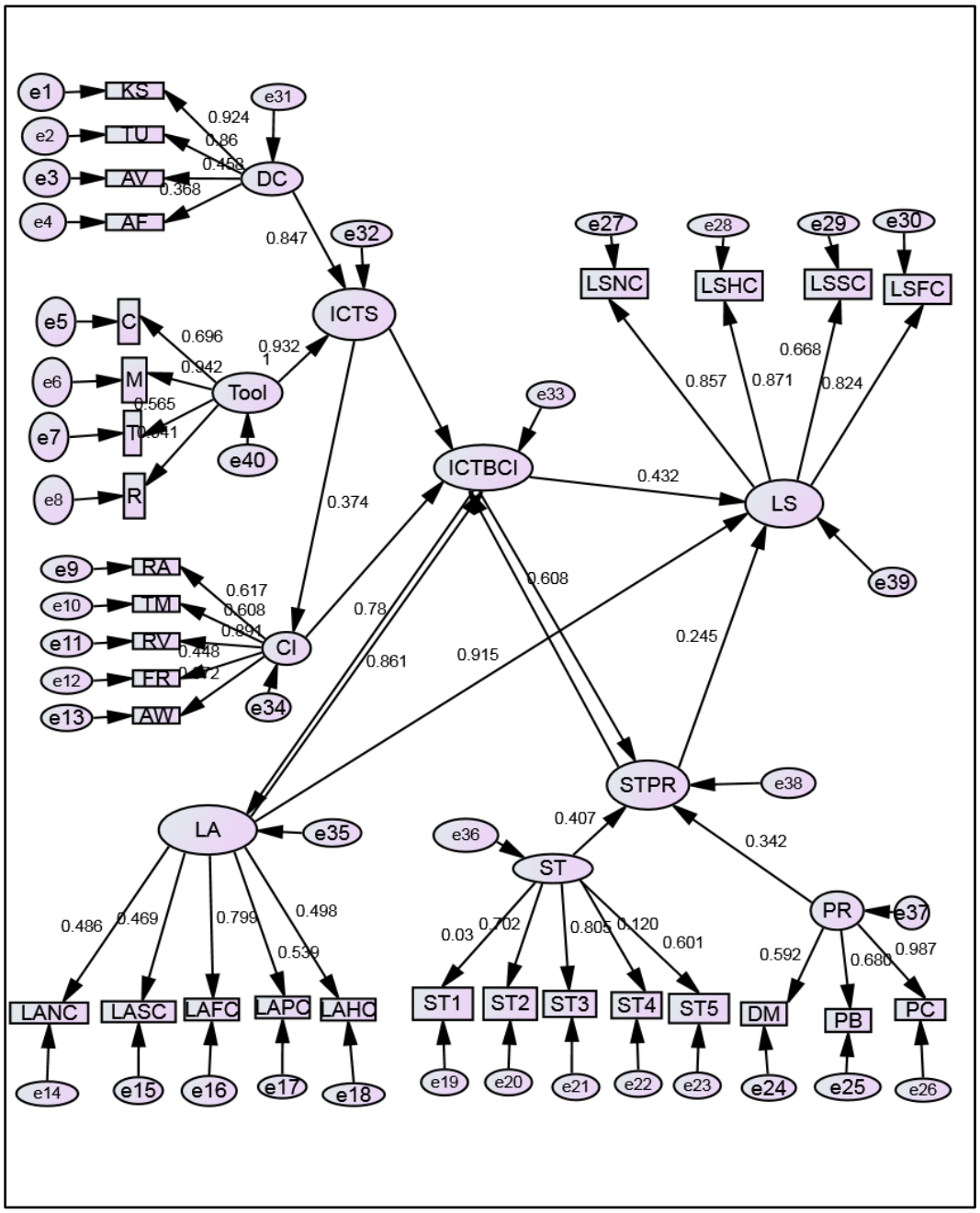


Figure 4.11: Initial Structural Model Path Diagram for Testing Hypotheses

The MLE method in AMOS software was used for structural model estimation and Figure 4.11 above shows how the model captures the relationships among construct variables. Table 4.15 below summarizes the results of the structural model estimation compared to the measurement model estimates. The results are discussed next in Section 4.8.1.

Table 4.15: Regression Weights for the Structural Model

Indicator Variable	Path	Construct	Measurement Estimates	Structural Estimates
M	<---	ICT Tool	0.804	0.942
C	<---	ICT Tool	0.75	0.696
T	<---	ICT Tool	0.473	0.565
R	<---	ICT Tool	0.912	0.941
AF	<---	DC	0.67	0.368
AV	<---	DC	0.77	0.458
TU	<---	DC	0.958	0.86
KS	<---	DC	0.98	0.924
TM	<---	CI	0.94	0.608
RV	<---	CI	0.608	0.891
FR	<---	CI	0.547	0.448
AW	<---	CI	0.587	0.872
RA	<---	CI	0.949	0.617
LANC	<---	LA	0.834	0.486
LAFC	<---	LA	0.869	0.799
LAPC	<---	LA	0.862	0.539
LAHC	<---	LA	0.858	0.498
LASC	<---	LA	0.653	0.469
PR	<---	STPR	0.695	0.342
ST	<---	STPR	0.692	0.407
LSFC	<---	LS	0.751	0.824
LSNC	<---	LS	0.896	0.857
LSSC	<---	LS	0.764	0.668
LSHC	<---	LS	0.899	0.871

4.8.1 Model Estimation

The first measure of fitness in the structural model is the regression weights to the constructs, as shown in Table 4.15 above. A structural estimate of greater than 0.8 is considered to have a significant path influence, 0.5 to 0.8 estimate values are considered to have a path influence that is moderate and an estimate of less than 0.5 is a small path influence (Hair *et al.*, 2010; Kline, 2011). Results of Table 4.15 show that Processes (PR--->STPR), Structures (ST--->STPR) and

Affordability (AF--->-DC) have a small influence path and should be looked into without deviating too much from the conceptual model and theory. The deletions of indicator variables were done one at a time from the model supported by the recommendation from Hooper, Coughlan, and Mullen (2008). The affordability (AF--->-DC) indicator was deleted at this point but the Process (PR--->STPR) and Structures (ST--->STPR), indicators were left for further analysis of their moderator effects that investigate the effect of ICT-based climate information on livelihood strategies.

4.8.2 Model Modification

The final model produced results that tested positive for the model fit using the various fit indices and applying the guidelines for a good model fit, as displayed in Table 4.16 below. Thus, both the measurement and structural models developed in the research are relevant since they achieved the overall acceptable measures for the various tested fit indices. On the same, Hair *et al.* (2010) and Kline (2011) suggest that using three to four fit indices would provide some assurance of model fit.

Table 4.16: Fit Indices for the Structural Model

	Chi-square = 528.3 Degrees of Freedom = 124			
Measure	**Fit Index**	**Expected**	**Result**	**Comments**
Goodness of fit	Goodness of Fit (GFI)	> 0.9	0.95	Acceptable
	Root Mean Squared Error of Approximation (RMSEA)	0.03 < x < 0.08	0.056	Acceptable
	Root Mean Residual (RMR)	-4 < x < +4	3.5	Acceptable
Incremental Fit Indices	Comparative Fit Index (CFI)	> 0.95	0.97	Acceptable
	Tucker Lewis Index (TLI)	> 0.95	0.98	Acceptable
Parsimony Fit Indices	Adjusted Goodness of fit (AGFI)	0-1	0.521	Acceptable
	Parsimony Normed Fit Index (PNFI)	0-1	0.48	Acceptable

4.8.3 Hypothesis Test Results

The findings of the structural model estimates are presented and compared with the alternative hypotheses suggested in the conceptual model. The structural model tests the following alternative

hypotheses:

H1: Rural women access and use ICT tools – such as, mobile phones and community radios in the utilization of climate information (seasonal forecasts, weather, and agro-advisories).

H2a: Rural women use ICT-based climate information to maximize access and utilization of their livelihood assets.

H2b: The access and use of livelihood assets by rural women increase their use of ICT based climate information

H3: Livelihood strategies of rural women positively change with the increasing availability and use of ICT-based climate information.

H4: Access to various livelihood assets increases the relationship between the use of ICT-based climate information and livelihood strategies.

H5: Structures and processes increase the relationship between the use of ICT-based climate information and livelihood strategies.

H6: Structures and processes increase the uptake of ICT-based climate information.

H7: Structures and processes increase the adaptation of livelihood strategies.

The direct structural model hypotheses (H1, H2, H3, H6, and H7) were analyzed using the path significance of each relationship. The results of the structural model estimates are summarized in Table 4.17 below.

Table 4.17: Direct Structural Model Hypotheses Test Results

Hypothesis	Construct	Path	Construct	Estimate	S.E.	C.R.	P	Supported
H1	CI	<---	ICTS	0.374	0.036	10.299	***	**Yes**
H2a	LA	<---	ICTBCI	1.018	0.003	2.225	***	**Yes**
H2b	ICTBCI	<---	LA	0.861	0.019	1.125	***	**Yes**
H3	LS	<---	ICTBCI	0.949	0.004	2.487	***	**Yes**
H6	ICTBCI	<---	STPR	0.608	0.092	2.258	**	**Yes**
H7	LS	<---	STPR	0.245	0.450	2.257	1.25	**NO**

The hypotheses are accepted or rejected based on the significance of the p-value which range from $p<0.01$, $p<0.05$ and $p< 0.1$. The values are considered highly significant, significant and

marginally significant, respectively. Concerning this study, the p-value ($p<0.01$) with three asterisks (***) and p-value ($p<0.05$) with two asterisks (**) were used since the sample size was more than sufficient (N=419). Based on this, hypotheses (H1, H2a, H2b, H3, and H6) were accepted and hypothesis H7 was rejected.

Of the hypotheses accepted, H1 stated that there was a correlation between ICT system (ICT tools and digital capital) and climate information. The results indicate a positive and significant path from the ICT system and climate Information ($\beta = 0.374$, CR= 10.299, $p >0.01$). Hypothesis H2 (H2a and H2b) investigates if there is any association between ICT based climate information and the maximization of livelihood assets and vice versa and the results demonstrate a positive and significant path ($\beta = 1.018$, CR= 1.125, $p >0.01$) and ($\beta = 0.861$, CR= 1.125, $p >0.05$). H3 investigates if livelihood strategies positively change with the use of ICT based climate information and the results demonstrate a positive and significant path ($\beta = 0.949$, CR= 2.487, $p >0.01$).

Hypothesis, H6 investigates if structures and processes influence the uptake of ICT based climate information, and the results show a positive and significant path ($\beta = 0.003$, CR= 4.850, $p >0.01$). Hypothesis H7 which investigates the influence of structure and processes on the adaptation of livelihood strategies was rejected. The results show no correlation between this association with a negative and not significant path, as shown by the following results ($\beta = -0.693$, CR= -1.101, $p =0.92$). However, before rejecting the hypothesis, the researcher determined which specific measured variables under structure and processes affect the overall significance of the H7 through the moderator effect analysis.

4.9 Moderator Effects Analysis

Hypotheses *H4* and *H5* in the conceptual framework represent the two construct moderating variables; livelihood assets and structures and processes that investigate the effect of ICT-based climate information on livelihood strategies. The independent variable (ICT Based Climate Information) and the moderating variables (Livelihood Assets and Structures and Processes) were transformed in the SPSS to form measured variables. Since the moderating variables were also constructed, the commonly used multiple group method of analysis for moderator effects

could not be used. The researcher opted to adopt the significance levels in the AMOS output for each of the single moderator effects. Every measured item was analyzed to get the exact moderating factor loading effect, and the p values for each path was compared with the threshold value of 0.05 for its significance, and the overall moderating effect was obtained.

4.9.1 Livelihood Assets

Hypothesis *H4* tests whether access to various combinations of livelihood assets moderates the relationship between access to ICT-based climate information and livelihood strategies. Figure 4.12 below depicts the relationships to support Table 4.18 which follows and displays the accepted or rejected hypotheses based on the p-value, the significance of whose values range from $p<0.01$(***) and $p<0.05$(**).

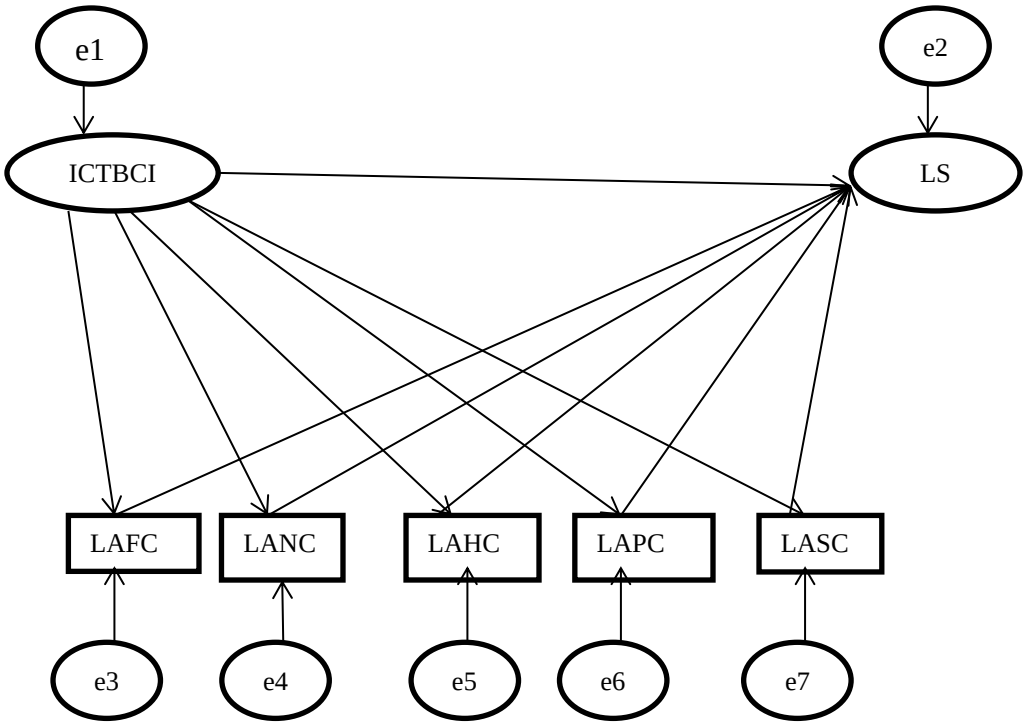


Figure 4.12: Path diagram of Livelihood Assets as a Moderator

Table 4.18: Moderating Effects of Livelihood Assets

Construct	Indicator	Construct	Estimate	S.E.	C.R.	P	Supported
ICTBCI	**LAFC**	**LS**	**.345**	**.031**	**11.139**	***	**YES**
ICTBCI	**LANC**	**LS**	**-.048**	**.041**	**-1.180**	**.238**	**No**
ICTBCI	**LAHC**	**LS**	**.171**	**.031**	**5.562**	***	**YES**
ICTBCI	**LAPC**	**LS**	**.045**	**.031**	**1.434**	**	**YES**
ICTBCI	**LASC**	**LS**	**.921**	**.149**	**6.180**	***	**YES**
ICTBCI	--->	**LS**	**.432**	**.050**	**2.362**	**	**YES**

Table 4.18 above captures the outcome for each path of livelihood assets that moderates (or does not) the effects of access to the ICT-based climate information on livelihood strategies as follows based on the p values.

- LAFC: Financial capital moderates the effects of access to the ICT Based Climate Information on Livelihood Strategies and the results show a positive and significant path ($\beta = 0.345$, CR= 11.139, $p<0.01$).
- LANC: Natural Capital did not moderate the effects of access to the ICT Based Climate Information on the Livelihood Strategies, and the results show a negative and non-significant path ($\beta = -0.048$, CR= -1.180 $p>0.1$).
- LAHC: Human Capital moderates the effects of access to the ICT Based Climate Information on the Livelihood Strategies and the results show a positive and significant path ($\beta = 0.171$, CR= 5.562, $p<0.01$).
- LAPC: Physical capital moderates the effects of access to the ICT Based Climate Information on Livelihood Strategies and the results show a positive and significant path ($\beta = 0.045$, CR= 1.434, $p<0.05$).
- LASC: Social capital moderates the effects of access to the ICT Based Climate Information on Livelihood Strategies and the results show a positive and significant path ($\beta = 0.921$, CR= 6.180, $p<0.05$).

Overall Livelihood assets combined data moderate the effects of ICT Based Climate Information on livelihood strategies at ($\beta = 0.119$, CR= 2.362, $p <0.05$).

Therefore, this study accepts hypothesis *H4* with livelihood assets (HC, PC, SC, FC) that tests whether access to various combinations of livelihood assets moderates the effects of access to ICT-based climate information on livelihood strategies.

4.9.2 Structures and Processes

Hypothesis *H5* investigates whether structures and processes moderate the effects of ICT-based climate information on livelihood strategies. The various institutions under the structure are the national government and its extension agents. These include the Kenya Meteorological Department, agricultural agents, NGOs, county government institutions, community-based organizations and agro-vets labeled as ST1, ST2, ST3, ST4, and ST5 respectively. The path model diagram for the Structure as a moderator is shown in Figure 4.13 below.

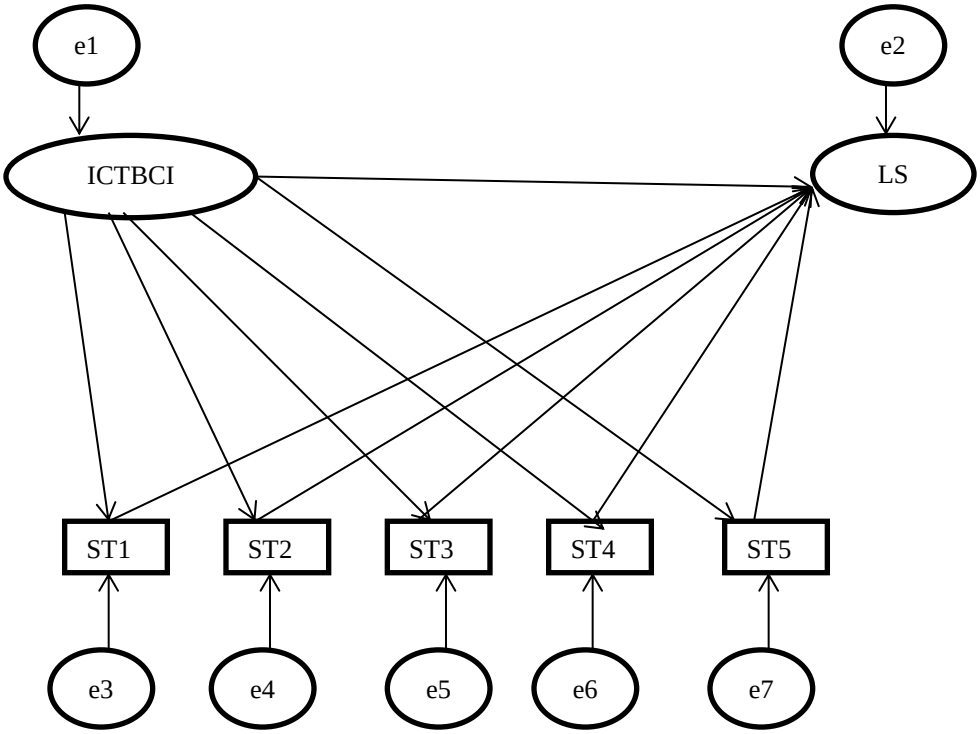


Figure 4.13: Path Diagram of Structures as a Moderator

Table 4.19: Moderating Effects of Structures

Construct	Indicator	Construct	Estimate	S.E.	C.R.	Supported
ICTBCI	ST1	LS	0.03	0.019	1.557	0.119
ICTBCI	ST2	LS	0.702	0.02	5.149	***
ICTBCI	ST3	LS	0.805	0.021	4.127	***
ICTBCI	ST4	LS	0.120	0.022	0.568	0.57
ICTBCI	ST5	LS	0.601	0.113	4.726	***
ICTBCI	--->	LS	0.432	0.054	8.19	***

The results of Table 4.19 yielded p values that were significant for ST2, ST3, and ST5, whose values range from $p<0.01$ and $p<0.05$. Those ST1 and ST4 were statistically insignificant for p-values, at $p > 0.1$.

Other observations are:

- ST1: National government agents such as Kenya Meteorological services and agricultural extension agents do not moderate the effects of ICT Based Climate Information on livelihood strategies
- ST2: Non-Government Organizations such as Caritas, ADSA, the Kenya Red Cross (ST2) moderate the effects of ICT Based Climate Information on livelihood strategies
- ST3: County government institutions moderate the effects of ICT Based Climate Information on livelihood strategies
- ST4: Community Based Organizations do not moderate the effects of ICT Based Climate Information on livelihood strategies.
- ST5: Agro-Vets moderate the effects of ICT Based Climate Information on livelihood strategies.

Overall, the combined values of Structures in place increases the effects of ICT Based Climate Information on livelihood strategies at ($\beta = 0.445$, CR= 8.19, $p<0.01$).

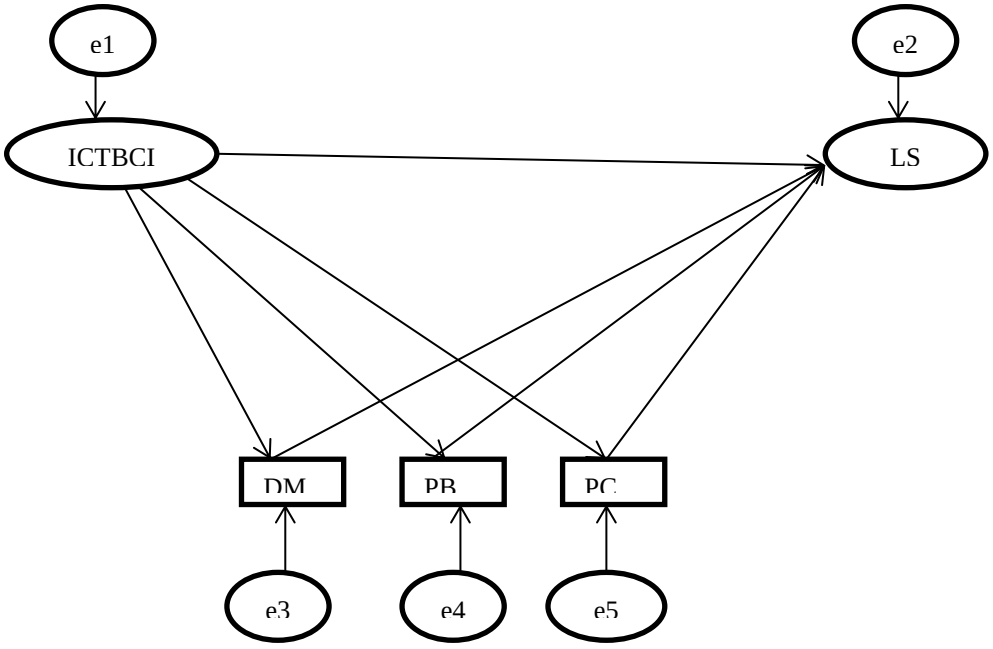


Figure 4.14: Path Diagram of Processes as a Moderator

The model for the processes such as policies, decision-making in household and cultural beliefs as moderators is shown in the path diagram of Figure 4.14.

Table 4.20: Moderating effects of Processes

Construct	Indicator	Construct	Estimate	S.E.	C.R.	Supported
ICTBCI	DM	LS	.592	.040	2.183	**
ICTBCI	PB	LS	.680	.028	2.554	**
ICTBCI	PC	LS	.987	.022	4.864	***
ICTBCI	--->	LS	.432	.049	8.868	***

Table 4.20 above shows accepted or rejected alternative hypotheses based on the p-value significance, whose values range from $p<0.01$ (***) and $p<0.05$ (**). It emerges that:

- DM: The person in charge of decision-making in the household moderates the effect of the ICT-based Climate Information on the livelihood strategies. They could be in charge of land preparation, cultivation, planting, access to extension services and financial support.
- PB: Cultural practices and beliefs like households in polygamous marriages, moderates the effects of the ICT-based Climate Information on the livelihood strategies.
- PC: Participation in the formulations and implementations of national government policies decisions like the Climate Change Policy, Gender Policy, and ICT Policy moderate the effect of the ICT Based Climate Information on the livelihood strategies.

Overall the combined values for Processes increases the effects of ICT Based Climate Information on livelihood strategies at ($\beta = 0.432$, CR= 8.868, $p<0.01$).

It is on this basis that the researcher accepted hypothesis *H5* with Structures (ST2, ST3, ST5,) that tests whether they moderate the effects of ICT-based climate information on livelihood strategies and Processes DM, PB, PC (like decision-making in a household, cultural beliefs, and policies) moderate the effects of ICT-based climate information on livelihood strategies.

The Final hypothesized Structural Model Path Diagram obtained is displayed in Figure 4.15 below where the path of structure and processes (STPR) to livelihood strategies (LS) (0.245),

Natural Capital (LANC), and parcel variables under Structure ST1 and ST4 were deleted from the model.

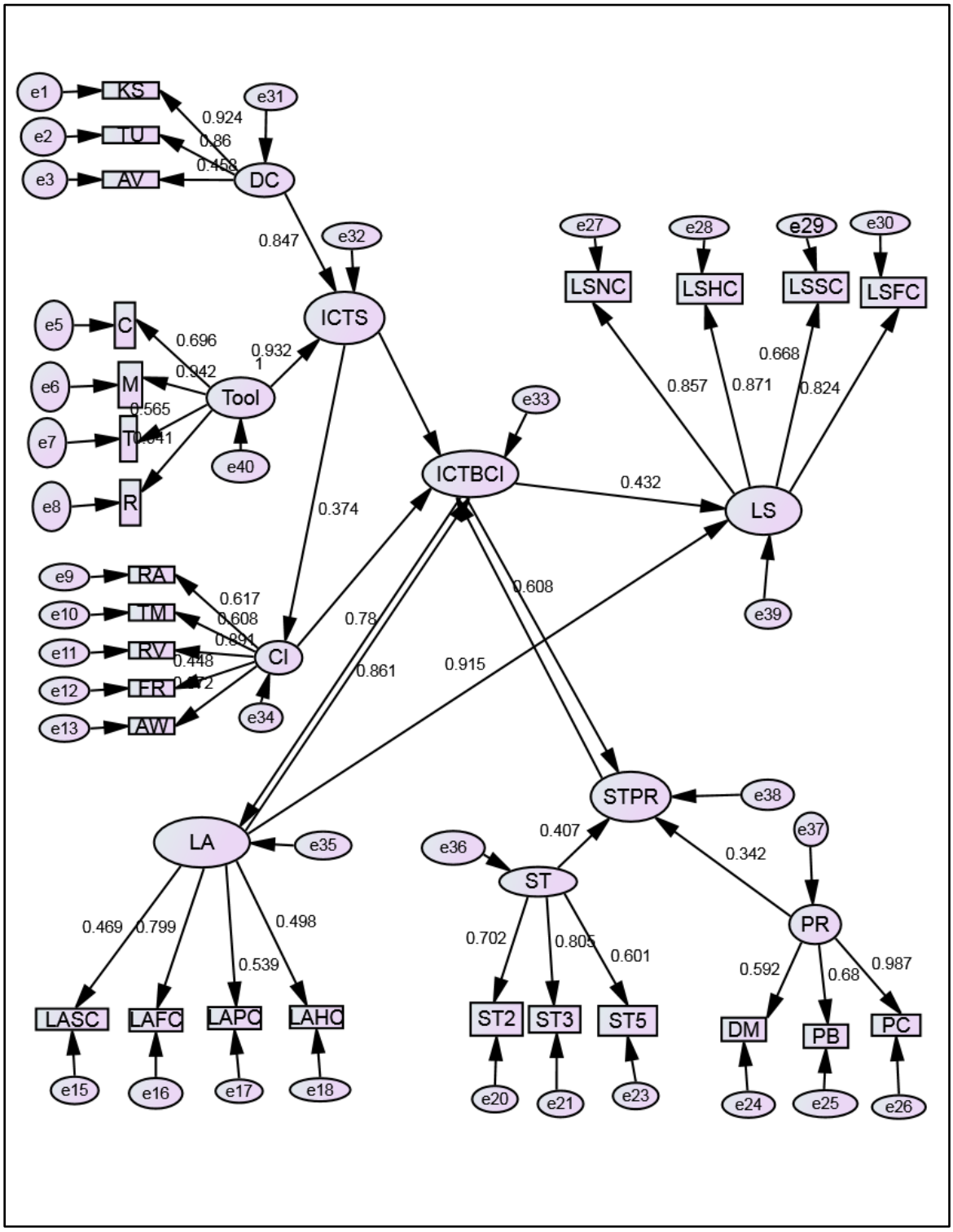


Figure 4.15: Final Hypothesized AMOS Structural Model Path Diagram

A simplified construct structural model path is presented in Figure 4.16 below with its hypotheses results and the standardized estimate results in Table 4.21

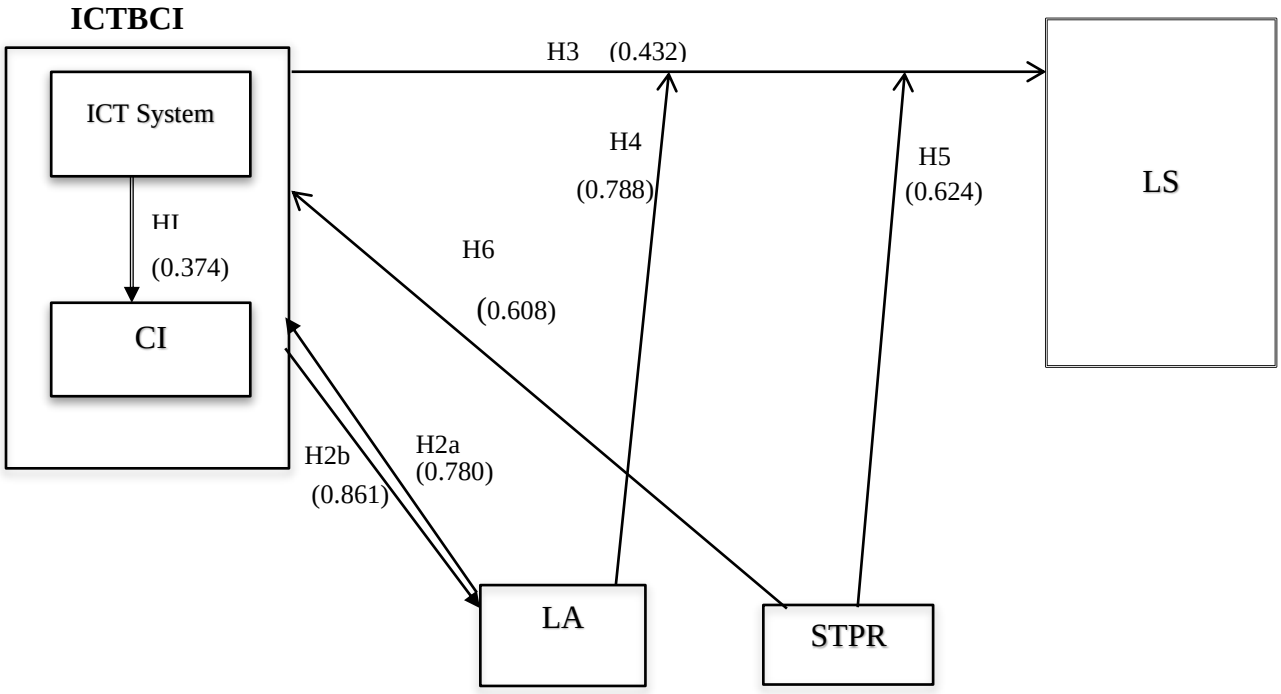


Figure 4.16: Simplified Structural Model of Hypothesized Construct Variables

Table 4:21 Standardized Measures for Hypothesized Structural Model

Hypotheses Paths	Construct	Path	Construct	Standardized Estimates
H1	CI	<---	ICTS	0.374
H2a	ICTBCI	<---	LA	0.78
H2b	LA	<---	ICTBCI	0.861
H3	LS	<---	ICTBCI	0.432
H6	ICTBCI	<---	STPR	0.608
H7	LS	<---	STPR	0.245

Hypotheses Paths	Construct	Path	Construct	Path	Construct	Standardized Estimates
H4	LS	<---	LA	<---	ICTBCI	**0.788**
H5	LS	<---	STPR	<---	ICTBCI	**0.624**

Table 4.21 above is a summary of all the alternative hypotheses. A significant path influence is observed from ICT based climate information to Livelihood assets H2b (0.861) since the estimate is greater than 0.8, while a moderate path influence (0.5-0.8) is observed for H2a

(0.780), H4 (0.788), H5 (0.624) and H6 (0.608). The path influence was considered small for H1 (0.374) and H3 (0.432) because the estimates were between 0.5 and 0.3. Any estimate below 0.3 like in the case of H7 (0.245) is rejected in the model because of a weak relationship supported by researchers like Hair *et al*. (2010) and Kline (2011). Therefore, apart from H7, all the other hypotheses were accepted in the simplified structural model. This is because structure and processes cannot directly influence the livelihood strategies adopted without considering other factors such as the climate information needs and the available livelihood assets of households in the rural community. Especially the digital capital that enables access and use of ICT tools in the rural level versus the national level. Table 4.22 presents a summary of the hypotheses results.

Table 4.22: Hypotheses Test Results Summary

Research Questions	Alternative Hypothesis	Findings	Explanation
RQ1: To what extent do rural women access and use ICT tools in the utilization of climate information?	**H1:** Rural women access and use ICT tools – such as, mobile phones and community radios in the utilization of climate information (seasonal forecasts, weather, and agro-advisories).	β=0.374 C.R.=10.299 p < 0.01	**H1 is accepted**: The results indicate a positive and significant relationship at p < 0.01
RQ2: To what extent does the use of ICT-based climate information by rural women influence their maximize access and utilization of livelihood assets?	**H2a:** Rural women use ICT-based climate information to maximize access and utilization of their livelihood assets. **H2b:** The access and use of livelihood assets by rural women increase their use of ICT based climate information	H2a: β=1.018 C.R.=2.225 p <0.01 H2b: β=0.861 C.R.=1.125 p < 0.01	**H2a is accepted**; The results indicate a positive and significant relationship at p < 0.01 and vice versa. **H2b is accepted**; The results indicate a positive and significant relationship at p < 0.01.
RQ3: What are the effects of using ICT-based climate information in the adoption of livelihood strategies by rural women?	**H3** Livelihood strategies of rural women positively change with the increasing availability and use of ICT-based climate information.	H3: β=0.949 C.R.=2.487 p < 0.01	**H3 is accepted;** The results indicate a positive and significant relationship at p < 0.01
MV-H4: Do access to various livelihood assets increase the relationship between ICT-based climate information and livelihood strategies	**H4:** Access to various livelihood assets increases the relationship between the use of ICT-based climate information and livelihood strategies	H4*:* β=0.119 C.R.=2.362 p < 0.05	**H4 is accepted;** The results indicate a positive and significant relationship at p < 0.05
MV-H5: Do structures and processes increase the relationship between ICT-based climate information and livelihood strategies.	**H5**: Access to Structures Processes increases the relationship between ICT-based Climate information and livelihood strategies	$H5_1$: β=0.445 C.R.=8.19 p < 0.01 $H5_2$: β=0.432 C.R.=8.68 p < 0.01	**$H5_1$ is accepted;** The results indicate a positive and significant relationship at p <0.01 **$H5_2$ is accepted;** The results indicate a positive and

			significant relationship at $p < 0.01$
IV-H6: Do structures and processes increase the uptake of ICT-based climate information?	**H6:** Structures and Processes increases the uptake of ICT-based climate information	H6: $\beta=0.608$ C.R.=2.258 $p < 0.05$	**H6 is accepted;** The results indicate a positive and significant relationship at $p < 0.05$
IV-H7: Do structures and processes increase the adaptation of livelihood strategies?	**H7**: Structures and Processes increases the adaptation of livelihood strategies	H7: $\beta=0.245$ C.R.=2.257 $p =1.25$	**H7 is rejected;** The results indicate an insignificant positive relationship at $p > 0.1$

(Source: **Researche**r); MV- Moderating Variable, IV-Intervening Variable

4.10 Chapter Summary

This chapter presented the findings of the quantitative data analysis. The analysis commenced with data management and then followed detailed descriptive statistics of the various measured variables. The descriptive analysis covered information on the geographical distribution where data was collected identifying characteristics of the respondents, the respondent's awareness of climate information, and the digital capital that facilities the respondents access to ICT tools. Others were on the ICT tools frequently used to access climate information, and finally, the livelihood assets owned.

Then, SEM analysis was used to assess the measurement and structural models. The measurement model confirmed that the data collected was consistent with the model before subjecting it to further tests and evaluation in the structural model. The results of the measurement model tests and fit indices were discussed in detail. It was in this context that the structural model was used to test the various hypothesized causal relationships between the identified constructs and the results indicated that a majority of the hypothesized relationships hold, except for the relationship between structure and processes and livelihood strategy.

Institutions policy, social and cultural factors needed to be considered in the context of what ICT based climate information is available and what livelihood assets the farmers have before livelihood strategies can be achieved. The moderating effects of the various identified variables were also tested and reported, and the individual moderator variables of natural capital, national government agents and community-based organization were found not to be significant on the

relationship between ICT based climate information and livelihood strategies. The next chapter presents and discusses the qualitative findings.

CHAPTER 5: QUALITATIVE DATA FINDINGS

5.1 Introduction

This chapter presents findings from qualitative data analysis specifically from the Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs). The qualitative data findings build on quantitative data analysis.

5.2 Demographic Characteristics

Tables 5.1 and 5.2 below show the demographic characteristics of the participants in the FGDs and KIIs. Signifiers P1 to P13 were used to identify the participants in the FGDs and the K1 to K14 signifiers to identify the interviewees in the KIIs.

5.2.1 Focus Group Discussion

The demographic characteristics of the two FGDs participants are in Table 5.1. They were selected to forestall gendered biases regarding the perception of livelihood strategies, their priorities and ultimate utility in uplifting familial and economic fortunes.

Table 5.1: Demographic Information of Participants in FGDs

Female /Male	Participants Signifier	Age Bracket	Marital Status	HH size	Head of HH	Education Level	Farm Expr. (Years)
Female Participants	P1	18-30	Married living apart (M)	5-7	Yes	Primary	10
	P2	31-45	Married living apart (M)	5-7	Yes	Secondary	20
	P3	18-30	Married living together (M)	5-7	No	Primary	10
	P4	>60	Widow (W)	2-4	Yes	Primary	40
	P5	46-60	Married living apart (M)	8-10	Yes	College	30
	P6	31-45	Single (S)	2-4	Yes	Secondary	10
	P7	46-60	Polygamous marriage (P)	5-7	No	Primary	20
Male Participants	P8	31-45	Married living together (M)	5-7	Yes	Secondary	10
	P9	46-60	Married living together (M)	5-7	Yes	Primary	20
	P10	31-45	Married living together (M)	8-10	Yes	Primary	10
	P11	46-60	Married living together (M)	5-7	Yes	Secondary	20
	P12	>60	Widower (W)	5-7	Yes	College	30
	P13	46-60	Polygamous marriage (P)	8-10	Yes	Secondary	30
	P14	>60	Polygamous marriage (P)	>10	Yes	Primary	40

The Gender and Development (GAD) theory is central in this study and supported too by Kimberle Crenshaw's (1989) notion of intersectionality. Therefore, studying the extent to which differentials in class, gender, and geography alter the perception of issues was critical. Although Crenshaw's ideas may appear dated, their proximity to GAD Theory, gendered realities in Kitui County and their relevance within the ongoing gender studies in Africa are still timely. Thus, notions of development and its politics may shift depending on whether the respondent is a man or a woman. This has implications in on what may be prioritized as climate information, or how this information may be used once it is accessed. Subsequent to this, variables that influence gender were analyzed because they enable the application of the theory of intersectionality within the context of gender and development narratives.

Majority of the women had primary education while the men had post-primary education as their highest level of education. Marital status was considered because it had implications on who was the household head and the decision-maker. It also reflected the vulnerability to gender stereotypes and access to land as a factor of economic production and empowerment. Gender dynamics tend to work against women in terms of decision making for the benefit of families as supported by the literature already reviewed. While married women have to contend with challenges of cultural expectations that they should defer to the authority of their spouses, unmarried women tend to be deprived of the right to access and own land in concurrence with the prevalent customary tenure systems that are patrilineal in rural Kitui despite the 2010 Kenyan constitution giving women equal rights to land. Therefore, it was vital to establish the marital status of the target group. These dynamics mean that for the policymakers and implementers who seek to deepen and spread the use of climate information in the ASAL smallholder farming, the starting point must target men and women at household levels, rather than from the perspective of gender in general.

Educational levels and gender were closely related to age as important variables. For this reason, age was a factor as it determines the chances of being household heads, gives indications of the extent of and experience in smallholder farming, versatility with ICT tools, as well as of

perceptions of farming as an economic activity. All the participants had more than ten years of farming experience.

Most of the households had between 5 to 7 members, reflecting results of the 2009 household survey census of Kitui County. Male participants were considered decision-makers since they are the heads of households (HHS).

5.2.2 Key Informant Interviews Participants

This study used key informant signifiers to represent the interviewees who were selected based on various demographic characteristic shown in Table 5.2. All the informants from these entities were in managerial positions and had extensive work experience.

Table 5.2: Demographic Information of Interviewees

Key Informant Signifier	Age bracket	Education level	Organization	Position	Experience (in Years)
K1	46-60	Ph.D.	KMD	County Director	5
K2	46-60	BA	ASDSP	County Coordinator	5
K3	31-45	MA	FAO-Kenya	County Programme Officer	3
K4	31-45	BA	FAO-Kenya	Programme Assistant	2
K5	31-45	BA	Caritas- Kitui	Project Officer	3
K6	46-60	BA	NDMA	County Drought Director	10
K7	31-45	BA	BvAT	Programme Officer	8
K8	18-30	Diploma	County FM LTD	Head Of Radio	2
K9	18-30	Diploma	Radio Thome FM	Marketing Manager	3
K10	18-30	BA	Syokimau FM	Traffic Controller + Schedule Programs	3
K11	46-60	BA	MOAWL	Principal Agri. Officer	10
K12	46-60	BA	MOAWL	Agricultural Officer	24
K13	46-60	MA	MOAWL	Chief Agricultural Officer	5
K14	31-45	Diploma	MOAWL	Head of Extension &Training	2

All the Key Informants happened to be males. Six (K1, K2, K6, K11, K12, and K13) were between 46 and 60 years old; five between 31and 45, while three were between 18 and 30 years. On education levels, K1 had attained a Ph.D. while K3 was a Master's Degree holder. A majority of the interviewees (eight in total) had attained a Bachelor of Arts degree, while three interviewees had Diplomas. Reflecting on their capacity in generating climate change awareness, climate adaptation capacity training, and dissemination climate information in the county.

5.3 The use of ICT tools to access climate information

This section discusses information on ICT Systems that entails the ICT tools owned by the community and the accessibility, availability, and affordability of the ICT tools.

5.3.1 ICT Tools and Digital Capital

The respondents found the mobile phone and the community radio necessary and helpful in adapting or mitigating the impact of climate change. However, they noted that availability and affordability were key challenges experienced in accessing the television and computer. This was coupled with issues such as poor network connectivity in the area when the ICT tools were available; the inadequate ICT infrastructure in some parts; the lack of operational skills especially among the elderly and marginally educated. Funds for airtime was used in seeking information that addressed their basic needs or social networks first before subscribing to informative news. Table 5.3 shows the key findings from the participants.

Table 5.3: ICT Tools and Digital Capital

Construct Variable	Key Findings
ICT Tools	• Mobile phones and radio were easily accessible and affordable to the community in, comparison to the television and the computer. • The ICT tools of preference in the access of Climate Information (CI) were the local radio and mobile phones due to its low cost and affordability. • Key Informants used a hybrid of ICT tools to reach the community for capacity building and climate information dissemination.
Digital Capital	• Poor network connectivity, inadequate ICT infrastructure, limited operational skills, and lack of finances for airtime and internet to subscribe to informative news. • Inadequate electricity coverage to power ICT tools; many reliant on solar power. • Digital divide in rural areas due to digital capital challenges.

K5, interviewee mentioned that "at least one member in the household owns a mobile phone or radio and for those who do not have one, they share within the household or from nearby neighbors." which empirically supports what Chaudhury *et al.* (2012) and Karanasios (2011) said in Chapter 2, section 2.5 but in the Kenyan context. Interviewees K6 and K4 had this to say respectively:

> "The mobile phone allows the community to obtain information immediately and regularly, rather than waiting for the weekly radio broadcasts, magazines, or letters. Furthermore, rather than being passive recipients of information, mobile phones allow individuals and our organization to take an active role in the search

> process, enabling the community and our organization [NDMA] to ask questions and corroborate information with multiple sources."
>
> "The E-Soko platform provides information via basic SMS and the growth of mobile penetration means we have a greater captive market, especially among the rural population, which is more concerned with farming. The platform sends regular updates to its members who were key intermediaries (Chiefs, Women SHG leaders, Agricultural agents) who then targeted farmers on specific content such as weather and market information enabling them to make the right decisions at the appropriate time along with a feature on their website that allows the intermediaries to interact directly and share knowledge."

K6 and K4 confirm the hypotheses that physical capital moderates the effects of access to the ICT based climate information on livelihood strategies and further supported by (Adera *et al*., 2014; Batchelor and Scott, 2001; Chapman *et al*, 2001:2002; Tall *et al*., 2014a) in the background literature. Most informants (KI, K3, K4, K11, K12, and K14) voiced their frustrations in the inadequate ICT infrastructure as a significant problem because they could not use ICTs to its full potential to effectively to communicate climate information, more so in rural areas than in the urban centers. They had to rely on the few available mobile phones and community radios since they were more affordable to relay climate information and early warnings of extreme climatic conditions to the community.

In the case of FGDs, all the participants could not afford computers or laptops but relied on Internet data bundles that were costly. This finding was expected to some extent due to the education levels (Table 5.2 above) and may explain the limited innovations in facilitating communication between people. P6 and P11 highlighted the role of 'flash-back' and 'Please Call Me' services as enablers of communication in defeating the barriers for lack of airtime where quite a number of the respondents used this feature. 'Flash-back' involves calling another mobile user, but disconnecting before the connected call is answered. It provides a method for mobile users to alert someone that they wish to be called, but either cannot or will not, pay for the call. The method is cost-free for the users, ensuring that communication, especially of vital information is passed between the people, especially when one does not have the money to call

or send a short text (SMS); and the corresponding party is willing to call back. The challenge would only be if the recipient also does not have airtime units to call.

Even with the remarkable spread of smartphones, there is the challenge of operational competence and access to climate information apps provided by some CIS providers, which, according to P4, is limited to a few individuals in the community who can afford smartphones or can access internet services. Accordingly, the few who own smartphones have to occasionally depend on relatives and neighbors for help in manipulating the gadgets. Yet, it is possible to get more awareness training that is locally relevant to use these gadgets as most do not need high levels of education but can be intimidating if one is not empowered.

Interviewee K12 affirmed that there were some levels of illiteracy among the communities in Kitui, who needed help on how to operate the said ICT tools for climate information access. Interviewee K1 said that the region experienced poor network connectivity, while interviewee K8 cited lack of electricity connectivity in the region. Urban towns like Mwingi, Kitui, and Mutomo had 3G network connectivity while most of the rural areas had 2G networks. Electricity connectivity was mostly available within the urban areas, despite the government's 'Last Mile' project meant for electrification of the rural areas. Majority of the people in the area used solar to charge their mobile phones and radios, but most did not have access to solar themselves due to the prohibitive cost of the initial installation of a solar panel and had to trek to community centers and urban centers to access solar facilities or to neighbors who had access to solar. Some of the residents used batteries to power their radios. Interviewee K9 from Thome FM Radio Station noted the following of the primary mobile phone service providers:

> "…Okoa Jahazi and Kopa Credo services from Safaricom and Airtel respectively have made it easy for their customers to communicate to the radio stations even when they are cash-strapped, allowing them to repay later on when they go to the shops and purchase airtime, making it affordable to all subscribers."

These are services to loan airtime and payment with a little interest. It is clear from the findings above that the local community have made an effort to capitalize on available ICTs to obtain or

disseminate the relevant climate information and use it in their daily operational circumstances. The question may remain how much and how timely.

5.3.2 Awareness, Knowledge and Usability of Climate Information

It was important to understand the participant's knowledge on daily and seasonal weather forecasts; therefore, weather symbols were used to stimulate discussions on seasonal and daily weather forecasts for two cropping seasons in selected AEZ's in Kitui County. The key findings are in Table 5.4 below.

Table 5.4: Factors that Influence the Success of Climate Information

Construct Variable	Factors	Key Findings
Climate Information	CI requirements	• 100% of farmers are aware of climate information and its importance. • Farmers do not exploit the full potential of CI. • The seasonal forecasts were vital for land preparation (seed selection, fertilizer, and pesticide application, weeding and harvesting)
	Salience	• To build trust, CI was tailored to local needs and reflected the AEZs where farmers live. • Relevant to the farmer's decision-making
	Timeliness	• CI not provided within a reasonable timescale to make it salient.
	Credibility	• Lack of the right local content from CI providers and quality assurance
	Contextualization	• CI translated into local language and translated into simple formats • The need for modern scientific climate knowledge to complement the indigenous knowledge
	Legitimacy	• The need for validity of CI coming from various sources • Fairness and transparency
	Complementary Information and Services	• The need for complementary services (financial, Insurance, agro-advisories) to augment climate information services increased willingness to pay.

All participants were aware of the need for climate information; and the necessity for daily, weekly, monthly and seasonal forecasts. Discussions revealed that more women than men used daily forecasts because access and use of information on rain patterns was valuable for planning post-harvest activities and for ensuring water harvesting for domestic and farm use. This included understanding the onset and cessation of rainy seasons, intensity and length of rainy seasons. P4, P12, and P14, who were above 60 years of age, relied heavily on traditional knowledge to predict the

daily weather but they expressed that this was not always accurate anymore due to the unpredictability of the climate patterns brought about by climate change.

The perception from key informants (K1, K7, and K9) was that the farmers understood the climatic changes that occurred in the area. The farmers offer remarkably consist reports of a rainy season that is growing shorter and less predictable and the frequency of droughts that had an impact on their agricultural yields, but overlooked elements of change at a finer geographic scales with attention to climatic factors that are most relevant. Of importance was that the farmers did not exploit the available climate information to its full potential for a myriad of reasons. However, some informants (K3, K5 and K6) engaged more with farmers by understanding what climate information farmers' want, for instance, in what format they would prefer and it's use. It was interesting to note that the education level and age was a factor where the participants were concerned, but not for the key informants. The younger participants in the FGDs, between the ages of 18-30 were more competent in the use of ICT tools and were able to understand the climate information relayed through the ICT tools and therefore were instrumental educating the less literate. For the key informants, age was not a factor because they were already knowledgeable in the area of climate change. However, most agreed that various climate information service providers did not give much thought on how climate information was interpreted.

Some participants in the FGDs had lost interest or had no trust in weather forecasts broadcasted over ICTs mainly because they perceived it as unreliable and not location-specific. They felt that if the climate information was more accurate, timely, relevant and easy to understand, it would help them prepare better for the planting season. The challenge that most participants experienced was the onset and duration of rain. P2 said; "if we know when rainfall occurs, our seeds and effort will not be wasted." This is was addressed by some key informants (K3, K6, K5, and K7) who claimed there is always room for improvement in climate information accuracy but the clarity of how to do this was not clear. Some stakeholders wished the weekly and fortnight updates were delivered more consistently as responders use it to monitor conditions as events unfolded. Several key informants (K1, K4, K5, and K8) stressed there were a few climate information service providers, providing local content apart from KMD, and therefore stressed the importance of

quality assurance. They stressed that if climate information was inaccurate, it had a significant impact on the crop production and food security of the farmers.

Seasonal forecasts on seasonal climate variables that focused on specific agricultural risks such as dry spells, onset and cessation dates of rainfall plus agro-advisories are more detailed and usually disseminated on the KMD website in the form of bulletins, or radio shows in partnership with development partners depending on availability of funding. These seasonal forecasts are considered an essential feature of climate information for future strategic interventions, though very few participants had access to these seasonal forecasts. This was attributed to very few participants were able to access these seasonal forecasts bulletin on the internet, or they expressed how the radio shows on seasonal forecasts were not frequent enough to make an impact. Farmers also commented that the generality of the seasonal forecasts made it challenging to use such forecasts for location-specific activities. For participants (P2, P5, P12, and P13) who received seasonal forecasts they did so twice a year before the two rainy seasons of March, April, May (MAM) and October, November, December (OND). This helped them prepare their land (seed selection, fertilizer, and pesticide application, weeding and harvesting) as well as harvest water.

It was also established that KMD had localized and repackaged the weather information into user-friendly products, including related advisories for crop farmers and pastoralists. K1 said,

> "The weather and climate information that we share must be local specific and reflect agro-climatic conditions otherwise it will not be relevant to the farmers, Predictions of rainfall are essential for localized areas, as patterns vary even in small areas."

The KMD and sector service providers developed and disseminated seasonal forecasts and agro-advisories to livestock keepers and farmers in Kitui. This is done through chiefs' meetings ('*barazas*'), seminars at a community level, mobile phones, and community radios, mosques and churches, government and NGO extension services, and local early warning systems. The participants collectively agreed that they trusted the localized climate information in the local Kikamba language and translated into comprehensible formats from the scientific data. This helped in contingency planning (post-harvest activities, farmer mobility, ensure water

harvesting) and decision-making, especially when received before the two rainy seasons of MAM and OND. Informant K1 said that translation of climate information into the local dialect was very costly and time-consuming, yet this a requirement for many participants. Most key informants also recognized that farmers needed a selection of additional services, such as financial and insurance services adding value to the farmers and increasing their willingness to pay for the climate information service.

5.3.3 ICT Tools and Climate Information

Interviewee K1 reported that they had established a climate information delivery mechanism. National, weekly and monthly forecasts are always available on the KMD website. At the county level, the daily short-term weather forecasts were disseminated through local FM radios, mobile phones, televisions, and via the internet to the relevant institutions who relayed the climate information to the communities. Table 5.5 below shows the comparison of different delivery methods of climate information using various ICT tools and a summary of advantages and disadvantages based on findings and literature.

Table 5.5: A Comparison of Different Delivery Methods of CI across Different ICT Tools

ICT Tool		Advantages	Disadvantages
Mobile Phone	Text-based	• Works on all phones. • Low set-up costs. • Low technical set-up. • Storage enables later viewing of SMS.	• Limitation due to illiteracy (both language and technical). • Costly to transmit in Local language and it escalates in line with scale. • Limitation on content (number of words per text)
	Voice-based	• Works on all phones. • Potential to reach more people. • Preference of interactive voice response (IVR) in Kikamba. • Richer content. • Higher quality of service	• High upfront set-up costs. • IVR systems are challenging to install and configure. • The need for significant infrastructure support to deal with incoming calls.
	Mobile data	• Richer user experience (functionality and content). • Fewer limitation of content (as number of words, broader access to content) • Helps overcome illiteracy by having images	• Limitation due to technology literacy • Smartphone requirement and cost implications
Community FM Radio Station	Voice-based	• Potential to reach more people • Climate information disseminated in the local language overcome illiteracy • Two-way communication • CI is free	• Access to programs not frequent • Lack of airtime to call back
Television	Voice-based	• Potential to reach more people • Dissemination of CI in local language	• Not interactive • Expensive to own

ICT Tool		Advantages	Disadvantages
		• CI is free	
Computer	Internet	• CI disseminated by KMD to various stakeholders and intermediaries • CI available on websites for free	• Poor network connectivity • Poor electricity coverage • Expensive to own

KMD broadcasts forecast information in Kikamba through the community radios and mobile phones using the SMS service for daily weather forecasts for households. Upon receiving the climate information, local FM radio stations share this with listeners at least twice in a day. Participants, P5, P7, P9. P11, P12 and P14 expressed that they would prefer the climate information in Kikamba and two-way voice-activated communication so they can ask questions. According to P9, who was between 46-60 years:

> "Sometimes, I do not understand the message that was communicated via SMS in English. It would be good if instead, the message was voice-activated and in Kikamba."

There was a general feeling by the key informants (K1, K3, K5, and K11) that the demonstrative aspects of ICTs played a crucial role in persuading the residents to use technology to address their climate-related challenges and enhance their productivity. This is an idea that was obtained from key informant K5, who stated that

> "ICTs are very influential in persuading others when you use video or can show them something that you have been trying to explain. Women tend to manage the hazards at the domestic and farm levels, including climate change. The women need greater access to climate information so that their livelihoods strategies are appropriate ……."

The interviewee K4 at FAO said that they used various avenues for relaying climate information and agro-advisories. This included weekly programs on television (Shamba Shape up) and a mobile web-based application platform (E-Soko) and radio programs. In the case of K11, from the Ministry of Agriculture Office in Kitui, they relay climate information using brochures, seasonally sponsored radio programs, 'barazas' field visits and trade fairs. The BvAT [Bio-Vision Africa Trust]) organization reaches farmers through the Farmer Communication Programme (FCP). The program is disseminated through; field studies by their officers; a sponsored radio program in Mbaitu FM 'The Organic Farmer Radio' (TOF Radio), 'The Organic

Farmer Magazine' (TOF Magazine), pamphlets, through the info-net on the internet and short messages (SMS). The principle agriculture officer K11 had this to say:

> "Through the use of ICTs farmers get access to climate and agricultural information services 10 times more quickly, MOA [Ministry of Agriculture] did not rely on a single channel to communicate, instead used multiple ICTs and face-to-face approaches. Thus, creating awareness through farm extension agents, trusted community leaders, SHGs, radio, and TV. Demonstrations of new agricultural technologies were undertaken by visiting pilot farms. This multichannel approach increased the scope and depth of communication and – through reinforcement ensured that messages were received and were turned into actions."

The multichannel approach is confirmed and supported by literature from the INAM model in chapter 2.

The findings of the study indicated that only FAO, radio stations and KMD communicated climate information daily. The rest mostly conveyed seasonal information before the onset and cessation of rains, or during emergency periods. KMD targeted the agricultural and media stakeholders while the rest of the informants passed the information to the community. As K7, from BvAT said:

> "We mainly target the smallholder farmers who are drivers of many African economies, but their potential is tamed by the unavailability of relevant information whereby climate information is vital and inappropriate farming methods."

K1, the County Director at the Kenya Meteorological Department from Kitui, added that:

> "Our primary target is the general public, due to financial challenges we have limited access to them. We use media tools such as the radio, mobile phone, television, and the Internet. We communicate daily climate information, 5-day

> forecasts, 7-day forecasts, monthly and seasonal forecasts; we as well provide the warnings and advisories such as heavy rains and storms, marine, strong winds, and temperature advisories not only to Kitui County but the whole country at large."

The project officer K5 advised that when reaching out to farmers using radio shows, proper timing is required to ensure substantial coverage and the ideal hours for women should be taken into consideration and most probably when they have completed most of the daily chores. Participants (P2, P6, and P10) from the FGDs agreed that the primary source of climate information was the local radio broadcast with P6 noting that "the radio always broadcasts news on the climate and weather information we should expect locally, especially after the news prime time." Since the public was aware that climate information is relayed through the radio, P2 added, "If I miss listening to the weather forecast, I always ask my friends or neighbors what the radio reported." P7and P10 expressed similar sentiments, the latter specifying that they find it more convenient to tune to the radio station during "news time"; this confirms why the climate information must be targeted and timed correctly.

The climate information from the local radios was free, and the listeners could call during live discussions. The climate information from the local radio stations was understandable since it was in Kikamba. The FGDs also established that besides the mobile phone and FM Radio stations, television programs were also accessible to a few residents. This was also confirmed by key informant interviews as discussed below. This was supported by the data on ownership of the ICT tools too as fewer owned televisions and computers. For instance, respondent P2 noted that information from the television is most useful on climate change and local weather warnings. Nonetheless, P2 asserted that her access to climate information would be more effective before the rainy season when needed to plan due to Kitui's propensity to droughts. The respondent further explained that in addition to climate information, agro-advisory information would be useful in helping her to prepare for climate change. This could be in the form of an Almanac that indicates the month suitable for planting specific plants; information on how to control plant pests; and information on soil type.

A Chairlady in her self-help group (P2) explained that ICTs help her obtain first-hand knowledge of significant issues on climate change variability, and therefore is equipped to guide others in

her group in making a better decision for their agricultural activities such as planning the time of planting, harvesting plus management of fertilizer and pesticides. A good example is that the majority of the participant received Kitui Daily Forecasts on their mobile phones in the form of Short Text Messages (SMS) from Kenya Meteorological Services as shown below

The above SMS text message from Kenya Meteorological Services is interpreted as:

> The Kitui forecast is for Tuesday; all areas will have sunny intervals except for the areas, 1, 5, and 6 (AEZs) that will experience showers in the afternoon. It will be windy in the SE with maximum temperatures of 27°C and a minimum temperature of 18°C.

The participants found these daily weather forecasts disseminated through the mobile phone useful because it was localized to Kitui and zone-based and therefore more specific. Key people, such as Chiefs and religious leaders in the villages were the intermediaries to receive such daily forecasts. In turn, they disseminated to other members in the community and explained to those who did not understand the technical language. Some respondents missed the essence of the communication due to the complexity of the technical language used by the Kenya Meteorological Department. To overcome the distrust of the accuracy of climate information, KMD has facilitated training to the first point of contact, the intermediaries.

A hybrid of communication methods such as face-to-face communications and capacity training helped in making the climate information clearer. The Chiefs' barazas were always conducted in the

locally dominant language (Kikamba) for faster assimilation and implementation. However, during the seminars, or Trainers of Trainers (TOTs) sessions, the participants were the more educated members in the community.

However, *barazas* by the chiefs from villages were also occasions to inform residents of seasonal forecasts and how to prepare for extreme weather patterns. Based on the expected climate forecasts and crop-cycle the residents were prepared on when and what crops to plant. This meant that the daily forecasts that were circulated using mobile phones and the seasonal forecasts that were circulated through the other ICTs (radio, TV and computer) was further reinforced through communal settings. The advantage of this approach is that it enables conversations to emerge among community members, and are opportune moments for those who need clarity to obtain the same from leaders and sharing of experiences.

However, it is important to note that both men and women preferred to receive climate information in a format that was more location-specific due to diverse weather variations in Kitui. In the case of mobile phones, respondents preferred climate information in the local dialect and voice-activated. Receiving of the climate information by the key informants, intermediaries, and women group leaders was solely free of charge. However, for those who wanted further information through messages or calls, their respective service providers charged these. The organizations that produced the pamphlets did so and distributed them to their target groups at no cost. This way, the organizations made sure climate information is affordable and accessible to everyone in the community.

All KIs established that the climate information given to them was relevant and accurate, as it had passed through screening and approvals before dissemination to the public. However, the issue of clarity and ease of understanding the climate information raised some concerns. For instance, according to the interviewee K1:

> "Most of the small-scale farmers are illiterate and above all are ignorant. They would prefer all the information in their native language, something that will only be possible through the aid of our collaborative stakeholders such as the radio and

> television stations that broadcast in the vernacular language. This comes at a financial cost that KMD is not able to fulfill due to challenges in resources unless we collaborate with other stakeholders."

The K11, the Principal Agricultural Officer, added:

> "If communities can be able to interpret the information that is given by the Kenya Meteorological Department, with simple terms and simple actions, communities can do a lot to mitigate the effects of climate change, and climate variability even before the big institutions come in to help."

Informants (K8, K9 and K10) from the local radio stations were happy that they could use the local language to reach the public. For instance, the Marketing Officer from Thome FM said, "whether educated or not, people are happy listening and understand better in their mother's tongue." The Kitui County's Ministry of Agriculture officials spoke in Kikamba during baraza's and sponsored radio programs. However, they also used both the English and Swahili in publications.

Several key informants recognized the fact that using a variety of complementary communications was a crucial factor to the farmers in the trust and acceptance of climate information. As K2 stated:

> "Communicating complex information does not always work through a single channel. There is the need to use a hybrid of communication channels and approaches (Video, radio, TV, farmer-to-farmer, SHGs, and physical spaces to interact)."

As suggested by another informant K5, radio shows can be used to raise awareness and sensitize the farmers on issues; videos were employed where possible to demonstrate good practice and increase the interest of individuals, Voice-activated messages were sent out to strengthen the practice and provide timely advice. These views were also supported in the FGD discussions above. Depending on the organization, the key informants suggested different ways for the

enhancement of dissemination of climate information. These included:

i. Collaborating with more organizations;
ii. Creating awareness to the public on the importance of receiving climate information;
iii. Utilizing bulk SMS method to reach all farmers;
iv. Offering extensive capacitive training to farmers;
v. Organizing more trade fairs;
vi. Having toll free services for climate information; and
vii. Using complementary communications approaches.

5.4 Influence of ICT Based Climate Information in the Maximization of Livelihood Assets

The use of ICT based climate information in influencing the access and utilization of the five livelihood assets (maximization) is discussed next.

5.4.1 Natural Capital

Land ownership and water lie at the core of natural capital. Most women confirmed they did not own the land they cultivated. This confirms to patriarchal patterns and difficult for them to make decisions on the use of the land. The key findings are in Table 5.6 below.

Table 5.6: Access to and Utilization of Natural Capital

Construct Variable	Key Findings
Natural Capital	• The disparity in land owned whereby women were marginalized. • Participants owned or cultivated less than two acres of land. • Rain-fed and river water was the primary source for agricultural and domestic use. • Climate information received through ICT tools has helped the participants in water and land management.

Most respondents cultivated or owned less than two acres, only one P13 (male in a polygamous marriage) owned 5 acres. The women overcame the issue of not owning land by leasing land through the membership of social network organizations. Many were demoralized as respondent P7 suggested:

> "Men are the heads of the family, and they tend to dominate everything. My children and I work hard to plant and cultivate our farm. After harvest, my husband has control of selling the produce, and the monies received even when he contributed very little to the hard labor or the input to the farm. He feels that since

> he owns the land, he should have a say in how the money utilized. This truly demoralizes me, yet one cannot sit idle when you have children. You will work regardless of what the man decides to do for the household."

Water is a valuable resource for agricultural and domestic use. Kitui has faced harsh times from lack of water to retrogressive patriarchal society. About 20% of the participants had access to piped, well or dam water. They depended on rain-fed or river water for their agricultural and domestic use. Many women were forced to walk long distances to get water for domestic use and farming, taking them away from household and farm duties. It means they also miss programs that would help them negate climate change and climate variability effects. This was confirmed by participants P3, P5 and P7; where one noted: "I have to walk at least 4 kilometers in search of water for domestic use daily". However, noted in the women's FGDs, they continue to play a leading role in the provision of water in their rural areas through self-help groups and with the help of non-governmental organizations and donor agencies. The Chairlady (P5) of Katitila Self-Help Initiative explained how a project by AMREF had a positive impact on their lives:

> "Before the construction of the well, I used to fetch water from the river, which took me five hours to make one trip. It was not safe, and my family could fall ill several times. We suffered to get clean and safe water for our families. Today, I am happy to say we have clean and safe water. Our vegetables and fruits are flourishing, and we are thinking of expanding our project by acquiring more land. The vegetables and fruits are sold at affordable prices to communities, and we educate others on proper nutrition. We share the money from our profits every year and take loans from the group, which helps us pay school fees and buy food for our families. "

Participant K5's tangible evidence of progress is shared by fellow group member P8, and like many women in her village, she used to walk for over three kilometers to collect contaminated water at a river.

> "Today, I only cover one kilometer to collect clean and safe water from Katitika giant well. The group has empowered me economically, and the

nutrition status of the households I am in charge of has improved. I was able to start a small business through a loan I got from the group."

In both FGDs, the participants agreed that ICT based climate information helped them know where and when to access water; and when and how to harvest water when there was a drought. They were also able to determine how much land to cultivate helping in the management of water and land resources. The ICT based climate information further strengthened their connections to the right markets and better market prices. By way of illustration, the early warnings they received through SMS and the community radios helped reduce risk and vulnerability to food shortages and natural disasters as related by participant P8:

"Last year, I received a message to look out for rains that was not the usual onset of the rainy season. I prepared my land and planted cabbage, maize, beans, kales and spinach I was the only farmer who took that chance and ended up having a bumper harvest based on this early warning climate information."

5.4.2 Human Capital

The effect of human capital on climate change is an extensive topic. In this study, the examination of human resources was limited to education levels, agricultural labor, extension (climate and agricultural) knowledge services, ICT knowledge and skills. Table 5.7 below shows key findings.

Table 5.7: Access to and Utilization of Human Capital

Construct Variable	Key Findings
Human Capital	• The gaps in schooling and literacy resulted in less proficient use of ICT tools and access to climate and agro-advisories information. • Marital status and age were influential factors for human capital. • Farmers relied on self and household for labor. • Learning through and with ICTs access to climate information services provided access to knowledge. • Knowledge of climate information was gained from SHGs and Institutions.

The gaps in schooling and literacy in understanding the technical information of climate information resulted in less proficient use of ICT tools and access to climate and agro-advisories information to some of the participants.

Institutions for climate-smart agriculture provided capacity-building workshops for better understanding of climate information and climate change at the community, government and organizational levels. The key informants stated that ICTs enabled service providers (Safaricom, Telkom, and Airtel) to monitor access to local services, but there was the need for more investment on their part by reducing the costs for the services. Farmers who had access to climate information through the various ICT tools gained skills and knowledge to adopt new livelihood strategies. On the other hand, K14 from the Ministry of Agriculture felt that it was not easy to quantify human capital but observed that the farmers had developed confidence in the weather forecast. In general, the key informants agreed that the farmers were able to improve on their farming practices.

Kenya meteorological department provided capacity training workshops on seasonal forecasts in collaboration with other stakeholders such as the ASDSP [Agricultural Sector Development Support Program]. They advised on crop varieties based on projected rainfall patterns. The county government, NGOs, and other institutions provided extension services such as agro-climatic-related training and agricultural advisory services to increase the farmer's ability in improving productivity. Agents delivered the extension services from Kenya Met, agricultural and livestock agents charged on information dissemination. Extension services took place in the form of field visits, technical advice in meetings, demonstration visits to model farms, or Farmer Field Schools (FFS). In the FGDs, very few female household heads and women in male-headed households had contact with extension agents, compared to the men. Participation in FFS was equally available to female community members in Kitui. However, female-headed households mentioned they were less likely to participate due to lack of time, information, and distance.

Most of the participants could not afford to hire outside agricultural labor; children, spouses, and the community provided the extra support. Marital status and age were confirmed to be influential factors for human capital. The male household heads were the primary decision-makers in the household. It was evident that age was a factor as participants shared that the younger men and women were more willing to share information and adapt to the changing demands of climate change. They were also ready to experiment on suggested crops compared to

the elderly who were not always willing to share indigenous knowledge and agricultural information from other sources.

5.4.3 Financial Capital

Social gathering for rotating savings and credit associations were found to be very popular in terms of financial capital, especially among women. Table 5.8 displays the key findings

Table 5.8: Access To and Utilization of Financial Capital

Construct Variable	Key Findings
Human Capital	• Financial services offered through ICTs are credit, savings, and remittances. • Access to CI through ICT tools increased income from agricultural farming and livestock

The Self Help Groups [SHGs] were very helpful for women who needed significant amounts of money. The use of ICTs provided increased access in rural villages to women cooperative institutions, such as Kenya Women Finance Trust (KWFT). The establishment of cooperative institutions provided significant assistance for women to meet individual financial needs too. For instance, the participants said access to credit, savings, and remittances are examples of financial services that improved their access to climate information through ICTs. This increased their income from agricultural farming and livestock, enabling them to pay school fees for their children, buy nutritional foods for the family, pay their medical bills, and buy water tanks for harvesting water. These financial institutions facilitated loans to SHGs because the chances of getting the loans paid were higher as the group held members accountable. For instance, table banking has enabled them to get involved in farming activities such as poultry rearing among other activities. According to P3 (the treasurer for Katitika Women's Group), they have been able to acquire loans and engage in economic empowerment projects that have transformed their lives:

> "We started with a 'merry-go-round' [rotating services] called *Ngonemwaitu,* where we took part in table banking that saw us start projects of economic empowerment."

M-PESA was praised as one of the best ICT innovations that enabled family members to receive and send money for business transactions. P8 and P10 found it easy to stay in touch with their

families and remit finances through M-Pesa, T-Kash, and Airtel money. There are similar innovations, such as savings (M-Shwari) and credit (M-Kopa). Some participants confirmed that they accessed insurance products using ICTs from micro-insurance programs like Kilimo Salama. Kilimo Salama allowed the participant to insure farm inputs against drought or excessive rain via prepaid handset fees.

Most participants noted the increased profit margins that resulted from increased access to ICT based climate information. When it involved paying for climate or agro-advisories information services at rural information centers, the women participants were less likely to have disposable income. K1, the Met County Director stressed that the whole range of climate information did not reach all the people in the community due to financial challenges. This necessitated them to look for outside sources of funding and collaboration with various stakeholders.

5.4.4 Social Capital

The women participants in the FGDs were members of various social groups. These incorporated mutual trust, solidarity and cooperation among society members. Table 5.9 illustrates some of the key findings on social capital.

Table 5.9: Access to and Utilization of Social Capital

Construct Variable	Key Findings
Social Capital	• The social networks and social help groups were channels of communications with the ICT tools enabling access to climate information and related agro-advisories and linkages to other farmers across villages and learning from each other. • The use of mobile phones strengthened connectivity and contacts for different households and social networks groups. • Social groups incorporated mutual trust, solidarity and cooperation.

The social groups were self-help groups involved in table banking, 'merry-go-round,' welfare groups, religious groups, Nyumba Kumi (Cell Groups), and other forms of investments groups. According to P5, (married woman between ages 46-60 but living apart), social networks are unlikely to be disbanded because they provide significant benefits to the community members. These have been used to support families when there are deaths and weddings.

The women participants held various leadership positions in these social network groups, and they all cited networking, visibility, decision-making skills, and respect from the community as the benefits

of these groups. While all the women belonged to more than one social group, only 2 out of 7 male participants in the FGDs were in a SACCO financial group.

Community-based organizations and financial institutions (KWFT in Kitui) considered the women's self-help groups (SHGs) effective channels for providing the women with access to agricultural inputs, climate information, credit, community participation, and markets, thereby increasing their human capital and financial capital. Participants, P8 and P10, found it easy to stay in touch with their families and remit finances through M-Pesa, T-Kash, and Airtel money. The ICT tools enabled the groups to have access to climate information and related agro-advisories and linkages to other farmers across villages and learning from each other. The use of mobile phones strengthened connectivity and contact for disparate households and social networks.

The key informants stated that social network groups and WhatsApp groups were excellent avenues and less costly method of reaching a bigger network of people. The key informants used this avenue because these groups had a common agenda and it was easier to reach out to them. According to KI1, KI2, and KI3 (all Ministry of Agriculture officers above 46 years), some of the benefits of using the social network groups were:

i. It was more accessible to reach the communities through these social network groups, primarily through the group leaders who are intermediary contacts;
ii. The SHGs was considered a faster method of climate information flow;
iii. Information was directly conveyed to the target audience in a short time; and
iv. It was easy to build trust in climate information through SHGS.

5.4.5 Physical Capital

Of significance was the reduction in transport needs and costs the participants experienced because of using ICTs in the access to climate information. Before then, the participants had to travel to agricultural or meteorological centers to seek for the info. Male participants noted that individuals who own mobile phones rarely move to other places to look for climate information; instead, they called colleagues to get information to guide them in making decisions on agricultural enterprises. Table 5.10 below displays key findings.

Table 5.10: Access to and Utilization of Physical Capital

Construct Variable	Key Findings
Physical Capital	• Access to ICTs influenced access to climate information • Access to CI through ICT tools increased income from agricultural farming and livestock • Most men in the household owned the ICT tools (mobile phone and radios).

Participants conveyed how through ICTs, they were able to improve on the purchased farm equipment due to the information received from radio and television program shows. Men participants noted that individuals who own mobile phones rarely move to other places to look for climate information; instead, they called colleagues to get information to guide them in making decisions on agricultural enterprises. The participants noted that they received text messages about climate information and markets prices on several occasions. The only complaint was that the packaging and language of the messages was limiting where information was sent in English. They were also able to buy or lease mechanized tools like tractors. The male FGDs mentioned how they were able to build better housing structures by using locally made red bricks, and quite a number of the participants increased their livestock assets primarily in the purchase of chicken and goats due to the income gained by improving on their livelihood strategies after receiving climate information.

Even though ICTs are increasingly becoming indispensable tools in disseminating information, the women participants P2, P4, P6, and P7 mentioned how they had limited access to ICTs and said most of their spouses had control and access to the ICT tools.

Some key informants voiced their frustrations in the lack of communications infrastructure that allows for the use of new ICTs and that was more severe in rural areas. In addition, the informants shared how ICTs and electricity go hand-in-hand. However, in rural areas of Kitui, only clinics, hospitals, shops, and half the schools were connected to the National Electricity Grid, disadvantaging 80% of the population who live in rural areas. The institutions facilitated and encouraged the use of solar as an alternative source of energy to alleviate this problem.

5.5 Moderating Factors of Structures and Processes

The KIs recognized the importance of collaborating and building strong partnerships with trusted technology providers, NGO's, content providers, project stakeholders along with local and national government bodies to help in the dissemination of climate information. Table 5.11 below shows some of the key findings.

Table 5.12: Moderating factors of Structures and Processes

Construct Variable	Key Findings
Structures and Processes	• The primary source of climate information is KMD. They collaborated with media and other institutions to disseminate daily weather and seasonal forecasts and agro-advisories. • Institutions provided capacity training on climate information and ICT skills • Institutions used ICT tools to relay CI and to access the community • No participation in national decision-making policies (ICT and Climate change policies) • Most men made the decisions in the household • Triple burden role of women (reproductive, productive and community) affects access to ICT tools limiting access to climate information and agricultural technologies

The key informants stated the use of ICTs to facilitate the creation of partnerships, allowing stakeholder collaboration via e-mail exchange, virtual meetings, e-conferences, online chats, and other online mechanisms. Using ICTs to capture, process and disseminate climatic information helped them highlight the multi-dimensional nature of impacts of climatic changes (on natural habitats and ecosystems, food security, new health threats, scarce water resources, and risks to human infrastructure among others).

Table 5.13 below shows how institutions collaborated with various stakeholders for the success of spreading climate information to the public.

Table 5.13 Institutions and Climate Information Awareness

Institutions	Stakeholders	Type of Climate Information
KMD	Caritas, MCAs, ASDSP, Kenya Red Cross, Media, NDMA, County and National Government, ADA	• Daily, seasonal forecast, and early warning forecasts. • Seasonal forecasts are disseminated at the beginning of the two rainy seasons MAM and OND.
Radio Stations (County, Radio Thome and Syokimau FM)	KMD, Caritas ASDSP, SASOL, ADRA, County Government	• We receive daily weather forecasts via email from KMD that was compiled updated and broadcast twice daily. • We work with KSDSP to disseminate seasonal forecasts twice before the two rainy seasons (MAM, OND) in an interactive radio program.

Institutions	Stakeholders	Type of Climate Information
Caritas	Local FMs, MAWI, MENR, KMD, KFS, KEFRI, NDMA	• The climate information dissemination was done mostly every week through SHGS
ASDSP	KMD, Radio stations, County government	• Seasonal weather forecasts, (short and long rains) including rainfall onset, cessation, and rainfall amounts expected and distribution, were disseminated twice a year through various avenues.
FAO	MOA, Ministry of Livestock and Fisheries, Water and Natural Resources, other UN arms, other development agencies	• E-soko platform where daily, weekly, seasonal, and future forecasts are available. • On average registered farmers on the E-soko platform receive five messages a week, two weather updates, two agriculture tips and one on market price information though this may vary because some crops and livestock need different types of information.
County Ministry of Agriculture	KMD, KEFRI, NDMA, MENR, MAWI, KFS, ASDSP, Caritas, NH Plus, FAO, local media, KARLO, National Government	• We receive seasonal weather forecasts and advisory on weather information from various sources and disseminate CI before the onset of rainfall twice a year to farmer SHGs.
Bio-Vision Africa Trust	ICIPE, KARLO, IFOAM, SIDA, Swedish Society for Nature Conservation, PELUM Association	• Daily, seasonal forecast and early warning forecasts and future forecasts that we disseminate to the community

The various institutions in Kitui considered KMD a highly credible source of information and collaborated with them to access and disseminate seasonal and short-range forecasts. Climate information forecast reaches humanitarian stakeholders from many different sources, Interviewee K1, however, said he provides localized information in partnership with governments at local and national levels. This is done at the beginning of the project both in terms of the provision of meteorological or extension services with "general advisories," thereby building credibility among the farmers. There was "a turning point" in 1997 for El Niño awareness in Kenya; before this "people did not understand what [El Niño] was and so many people experienced heavy losses because of ignoring it" (K6). Now, the media and the public take a keen interest in *El Niño*, so according to K2 "people are interested, they are hungry for this information, and once you talk of the climate extreme events, in fact, they are the ones who come to look for you." The 2014 global warning false alarm also made some communities doubt the Kenya Red Cross climate information for 2017, but they have continued to build trust by working with social network groups.

At the same time, institutions such as the Kitui County government, Caritas, and KMD organized training sessions for intermediaries as TOT during the climate training project initiative that started in

2014 where the TOT were equipped with skills on how to access and interpret climate information. Targeted for such training were women leaders of SHGs in the rural community. KMD provided rain gauges to key members in the community and trained them on installation and recording of information from the gauges. The community members could adequately read the gauge and relay the information obtained using mobile phones to KMD for analysis and KMD transmitted the analyzed data through the community FM radio stations. For instance, Respondent P3, who received training, had this to say:

> "When it rains I record the rainfall amounts over 24 hours and communicate the data to the Kitui KMD using my mobile phone, they, in turn, analyze the rainfall data and transmit the information to the community radio station for dissemination."

Other institutions, such as FAO, Kenya Red Cross, and BvAT and NDMA, used the more localized season forecast climate information to promote humanitarian engagement with the communities. The rest of the KIs targeted the public while others, such as the Ministry of Agriculture, Water, and lands (MOAWL) and FAO, were more specific to the farmers. Organizations like the Ministry of Agriculture and the NGOs targeted group leaders and agricultural extension officers during capacity training. The expectation was for them to trickle this training to their group members in the communities. However, there is evidence from many participants that this is not the case. Some of the reasons given by the potential trainers are limited financial resources, especially for the extension officers and intermediaries, who were not able to reach a majority of the rural farmers due to lack of facilitation to buy airtime. There were also cultural challenges where some women were not allowed by their husbands to speak to male agricultural agents.

The focus discussions claimed that NGO's such as Bio-Vision Africa Trust, DANIDA, Caritas, and USAID had the most significant impact on the dissemination of climate information. During the OND rainy season of 2017, the agricultural agents helped in the distribution of seeds when there was an invasion of armyworms. Some of the participants received climate information from agro-vets during the purchase of farm inputs and were educated on the pros and cons of what they were buying.

The finding in the FGDs found common characteristics exist where access and use of climate information were influenced by factors such as social-culture, religion and gender. In social-culture, some women were not accorded the same rights in the access to ICT and some mentioned they were restricted from interacting with 'external' individuals other than their family members. In addition, the triple role of women (reproductive, productive, and community roles) highlighted in the GAD theory constrained women in seeking climate and agricultural information owing to the lack of time, mobility lack of approval from spouses. Most of the women participants complained that the primary decision-maker in the household was the men who at times were very oppressive, chiefly because of the gendered ownership of land and other resources, which empowered men over women. The men did not seem to have any problem with the cultural practices hindering the dissemination and utilization of climate information. However, P7 stated that male dominance in decision-making was a hindrance to the dissemination of ICT based climate information and participant. P4 and P14 did not believe in access to climate information beforehand expressed climate change as an act of God believing that predicting climate information will bring bad luck to the community.

The male participants P13 and P14 felt that practices of polygamy, in their household, helped the family in the sharing of farm labor and household duties, thereby increasing their incomes. Participant P7, who is the first wife, felt vulnerable when her husband took a second wife because household resources, including land, was shared between the two families. Almost all the men were for polygamy, but the younger women (P1 and P3) were against it.

The focus discussions revealed how the participants understand the local climate and its impacts and what required to be done, but are challenged due to the lack of resources and capacity to respond strategically. The participants reported that they had little input in national decision-making policies (Climate and ICT Policies), and were not all well represented by community networks and civil society organizations, and generally remain poorly served by the national governments. Since the onset of the various partnerships among the institutions, there was recorded improvement of awareness and ability of the public to receive climate information. This led to improved decision-making livelihood strategies in the community, which is discussed in the next section.

5.6 Livelihood Strategies

In this study, climate-smart agriculture (CSA) refers to the livelihood strategies adopted. Farmers from the FGDs and the KIIs from various institutions shared their views on the broad spectrum of livelihood strategies that they used to adapt/mitigate climatic changes after receiving climate information and agro-advisories via ICT tools. In response, farmers have adopted a range of practices and behaviors to actively mitigate the perceived impacts of climate change (Table 5.14) The CSA practice employed were; soil and water conservation, crop management practices, non-agricultural activities, and migration which influenced their livelihood strategies.

Table 5.14: Extent of Use of Climate-Smart Practices in Kitui County

Construct Variable	Type of Practice	Livelihood Strategy Activities
Livelihood Strategies	• Soil and water conservation	• Mulching • Micro-irrigation • Water catchment
	• Crop management practices	• Use of improved seed • Use of drought-resistant varieties • Planting early-maturing crop varieties • Early planting • Use of Zai Pits • Timely agronomic practices • Crop rotation • Value addition to crops
	• Other Practices	• Integration of livestock, agroforestry, and crops • Use of small-scale irrigation • Introduction of zero-grazing • Alternative non-agricultural activities • Migrate to urban centers

5.6.1 Soil and Water Conservation Practices

For the participants who used the climate information – and agro-advisories accessed through ICT tools –the result was improved agricultural practices that included micro-irrigation, mulching, Zai pits and use of water catchment areas. However, the use of mulching and water catchment (use of trenches) was the most common with women in Kitui. Men used mulching because they had to be purchased, and they were financially empowered to purchase mulching materials off-farm. Women obtained mulch from crop residues collected from their farms. Women did not practice the construction of trenches because it was labor-intensive making it tedious for them to invest their time in creating water catchment areas.

Micro-irrigation, at its infant stage, was an emerging soil and water conservation practiced by farmers in Kitui County. The younger male farmers (P8, P10) mostly practiced micro-irrigation by growing high-value crops such as fruits, vegetables and tomatoes. Domestic water harvesting was undertaken using traditionally constructed water tanks, but more tanks that are modern were utilized after funding facilitated by organizations. The lack of financial resources in obtaining raw materials prevented soil enhancement practices among the participants. The use of organic manure and artificial fertilizers were the leading practices for enhancing soil fertility. Livestock and human waste were obtained for organic manure, and zero-grazing was a common practice among the farmers, since many of the households owned at least one to three number of livestock. The officer K5 from Caritas said how they initiated Self-Help Groups, whose main agenda was harvesting the runoff water and the water from the roadside by digging of terraces. Further, K10, the traffic controller at Syokimau FM mentioned that there were increased statistics of dam and tank construction in the region. These increased water-harvesting practices made the farmers increase their food production and thus, food security.

5.6.2 Crop Management Practices

Participants P6 and P12 mentioned the changes in crop management practices adopted after receiving climate information by acknowledging that widespread availability and use of climate information had favorably altered agricultural practices in the region. The primary crop-related practices meant to enhance crop production included: use of drought-tolerant varieties; carrying out of timely agronomic practices, intercropping; and agroforestry.

The use of drought-tolerant crop varieties (green grams, sorghum, and cassava) is now widely used in the semi-arid areas of Kitui. The use of drought-tolerant crop varieties is becoming more popular given the intermittent rainfall as well as the failure of farmers to predict the times when the rains set in. Farmers (male and female) were quite aware of these practices like timely weeding, early planting, and timely harvesting. These three practices are more popular today as farmers are unable to predict the weather accurately. Besides, the rainfall is unreliable and erratic, so farmers carry out the practices to harness moisture when it is still available.

Crop rotation and intercropping were a common practice, which produced various products that

increased food security and diversified farmers' household income. Often a set of three or four crops are planted on a rotating basis, ensuring that by the time the first crop is replanted, the pests that attack it are substantially reduced. Another side benefit of crop rotation is that it improved soil productivity.

Most farmers acknowledged using the home-saved seed for farming. However, the use of improved seed allowed farmers to enjoy better yields and early maturation. Such crops still yielded produce even with shorter rain and are resistant to pests and diseases. Most of the improved seeds are inaccessible and unaffordable to the farmers.

Almost half of the households in the FGDS also practiced agroforestry with livestock rearing and crop production a form of livelihood strategy diversification. Common trees were mangoes, avocado and citrus. Women participated more than men in tree planting as more of them were in the targeted SHGs. Besides, the forage from the fruit trees was sometimes used as fodder and branches as firewood. It was also evident that a majority of men were interested in planting commercial trees such as Melia Volkensii, (Mukua), Grevillea Robusta and Cyprus trees.

A number also pursued alternative income-generating activities. Women invested in livestock activities like rearing goats, chickens, and eggs for sale. The men invested in cows, donkeys and beekeeping. Most men in the households migrate to urban centers looking for employment to seek alternative income following potential loss in agricultural productivity from severe weather events such as severe drought period.

All these responses suggest that the community was experiencing a gradual increase in crop yields. Some participants affirmed that they had witnessed a positive impact on receiving the ICT based climate information, for example, respondent P13 said:

> "It is not like before when people used to stay idle during the drought seasons. Nowadays, after people have gained knowledge and are better informed and also from the lessons learned from the various institutions in the community, we can plant near the riverbeds where we have dug water wells and able to practice irrigation. We can harvest runoff water for storage, there are those of us who have

> dug boreholes, and therefore able to water our crops all season. These activities have helped us improve our livelihood in the whole community since we have food throughout the year."

On their part, participants P13 and P7 concluded that:

> "We are not at the peak of the food basket yet; in fact, we are far from attaining food security in our county. However, I can confidently say that we have achieved great milestones and are continuing to improve and eventually, Kitui will be renowned for food security rather than the relief food that we always receive from the government and the NGOs."

> "I have realized greater yields and produced a marketable surplus, improving our household security. I used to harvest one bag of maize, but now I harvest four, and I used to harvest two bags of sorghum, but I now harvest eight."

Other favorable achievements cited by K5, K2, and K14 were the adoption of more resilient agricultural practices, such as improved storage of agricultural produce with the reduction in aflatoxins and outbreaks in crop diseases as well as increased confidence and awareness of farmers, mostly in improved agricultural practices. On the contrary, it was the perceived opinion of the K1 the County Director at the Kenya Meteorological Department that the adoption of improved livelihood strategies could only be achieved upon timely and correct utilization of climate information. He suggested that most of the residents even after being advised on the onset and amount of rainfall highly preferred the traditional crops, instead of the drought-resistant crops such as millet and sorghum thereby not achieving improvement on their crop yields. However, most of the KIIs revealed that with increased awareness and decision-making attributes among the farmers led to improved food security and income because of better adoption of livelihood strategies. As K2, the County Coordinator said, those participants who had undergone adaptation and development skills had increased their food security and incomes from the sale of surplus produce, especially green grams and sorghum. The interviewees, K3, K5 and K14 observed the following respectively:

"The community has gained skills in land management by practicing soil preparation, minimum tillage, crop rotation, better pest control, maintaining soil coverage, and water harvesting thereby increasing yields and hence better income."

"The community has increased adoption of soil and water conservation practices through terracing, construction of Zai pits, road water harvesting and adoption of climate-resilient agricultural practices."

"There has been an increase in the adoption of climate and weather relevant crop varieties such as improved seeds use of drought-resistant varieties and crop rotation."

5.7 Synopsis of Key Findings

Based on the conceptual framework, the outcomes of the key qualitative findings are summarized in the following Table 5.15.

Table 5.15: Synopsis of Key Qualitative Findings

Construct Variable	Key Findings
The use of ICT Tools to Access Climate Information	
ICT Tools	• Key Informants used ICT tools to reach the community for capacity building
Digital Capital	• Inadequate ICT infrastructure and poor network connectivity were found to be a challenge by both respondents, FGDs and KIIs. • Most respondents had limited operational ICT skills. • Lack of finances for facilitation the intermediaries to forward climate information to the community and internet to subscribe to informative news. • Digital divide in rural areas due to digital capital challenges.
Climate Information	• Climate information in the local language was preferred and voice-activated messages to address illiteracy. • Location-specific climate information was required to build trust issues on broadcasted weather forecasts. • Climate information received through ICT tools has helped in water and land management. • Due to the unpredictable nature of extreme climate events, farmers cannot rely only on indigenous knowledge to predict the weather but need modern scientific climate knowledge.
The Influence of ICTBCI in the Access to and Utilization of Livelihood Assets	
Natural Capital	• Climate information received through ICT tools has helped in water and land management.
Human Capital	• The gaps in schooling and literacy resulted in less proficient use of ICT tools and access to climate and agro-advisories information. • Learning through and with ICTs access to climate information services provided access to knowledge. • The use of ICT increased knowledge of climate information gained through channels of

	SHGs.
Financial Capital	• Financial services offered through ICTs are credit, savings, and remittances. • Access to CI through ICT tools increased income from agricultural farming and livestock
Social Capital	• The social networks and social help groups were channels of communications with the ICT tools enabling access to climate information and related agro-advisories and linkages to other farmers across villages and learning from each other. • The use of mobile phones strengthened connectivity and contacts for different households and social networks groups.
Physical Capital	• The use of ICT tools to access CI reduced transportation needs and costs.
The Influence of ICTBCI on livelihood Strategies	
Livelihood Strategies	• The use of ICT tools to access CI enabled the farmers to employ the following climate-smart agriculture (CSA); soil and water conservation, crop management practices, non-agricultural activities, and migration
Moderating Factors	
Structures	• Institutions used ICT tools to relay information and to access the community. • Institutions provided capacity training on climate information.
Processes	• Triple burden role of women (reproductive, productive and community) affects access to ICT tools limiting access to climate information and agricultural technologies.

5.8 Chapter Summary

Local farmers have attested to the need for modern scientific knowledge to augment their traditional climate knowledge. This is because they have experienced unpredictable and extreme climate changes in Kitui. Further, the relevant development actors and climate service providers have worked together to create trust and disseminate climate information to the small-scale rural women farmers. Accurate seasonal forecasts were available from the KMD mostly online and during radio and television weather reports but were found to be less accurate. There were daily and weekly local forecasts available through a combination of satellite data and local weather stations, which feed open weather sources online. This information, however, hardly reaches rural farmers, particularly women, except through related NGOs, governmental institutions that directly deal with farmers and companies that work closely with rural farmers. These organizations usually work in specific communities and were unable to provide climate information continuously. Some of the barriers mentioned were lack of infrastructure, affordability, cultural and societal factors and low literacy rates.

ICT Infrastructure in the rural areas of Kitui was found to be inadequate, but there were ICT tools that were available and in use; namely mobile phones and radios. However, there was an internal urban-rural divide, which meant even further deterioration of services in rural areas. This was evident in the inadequate electricity and internet connectivity in rural communities. Solar

power was mostly available in rural areas. This is due to a heavy emphasis on renewable energy that is cheaper in Kitui County, as confirmed in the literature (Kitui County CIDP, 2018-2022). The institutions and government agencies, therefore, focused on using these available technologies in the dissemination of climate information and agro-advisories needed by the rural farmers. This study found that the use of text-based systems is not feasible in the context of rural Kitui where people were generally illiterate. Therefore, the participants preferred using local languages and voice-activated in the delivery of climate information.

Farmers who accessed relevant climate information tended to improve their agricultural practices in soil, water conservation, and crop management practices, thereby increasing their yields and enhancing their livelihoods by extension. Intermediaries were a vital source of contacts in the delivery of relevant climate information and its agro-advisories. The farmers who accessed new ICT based climate information adopted new livelihood strategies and maximized livelihood assets.

In general, the FGDs and KIIs revealed some socio-cultural dimensions that influence the uptake of climate information in Kitui County, especially among low-income smallholder farmers. These dynamics demonstrate the delicate mix of the existing modernity of information on the one hand and cultural holds on the economic activities of the people on the other hand. The FGDs also exposed the gap between the high theory of scholars in the respective fields of ICT and gender studies on the one hand, and the practical realities that determine the extent to which theoretical ideas are matched with technological advancements to affect the lives of locals who are trapped between culture, material poverty, and ecological hardships.

CHAPTER 6: DISCUSSIONS AND SYNTHESIS OF FINDINGS

6.1 Introduction

The mixed-methods approach used in this study provided an opportunity to use data triangulation across the quantitative and qualitative findings. A concurrent triangulation approach was employed during data analysis for in-depth study and to raise the credibility of the findings (Creswell and Plano, 2011). Therefore, this chapter presents the synthesized quantitative and qualitative results by systematically reviewing the findings and consequently discusses the triangulated outcome.

6.2 The Use of ICT Tools to Access Climate Information

The following findings addressed hypothesis H1 on the positive correlation between ICT system (ICT tools and digital capital) and climate information. Whether or not farmers will access climate information is determined by the types of climate information and agro-advisories made available by the KMD and other providers and the mode of communication channels used to disseminate information, and its demand.

Both the qualitative and quantitative findings revealed interactive community FM radio stations (County FM, Syokimau FM, and Radio Thome, among others), and mobile phones were mostly used to communicate climate information (weather, seasonal forecasts, and agro-advisories) to the small-scale farmers. They widened the approach with opportunities to reach other farmers in Kitui County at expanding scales (Gumucio *et al*., 2018). Mobile phones and community radios were found to be relatively affordable, available, and easily accessible compared to television and computers in transmitting climate information supporting the literature (Hampson *et al.,* 2014; Mittal, 2016; Tall, Davis and Guntunku, 2014a; Tall e*t al*., 2014b, Muthama *et al.,* 2003).

The high rate of mobile phone penetration was collaborated by the report of Communications Authority Kenya [CA] (2018), where the mobile phones subscription and coverage had surpassed 40 million in 2017 and 46 million in the first quarter of 2019 with 100% penetration. The qualitative study brought out the fact that although the mobile phones were the most accessible and an instantaneous method of communicating climate information, the use of community FM radio stations provided the participants with climate information in the most

understood language, Kikamba. Farmers had the opportunity to listen to the programs to get essential climate and agricultural information.

The GAD theory was useful in understanding how ICT use marries with gender dynamics in rural villages in Kitui. An issue that came out sharply among the women was the differing access to media, and control of ICTs between men and women. It was evident that the women were less likely to own and control the use of ICT tools, in many cases, due to the lack of financial resources and educational constraints. Even with access, gaps in schooling and literacy resulted in less proficient use based on the empirical findings (McOmber *et al.*, 2013; Tall *et al.*, 2014c).

While radio programming in Kikamba was used with increasing regularity in climate services to address these constraints, the triple role of women was found to hinder women's ability to listen to radio programs due to the time of broadcast, which verified Tall *et al.*'s thesis (2014) though in a different jurisdiction. Notwithstanding these challenges to access, in some situations, women reported that mobile phones were a highly useful tool for receiving information. Furthermore, they were more likely to rely on friends and family to provide access to such communication tools (Coulibaly *et al*., 2017; Hampson *et al*., 2014). In the women's FGDs, many expressed that they would prefer multiple radio broadcastings of weather and climate information throughout the day increasing their chances of listening to the programs. Some of their responses tied in with the Tanzanian study supporting women's preference and recognizing the obstacles women face in listening to the radio freely. It recommends that weather and climate forecasts and advisories be transmitted several times during the day to allow women to listen to the radio (CICERO, 2018).

The use of Information Needs Assessment Model [INAM] was useful in explaining the fundamental barriers cited throughout the findings in regards to the language and format in which climate information was packaged (Moser and Dilling, 2012; Moser, 2014). Preferred was information communicated through radios and translated in local languages and dialects, using local metaphors and examples. This was in line with ALIN (2013) and other authors above who also support the findings where respondents suggested using entertaining communication modes such as music to enable better understanding. In addition, the intrinsic factors shaping the

challenges for information usability that come up in the findings include the perception on the accuracy and authenticity of information communicated as well as the timeliness of the information. For example, the seasonal outlook from the metrological department that was meant to support the farmers in preparation of the upcoming rainy seasons (MAM and OND) arrived about a month late and therefore not useful to prepare against the impacts of climate change.

Additionally, the qualitative findings identified how literacy and education level influenced the understanding and interpretation of climate information. As a result, men were better prepared to interpret seasonal forecasting. It was also challenging for women to access agro-climatic information transmitted via SMS; they preferred voice messages. Authors like Caine *et al*. (2015) and Kyazze *et al*. (2012) support these findings. Therefore, the INAM model was central in checking if the providers of climate services developed media and ICT-based channels tailored to women's needs.

The analysis of the digital capital showed several challenges experienced by the community in accessing ICT tools and services due to inadequate ICT infrastructure, poor network connectivity, limited access to power and affordability of initial cost of installation of electricity and even solar power. In this study, women were limited in the ownership and use of the ICT tools due to lack of financial resources further reinforcing GSMA (2012) and Hampson *et al*. (2014) results. Furthermore, the quantitative and qualitative findings confirmed the gender inequalities in literacy, formal education, and technical literacy (CICERO, 2018; GSMA, 2012; Owusu *et al.,* 2017). Despite women's limited ownership, participants sought help from children, neighbors, and Cybercafés when one needed assistance on a specific ICT tool, which is also supported by hypothesis one.

The findings established that for those recipients who received regular weather updates through SMS and radio broadcasts found the climate information useful when accurate, timely and relevant (Mittal, 2012). The farmers who received daily, weekly, and seasonal weather information in time to the two rainy seasons (MAM and OND) reported less weather-related crop failures compared to those who did not receive the information. The outcome corroborates the

INAM model by Dhingra and Misra (2004) showing that unless the information meets the people's needs and is well packaged: it will not have an impact.

In summary, the rural communities' preferences to climate communications were:

- The content of the information communicated;
- The urgency of the communicated information;
- The scale and type of information (seasonal forecasts at the national or local scale);
- Reliability and trust in information sources (some communities prefer the locally known and trusted intermediaries while others distrust information from meteorological officers);
- Accessibility of the communication channel; and
- The type of information communicated.

6.3 Influence of ICT-based Climate Information on Livelihood Assets

The following findings answer research question two and accept hypothesis H2. It supports the positive relationship of the use of ICT based climate information enabling access and utilization of livelihood assets and having access to various livelihood assets influencing the uptake of ICT based climate information

The quantitative and qualitative findings investigated whether the use of ICT based climate information by rural communities enabled them to maximize access to and utilization of livelihood assets and vice versa. Also, it addressed how access to various livelihood assets influenced the uptake of ICT based climate information. The results as supported by the following:

Natural Capital: The quantitative findings showed that access to climate information through ICT tools enabled the rural women in the community to lease more land to cultivate through social network groups they had joined; and determine water sources for agricultural, livestock and domestic use. The qualitative findings build on the quantitative findings where ICT based climate information improved access to availability and management of land and water resources. This, in turn, strengthened access to the market for agricultural products and better market prices. The early warnings received through SMS and the community radios helped

reduce risk and vulnerability to natural disasters and food shortages (CICERO, 2018; GSMA, 2012; Owusu *et al.,* 2017).

Human Capital: Most farmers were primary and secondary school graduates. In the FGDs, brought out was the need for more capacity training in the operation of ICT tools and the understanding of the scientific climate data, which remained a challenge for most. Many respondents complained that the information they received was packaged in format, (scientific and English language) they did not understand. Further assessment of the issue of literacy in the FGDs revealed that end-users were open to voice-based information delivered in their local language. In a workshop, the researcher participated in 205, KMD was working on the modalities of disseminating the climate information in the local Kikamba language; these empirical findings could further expedite and support such initiatives. Capacity building at the community, government, and organization levels further helped in alleviating literacy issues in the rural community. Women in the FGDs mentioned that even when they had access to ICT tools, they confronted challenges in the operation of the ICT tools because of their low literacy levels.

The available ICT tools enabled participant's access to climate information services, providing access to knowledge through agricultural and meteorological agents. The qualitative findings revealed that residents who attended capacity training learned new networking skills, knowledge on basic computer skills, and knowledge and awareness of climate information. Both the quantitative and qualitative findings further revealed that the participants depended on family members for farm labor and could not afford to hire outside labor, therefore relied on the large family size of 5-7 members to help on the farm. The FGDs findings showed that a high percentage of the heads of the household choose to migrate to urban areas, and this was triggered by the small size of farming land with low crop yields for household needs. Considering that the availability of their human capital was better than natural capital, the men in the households chose to migrate to supplement the household income.

Financial Capital: The findings revealed that ICT tools in use increased access to financial services for the residents in the villages. Social networks for rotating savings and credit associations (SHGs) were vital among rural women, especially for women who needed

emergency funds. The most popular in the rural villages were women cooperative institutions like Kenya Women Finance Trust (KWFT). The rural women used these cooperative institutions to meet their financial needs for school fees, water tanks, essential nutrition, and household needs, which Gumucio *et al.*, (2018) had also hypothesized. These social networks enhanced the women's limited financial capacity that affected their ability to afford ICTs tools that helped them access accurate climate information.

Social Capital: Venkatasubramanian *et al.*'s (2014) result highlight the usefulness of community-based and social network groups; also corroborated the quantitative and qualitative findings. During the FGDs and KIIs, the social networks and social help groups were useful communications channels with the ICT tools enabling access to climate information and related agro-advisories. It also helped link farmers across villages to learn from each other. The participants stressed the use of mobile phones, strengthened their connectivity and contacts for different households and social networks groups. Participation in social network groups and networking with institutions improved access to the provision of agricultural inputs, climate information, credit and markets, thereby enhancing human and financial capital. Though the women were challenged in terms of access to ICT resources, the social network groups they joined improved their chances of receiving the climate information. The women farmers, in particular, found climate information reliable when it came from a trusted individual or their social network. Both quantitative and qualitative findings showed that social capital had a significant impact on the income and welfare of the residents by improving the outcome of their livelihood strategies as supported by (Ngigi *et al.,* 2017). The ICT tools enabled communications by migrant workers, especially the men working away from home to get in touch with their families and to send money regularly. The quantitative findings iterated the benefits achieved such as empowering them in leadership positions, networking in access of knowledge and information, improved their farm decision-making, and trust among themselves and of institutions by joining such social network groups supported by Gumucio *et al.* (2018) though their focus was in sub-Sarah Africa in general but still relevant. Additionally, Ngigi *et al.*'s (2017) research in Kenya indicates that while belonging to social groups might help facilitate enhanced access to early warning information and more sources of information for both husbands and wives, a higher proportion of husbands acquire climate information through social groups.

Caine *et al*.'s (2015) review of mobile applications for climate information supports this study's findings where the mobile phones were a convenient means of accessing climate information for the women when they were often limited from other ICT channels due to mobility and time constraints. Besides, women's free time influenced their call patterns, which was also corroborated by GSMA (2012). Owusu *et al.* (2017) also collaborate our qualitative findings where women expressed that they were more likely to use mobile phones to contact market women for market prices; while men did so for agricultural input dealers and to financial institutions.

Physical Capital: The facilities and infrastructure to support farming were considered insufficient in the rural areas versus the urban areas in Kitui. The transportation infrastructure for agricultural development was very poor. Recent infrastructural road developments (Kibwezi-Kitui road project) report by the Kenya National Highways Authority (KNHA, 2018) has seen the residents of Kitui celebrate the first tarmac road since independence in 1963. The road development will facilitate faster movement of goods and services and unlock the economic potential of Kitui and Makueni counties.

A digital divide also exists with unreliable internet access in rural villages or unavailable due to lack of electricity (GSMA 2012). In contrast, mobile telephone and radio reception was widely available and often reliable; therefore, the focus on disseminating climate information was through the available technology. Climate information received through mobile phones and radios helped to reduce transport needs and costs that would have been used traveling to source for the information and enabled the availability of climate information, agricultural inputs, and market sources in a faster and convenient way. Service providers in Kitui were also able to monitor access to local services with ICT tools.

The qualitative findings emphasized the pronounced gendered patterns in the ownership of ICT tools. Generally, men more than women tended to own communication assets such as radios and mobile phones thus potentially limiting women's access to climate information products. These findings are supported by several authors already reviewed (Coulibaly *et al*., 2017; Kyazze *et al*.,

2012; Hampson *et al*., 2014; CICERO, 2018). The younger generation also accessed ICTs more than older men and women.

6.4 The influence of ICT-based climate information on livelihood strategies

The findings in this section answered the third research question and supported hypothesis H3 that livelihood strategies positively change with the use of ICT-based climate information. The quantitative and qualitative results confirmed that for the farmers who received climate information and agro-advisories through ICTs, adopted livelihood strategies like soil and water conservation techniques and crop management practices. The farmers have improved their agricultural yields and productivity, increased savings and earnings and hence increased access to loans.

Using information collected from focus groups and key interviews except for K1, most farmers stated that they had benefited from improved access to information including on protection from weather-related damages, cultivation practices and seed variety selection. The accuracy of weather information accessed by most of the participants helped increase farm productivity and improved livelihoods. It helped farmers adapt to climate change (Cherotich *et al.*, 2012). It means that the results of the farming harvests were affected by the accuracy of the information accessed.

The residents in Kitui achieved food security by practicing climate-smart agriculture (CSA), after receiving ICT based climate information (FAO, 2010b). These climate-smart agricultural practices adopted by the farmers were soil and water conservation, crop management practices, and other non-agricultural practices.

Craufurd and Balaji (2014) further reinforced our findings where access to tailored ICT based climate information (weather, seasonal forecasts and agro-advisories) allowed the farmers to make better use of their land and limited water resources effectively. The farmers were then able to optimize the timing of sowing, planting, fertilizer application, irrigation, harvesting, and spraying of pesticides and herbicides, and improve cropping pattern selection. Ultimately, such improvements helped increase production, reduce losses and decrease production costs.

6.5 Livelihood Assets as Moderating Variables

The findings on livelihood assets as moderating factors support the fourth research question and hypothesis H4 that states that overall livelihood assets moderate effects of ICT Based Climate Information on livelihood strategies. Overall, livelihood assets moderate the effects of ICT Based Climate Information on livelihood strategies.

Drawing from Bourdieu's social capital concept of "social obligations and connections, which is convertible, in certain conditions, to economic capital," institutions in Kitui used women's self-help groups (SHGs) as a channel to address the power dynamics in households. This minimized the institutional bias and gender-based differences in access to group processes that limited women's access to technical information, training and support. Furthermore, women as "communicators" and more gender-sensitive techniques were found to facilitate women's access to ICT based climate information. Therefore, women respondents considered SHGs as effective channels of communication for them to access climate information, agro-advisories, agricultural inputs, credit, community participation, and markets. Specifically, Caritas, KMD, and FAO demonstrated the effectiveness of using women's groups as "knowledge providers" of climate information. Women leaders from diverse types of community-based organizations served as intermediaries between women farmers and the formal institutions that would otherwise exclude or overlook them in the dissemination of climate information and agro-advisories, evidenced from the FGDs and KIs; and supported by Rengalakshmi *et al*. (2018).

Although the Kenyan government has introduced several laws and policies to promote gender equity, discrimination against women remains prevalent in rural Kitui (Knapman and Sutz, 2015). The findings affirmed the fact that the radio is the universal ICT tool, especially for the areas with geographical barriers (ITU, 2005; Myers, 2008). Access to radio signals allowed farmers to surpass geographical barriers. Land, as natural capital, is a vital asset for agriculture in Kitui because it is the gateway to increased access to other opportunities. Despite that, the data from the household survey shows that women's lack of land ownership limits their decision-making power within the household over crop production. Their spouses or parents owned the land, and the land acreage available for cultivation was far less than five acres. This is in concurrence with the customary tenure systems that are patrilineal. The women overcame the

issue of not owning land by acquiring land for cultivation collectively through social network groups or community-based organizations.

Besides, a natural capital like water in Kitui is very scarce. Findings from the household survey show that rural women depended mostly on rain-fed and river water for agriculture and domestic needs. Most were significantly disadvantaged in their access to piped, kiosk, well and dam water. Also, the women had to travel far distances to access water. The FGDs presented mixed findings for gender differences in water use and access. In this study, the GAD tools were relevant to understand how the gender of the informants affected the level of their responsibility and their actual status in their livelihood; supports the thesis of McOmber *et al*. (2013) though their discussion was generic and this study delved on specificity. The men felt they were responsible for the water source since they made sure they had it available for their farming needs and women for domestic use and small-scale farming.

Even though the women, had improved access to some resources through SHGs channels, the lack of critical resources was still a factor among the women participants affirming the power dynamics in the GAD theory on the challenges that exist in the gendered access to resources. In cases where men have more access to livelihood assets, women are excluded from decision-making processes involving livelihood assets such as land was common. The ability to access climate information through mobile phones allowed women to be able to access practicable livelihood assets; therefore, it can be implied that livelihood assets directly grow with the ability to access information.

The effect of human capital on agriculture is a broad and extensive topic. This study is limited on education levels, agricultural labor, ICT knowledge, and extension (climate and agricultural) knowledge services. The gaps in schooling and literacy level and the understanding of the scientific climate data information resulted in less proficient use of ICT tools and climate and agro-advisories information. The FGDs and key informant interviews confirmed the absence of relevant training relevant to this digital age. Given the limited access to schooling, the women respondents were less likely to have the requisite education, knowledge and ICT skills.

Agricultural labor refers to women's ability to produce outputs and supplemental labor; where children and spouses provided non-paid labor. The FGDs established that non-paid labor was common due to assistance from large household sizes of at least six members, small farm acreage and the lack of funds to hire outside labor. The research implemented the GAD Tools analysis in the household survey questionnaire, FGDS, and KIIs (Momsen, 2004). This was implemented to differentiate the experiences of women in receiving climate information and having access to advisories. Using these GAD tools, the identified ICT and the attendant climate information explicitly considered women to be agents of change rather than passive or compliant development recipients (Carr *et al*., 2016; Cornwell, 2016). The male household heads were considered the primary decision-makers in the household and the age (68% = 31-60 years) gave indications of the extent of experience in smallholder farming and the versatility with ICT tools use.

The key informants, through extension agents who were trained as intermediaries, articulated the various methods for communicating climate information and agro-advisories. Extension agents from the county meteorological office and agricultural agents from the county MOA delivered extension services on the ground after going through capacity training (TOT in 2015) on climate information. According to the FGD participants, fewer female heads of households and female spouses in male-headed households had contact with extension agents compared men. The rest were unable to access these extension agents due to social-cultural factors, such as not being seen communicating to a man other than their husbands and lack of financial resources from both the extension agents and the recipients of the climate information. Women who participated in capacity training offered adopted farming practices, including soil fertility management, water management, improved seed varieties, and pest control techniques. This supported the literature by Davis *et al*. (2010).

Women's inability to control and accumulate financial savings in rural communities, especially in developing countries exposes them to adverse impacts of climate change compared to men (Davis *et al*., 2010). For example, the women in the FGDs explained the lack of resources to invest in improved farming practices hindered their crop yields. Their financial status limited their control over what new farming practices to adopt, but the male family members had control

over income and credit. GAD was, therefore, a useful practical and theoretical approach in this research to understand how ICT use ties with gender dynamics in rural villages of Kitui County (Grisby, 2013). GAD helped explain how the women participants' welfare was affected by the lack of resources, which is also gender-based.

Many female respondents did not have time to pursue further education or to assume leadership roles in the community because of the triple burden of productive, reproductive and community activities. The focus group discussions revealed that the majority of women traveled by foot, whereas men used bicycles and motorcycles, and this was due to financial reasons.

The findings from respondents in the household survey offered the challenges in ICT digital capital (accessibility, availability, and affordability). Wyche and Olson (2018) referred to how the state of low usage of ICTs tends to affect women in rural areas more than any other population group. Using the relevant information available, the GAD tools analyzed the lived experiences of the residents, which may be related to their respective genders. The respondents confirmed the same by expressing frustration in the lack of communications infrastructure for the use of new ICTs as the main problem and severe in rural areas of Kitui. Also, the fact that almost 80% of the rural people were not connected to the National Electricity Grid, so they had to depend on solar energy. There was the additional fact that they could not have enough money to pay for the ICT tools and services and electricity.

Despite these challenges, through social capital, channels of communications with the ICT tools enabled access to climate information and sharing among farmers from other villages. Credit, savings, remittances are examples of financial services offered through ICTs that has improved access to climate information increasing income from agricultural farming and livestock; and their livelihood strategies. Participants noted that because of increased access to improved climate information, they were able to increase their profit margins. For some, the availability of climate information through the ICTs increased financial access and augmented remittances from migrant workers.

6.6 Structures and Process as Moderating Variables

The qualitative and quantitative findings that follow support hypothesis H5 (Structures and Processes) positively increases the effects of ICT Based Climate Information on livelihood strategies.

In moderating the relationship between ICT-based climate information and livelihood strategies, Fu and Akter, (2011) support our findings on traditional approaches, where climate information communicated through face-to-face interaction forums in conjunction with ICT tools enhanced the usability of climate information. Traditional approaches included community meetings (*barazas*), workshops, or through the use of key intermediaries such as extension agents. Intermediaries consisting of women leaders from SHGs, chiefs, agricultural agents, and religious leaders assisted with the dissemination of climate information. These are respected community members so when they shared the information they received to the wider community through mobile phones, it was taken as authentic; and supported the World Bank (2012) discourse on the same.

In line with the process of devolution and decentralization, Kitui's County Director of Meteorological Services (CDM) main responsibility is to deliver and develop CIS, which can best support both the development of the County as well as the decision-making needs of the County's principal livelihood groups. The developed Kitui County Climate Information Services Plan (KCCISP) was to deliver accessible, timely, relevant information which support local, sub-county and county-level decision making at time frames of hours, days, weeks, months, seasons and years for improved livelihoods and resilience building towards the impacts of climate change (KCCISP, 2015). KMD used the SLA core principles of people-centered, participatory and partnership with local groups and organizations (Caritas, ASDSP, Media, NDMA, and the Kitui County government) to engage with existing socio-cultural norms around gender roles and behaviors. In partnership with various institutions, KMD disseminated localized and repackaged information via ICT channels into user-friendly products. For instance, respondents received Kitui daily forecasts by text, specific to an AEZ on their mobile phones in the form of text messages (SMS). The radio stations provided climate information and agro-advisories during scheduled radio programs in collaboration with various institutions (KMD, ASDSP, NDMA,

MOAWL, NGOs, and CBOs). Organizations such as Caritas-Kitui, FAO, ASDSP, and MOA facilitated capacity training.

Bourdieu's and the GAD theory helped explain the increasing women's access to male-dominated groups and environments that depended upon significant changes in social processes and shifts in power dynamics at different levels (household and community). The local groups and organizations (ST2, ST3, and ST5) assisted with facilitating access to extension services and training for those currently excluded from such services in their communities. Programs piloted by FAO and Caritas-Kitui, demonstrated the potential for change offered by this kind of approach. After receiving information through radio programs, participants identified significant concerns and development goals. This initiative has demonstrated a positive impact on existing behaviors, practices, and perceptions related to women's role in the community. The key informants from ASDSP, NDMA, and Radio Stations utilized similar approaches in the general distribution of climate information to promote inclusivity and identify the types of information desired by members of the community.

The GAD and Bourdieu's theory of Class and Social capital principles addresses the complex social-cultural norms, political, gender dynamics, and power imbalances in the households and community. For instance, the household survey findings indicated that social and cultural issues increase the effects of ICT based climate information on livelihood strategies positively. After probing separate FGDs, participants identified separate roles and responsibilities of women and men, which vary by socioeconomic status and corroborated by Grassi *et al*., (2015). These triple roles reproductive, productive and community that were highlighted in the GAD theory constrained women in seeking climate and agricultural information due to lack of time, lack of mobility caused by cultural restrictions that prevent specific transportation or lack of approval from husbands (Venktatasubramanian *et al.,* 2014).

Socio-cultural norms as addressed by Bourdieu's social capital concept and the cultural issues in the processes of our conceptual framework were found to limit women's extra-communal mobility, and public interactions between women and men, restricting women's access to agro-climatic training and extension services (Rengalakshmi, Manjula and Devaraj, 2018).

Nevertheless, community-based and female-dominated groups have proven in this study to be an essential means by which women improved their access to climate information. Furthermore, women tended to trust information that came from familiar sources, and at locations, they commonly frequented especially market days, during prayer meetings and around water points (CICERO, 2018; Roncoli *et al*., 2009; Roncoli *et al.,* 2003; *Tall et al*., 2014c).

The FGDs findings revealed pronounced gendered patterns in the ownership of ICT tools. In general, men tendered to own assets such as radios and mobile phones more than women did (Coulibaly *et al*., 2017; Kyazze *et al*., 2012; Owusu *et al*., 2017; CICERO, 2018), thereby limiting women's access to climate information (Coulibaly *et al*., 2017). Additionally, ownership and use of the said ICT tools indicated that younger individuals access ICTs more than older women and men (Cherotich *et al*., 2012; Chaudhury *et al.,* 2012); Kristjanson *et al*., 2012).

6.7 Structures and Process influence the uptake of ICT based Climate Information

The qualitative and quantitative findings were supported by hypothesis H6, that structure and processes in place positively influenced the uptake of ICT based climate information.

Institutions are crucial determinants of how climate adaptation processes take place, and they can play a critical role in ensuring that vulnerable systems adjust to climate changes and uncertainties. They can constrain or allow access to markets, regulations, finance, resources, and technologies vital for potential opportunities posed by climate change.

Within vulnerable communities in Kitui County, the role of institutions has contributed to shaping adaptive capacities and actions. The institutions interviewed have taken the opportunity of the widespread diffusion of ICTs to redefine how information is created, managed, and disseminated. In Kitui County, the institutions have enabled the implementation of various adaptation actions at the community level as discussed in detail in the previous sections; and supported by Rengalakshmi *et al*. (2018) and World Bank (2012).

The growing demand for mobile phones in rural areas has motivated mobile network operators (MNOs) like Safaricom and Airtel to become leading players in the provision of climate and

agricultural information, gaining rural market share and improve their brand loyalty (Caine *et al*., 2015). Despite the growing demand for mobile telephony, the county government needs to invest more in the ICT infrastructure (CIDP, 2018-2022)

Respondents confirmed that networking and decision-making were benefits most valued by respondents. It can be said that the access of the participants to different advisory services helped them plan their livelihood strategies. More than half of the respondents reported that they gained respect when they joined religious organizations and savings groups. Social connections can also mitigate the lack of access to information. The number of respondents who are in leadership positions or who gained visibility by joining these social network groups is less than 40%. Empowerment of these sectors can be improved with access to social capital and ICT tools.

The KMD and government agencies lack the technologies (satellite weather stations) and material resources needed for downscaling climate projections to specific locations (Ziervogel and Zermoglio, 2009). In terms of access, in some government agencies, access to climate information is restricted to only a select few individuals (BBC World Service Trust, 2010; Muchunku *et al.,* 2014). NCCAP [National Climate Change Action Plan, Kenya], confirms the responses that access and use have been inhibited by factors such as language barrier, unsuitable mode of communication, poor infrastructure, and poor repackaging of the information (Muchunku *et al*., 2014).

6.8 Summary

The quantitative and qualitative findings established many factors influenced the success of ICT based climate information and its influence on livelihood strategies. A critical starting point for the success of ICT-based climate information services was ascertaining a comprehensive understanding of the climate information needs of different farmers, mainly the vulnerable (women, elderly, poor) to climate hazards within their specific technological, social-cultural and social-economic circumstances were considered. Table 6.1 below, gives a summary of the factors influencing the success of effective communication of climate information and the theories in the study that helps explain these factors.

Table 6.1: Summary of Barriers to Effective Communication of Climate Information

Barrier	Factor	Explanation	Theory	Source
Social barriers	Cultural barriers	• Reliance on indigenous/ traditional methods of climate forecasts. • Women cannot freely communicate to male extension agents • The belief that CC is an act of God	Bourdieu's social class	Kristjanson *et al*., 2014; Luseno *et al.*,2003; Tall *et al*., 2014c
	Livelihood Assets constraints	• Limited access to television, TVs, and internet; • Limited access to land and water; • Limited access to information sources.	GAD Bourdieu's social class	Mittal,2012; Saravanan, 2011;
	Low capacity to take up CI	• Limited understanding of CC issues; • Limited access to livelihood assets.	GAD Bourdieu's social class	Mpandeli and Maponya 2013; Speranza *et al*., 2010
	Affluence and illiteracy levels	• Urban and educated communities can access and understand CC issues better.	Bourdieu's social class GAD	Karnaisos,2011; Luseno *et al.*,2003;
	Gender	• Gender roles and responsibilities; • Women's limited access to information sources.	GAD Bourdieu's social class	Care International, nd; McOmber *et al.*, 2013 Tall *et al*., 2014b
Content related barriers	Language barrier	• Poor translations of climate change terminologies into local languages.	INAM Bourdieu's social class	BBC World Service Trust,2010a;Harvey,2011;
	Timeliness of CI	• The need for CI before the onset and cessation of rainfall for farming and livestock decision-making plans.	INAM	ALIN,2013; Luseno *et al*., 2003;
	The technicality of the message	• Framing of CI in a format and language that makes it difficult to understand by users	INAM	Luseno *et al*., 2003; Moser,2014;Njuki, 2013;
	The remoteness of the area	• Limits access to climate information; • Farmers have little access to information except through the radio.	INAM	Luseno *et al*., 2003; Saravanan, 2011
Technology related barriers	Digital Divide	• Limited access to ICT, for example, the internet (Rural vs. Urban); • Limited technological skills.	Bourdieu's social class INAM	Luseno *et al.*, 2003; Mittal,2012;Ospina, 2012
	• Digital skepticism	• Fear/Lack of trust in ICT communication channels.	Bourdieu's social class	ALIN, 2013; García de Jalón, *et al*., 2014;

(Source: Researcher, 2019**) Key**: CC- climate change; CI-climate information

From the findings, it was clear that the understanding and use of climate information was hindered by intrinsic and contextual factors in the influence of livelihood strategies, as shown in Table 6.1. Typically, intrinsic factors involved communication approaches used such as ICT channels and packaging of the climate information. The contextual factors involved the community's traditions and religious beliefs; the social structures and networks; indigenous knowledge. It also included locality (rural versus urban), content-related and technological

barriers. Community FM radio stations and mobile phones were the preferred channels for communicating climate information in the ASAL regions of Kitui County which was widely supported in literature from other jurisdictions (Caine *et al*., 2015; Hampson *et al*., 2014; Jones and Siemering, 2012; Mittal, 2016). A critical obstacle observed was how to meet the needs of the farmers economically and sustainably for local specific, timely and relevant climate information. A hybrid of delivery approaches was preferred where the radio and television appeared to be a better delivery method, which used the local language than the mobile phone with SMS.

In addition to the ICT tools, success in delivery of climate information included communication approaches that were interactive and involved known and trusted intermediaries who helped in the interpretation of more complex information — offering the farmers the best opportunity to embrace new agricultural practices. Social network groups were considered important channels for fostering knowledge exchange among the farmers on climate information and this was supported by literature, in this context (Gbetibouo, 2009; Bisht and Ahluwalia, 2014). Projects that included financial and insurance services and focused on the crop calendar gave the farmers an added incentive to use climate information.

Farmers pinpointed infrastructural constraints, lack of access to credit, and lack capacity for risk-taking as the primary factors that constrained the full use of climate information. The lack of critical resources such as land and water among the women participants who lived in sectors with geographical barriers affirmed the power dynamics in the GAD Bourdieu's theory, which established the challenges that exist in the gendered access to resources. The Patriarchy-driven exclusion of women from decision-making processes involving livelihood assets was common where men have more access to livelihood assets. The results showed that the ability to access climate information using the available technology could mitigate the vulnerability of the women in this sector.

In conclusion, the findings of this study and some of the literature already reviewed which confirm that in order to close the science-policy communication gap, messages should be conveyed in a format, language, and form that is captivating and easy to understand for the user.

The success factors above reflect well-established principles of information needs assessment model (INAM), Bourdieu's theory of social capital and the Gender and development theory (GAD). The lesson learned from the responses is not to overlook principles from the supporting theories in the excitement of using ICT tools to provide solutions to information gaps.

CHAPTER 7: ACHIEVEMENTS, LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

In conclusion, there is an overview of the research questions and the main impacts obtained from the field research in this study, considering how it has illuminated the relationship between ICTs, climate information and livelihood strategies. The researcher specifically addressed the achievements of the results based on the research questions. It follows with the contribution to knowledge. There are also clear recommendations for practice and further research.

7.2 Achievements

A rigorous evaluation process using the sustainable livelihoods framework was used in this study as an analytical tool. The documentation generated a rich repository that other researchers can use to advance knowledge. The outcomes of the research include two peer-reviewed journal publications, and six high impact peer-reviewed conference proceedings. These have played an important role in the dissemination of knowledge from the research.

The research questions set at the onset of the study were useful in guiding the research process and evaluating the achievement of the research objectives. This was followed by an overview of the research questions and the main impacts obtained from the field research on the relationship between ICTs, climate information, and rural women's livelihood strategies.

In the first research question, we found that rural communities, especially women, use ICT tools to access climate information. The researcher established that mobile phones are the most available ICT tool in the community that offers affordable access; it was complemented by the radio where literacy and language barriers were a challenge, of value was the incorporation of the radio into the smart mobile phone. Consequently, mobile phones and community radios were found to play a critical role in improving the rural women's access to real-time, relevant climate, and agro-advisories information reducing information asymmetry in the rural context. Television and computers were not used a great deal to access climate information mostly due to the affordability of the said ICT tools making the relationship in hypothesis H1 weak.

The second research question supported the use of ICT-based climate information that positively increased rural women's maximize access and utilization of livelihood assets. The use of the GAD Theory and Bourdieu's Theory of Class and Social Capital explained the factors that prevent women's access to climatic information, such as illiteracy, gender factors, financial factors, language barriers, lack of familiarity with information technologies and socio-cultural attitudes.

The rural women's differing access to ICT and livelihood assets meant women require both different kinds of information, as well as different channels for accessing climate information. These include radio, SMS, and voice messaging, as well as access through social network community groups. The INAM theory further reinforced research question two where there was the requirement to meet the information needs of the residents who stated their desire of climate information that was relevant, accurate timely and in the local language that they could understand.

A number of the findings were also corroborated by the literature reviewed in Chapter 2. For example, Luseno *et al.,* (2003) supported research question two on how ICTs have increased the rural community's access and use of livelihood assets by improving their access to climate information, access to institutions and social networks, reduced transport costs, and financial services.

In addressing research question three, there was evidence that the increasing availability and use of ICT-based climate information by rural women farmers enabled them to adopt new livelihood strategies such as improving on new agricultural practices like crop management, soil and water conservation practices. Women also engaged in alternative livelihood strategies to spread their livelihood risk in cases where they had to cope with severe climate variation. These interventions improved livelihood strategies and led to strengthening their livelihood assets and improving their livelihoods by extension. These livelihood strategy outcomes cannot be attributed to ICT alone, but the manner in which ICTs had been implemented.

The moderating hypothesis H4 depicts a strong relationship where access to various livelihood

assets positively increased the relationship between ICT-based climate information and livelihood strategies. Respondents in the survey and the participants in the FGDs –who had access to social, financial, human, physical and natural capital – enhanced their access to climate information through ICT tools, which in turn helped them adapt to new livelihood strategies. The SHGs the women joined helped them improve their access to these livelihood assets. Development actors in the community disseminated climate information that addressed climate variability and change and targeted the SHGs that had a common goal of improving their livelihoods. Access to small acreage of land for cultivation and access to water was found to be a challenge for most of the rural women and therefore not a robust moderating variable in addressing the relationship between ICT-based climate information and livelihood strategies of the rural women.

The various institutions (Kenya Meteorological Department, agricultural agents, NGO's, agro-vets and the country government) on the ground facilitated access to ICT-based climate information and related agro-advisories by providing capacity training, financial access, ICT infrastructural improvements and implementing ICT and Climate Change standards and policies locally and nationally. Depicting a strong relationship and supports hypothesis five, on how structures and process positively increase the relationship between ICT-based climate information and the new livelihood strategies adopted by small-scale women farmers in the rural community. Although further improvement is still required by the county meteorological offices (ST1) in downscaling relevant, accurate climate information and in formats that can be understood by most. Community-based organizations were found not to contribute strongly as a moderating factor. Past studies on the sustainability of CBOs in Africa show that the primary sources of finance for these organizations are contributions from the members of the organization, society, and donors and most of the CBOs lack sustainability of their projects and they mostly leave some projects hanging hence failing to meet its objectives (Wanjohi, 2010).

The involvements of the community and grassroots intermediaries was identified as the key factors that fostered local ownership and trust of ICT based climate information. It included the availability of content and climate information services that respond to the most pressing needs of the rural women farmers supporting hypothesis six on how structures and process positively

improved the uptake of ICT-based climate information. Low-cost access to ICT infrastructure was necessary for the successful use of ICT in the rural area under study, but this alone was not considered sufficient. Of concern was the implementation of ICT projects that were not sustainable over time, and therefore, the need for organizations and the county government to consider the appropriate incentives to work with the marginalized groups.

Wyche and Steinfield (2016) verifies some of the barriers to ICT use, which was seen to stem from social and institutional structures, and was manifested in a lack of affordability and relevant content, language issues, low functional literacy, attitudes, culture, lack of time and/or lack of interest. For public access facilities in remote rural areas, inappropriate design, content and services, lack of privacy, long waiting times and poor network quality were inhibitors; further cementing the background work by some authors (Ballantyne, 2004; Miller, 2004).

Hypothesis seven that addressed how structures and process influenced the adaptation of livelihood strategies of the small-scale women farmers in the rural community. This is probably because of the top-down implementation of projects that were found not to be successful in rural Kitui because it did not involve the end-users of the information required. The participation of the residents on the onset of implementation of projects was necessary in order to make an impact on the adaptation of livelihood strategies.

Through a disciplined inquiry, using field research in combination with the synthesis of research from literature, this study has supplied evidence and logical arguments in building a case to suggest the merits of the mobile phone and community radios as cost-effective ICT tools in disseminating climate information — consequently, access to the ICT-based climate information influenced the improvement in livelihood assets and livelihood strategies. The researcher has shown how each of the constructs in the conceptual framework played a central role, often reinforcing each other, thereby providing a better understanding of how ICTs can contribute to improving the livelihoods of those most in need the rural women. Ultimately, the research finding shed light on the nexus between ICT based climate information usage, the power dynamics in the intra-household setting, and the improvement in rural livelihoods.

7.3 Contribution to Knowledge

i. The thesis generated a rich repository that other researchers can use to advance knowledge, and the outcomes are eight peer-reviewed articles.

ii. Methodological Contribution-The operationalization of the SLF as an analytical tool and testing the framework in a quantitative methodological approach contributed to ICT4D.

iii. Digital System – the integration of the Digital System (ICT Tools and Digital Capital) reinforced the SLF in addressing climate change, ICT and gender discourse.

iv. GAD, Bourdieu, and INAM theories provided a better understanding of the gendered factors and intra-household dynamics as crucial factors to consider in influencing policy in the ICT-CC and Gender discourse.

7.4 Conclusions

This study has four key conclusions.

i. The researcher set out to test the sustainable livelihood framework for understanding whether ICTs can contribute to livelihoods through access to climate information. The result is a modified conceptual framework based on the sustainable livelihood framework characterized by a forward-looking future longitudinal perspective, exploring the interaction between micro-, meso-, and macro-levels that will address livelihood outcomes in a future study. Even though the scope of the research is insufficient to generalize about relationships between ICT and the constructs (ICT tools, digital capital, climate information, livelihood assets, structures, processes, and livelihood strategies) in the SLF in general, the conceptual framework and the theoretical models were useful for understanding the drivers and processes linking ICT with these constructs. Informed by the sustainable livelihood approach, the enhanced framework represents a new way of operationalizing this multi-purpose SLF.

   A key finding was that these constructs were interrelated and driven by knowledge. For example, knowledge derived from access to climate information through ICT mediated activities expanded farming practices in the AEZ catchment areas in Kitui. The application of these farming practices in the form of new livelihood strategies showed results such as improved yields and productivity. By offering the farmers greater choices, the findings

showed the use of the enhanced SLF as an analysis tool empowered and encouraged farmers to seek more climate information. Another notable finding was that it was not ICT *per se* that drove these processes; the answer lay in how ICT was implemented in a community setting to derive benefits to the community users.

Therefore, the various responses and systematic analysis made the enhanced framework relevant to gaining insights into the link between climate information and livelihood strategies through ICTs among rural communities in Kitui. The framework and the research findings are also timely in light of the increasing realization of ICTs potential in contributing to climate change adaptation and mitigation.

ii. The findings in this study have shown that ICTs provide rural households with speedy and accessible modes of communication, thereby increasing their ability to maximize access and utilization of the livelihood assets. The mobile phone and the community FM radio stations, the most used ICT tools, contributed to a reduction in poverty and improved rural livelihoods in several ways. First, the expansion and strengthening of social networks increased people's ability to address emergencies and work together. By extension, this reduced costs and increased productivity. Second, mobile phones enabled rural farmers to cut down on travel costs. This minimized physical risks and maximized outcomes of necessary journeys. It amplified activities efficiency and the ability to send and receive money. Third, ICT tools, particularly the mobile phone, help rural traders and farmers to secure better markets and prices; and save time. It also helped them to communicate climate-related information in real-time.

iii. It is evident that providing women with access to assets, and means to generate more income may enable them to improve their livelihood better, but for it to be transformative to address the root causes of poverty and gender inequality calls for more than facilitation women's access to assets or creating enabling institutions, laws and policies. There is a need for a shift in consciousness and an engagement with culturally embedded normative beliefs, understandings and ideas about gender, power and change. This requires a process of empowering women's organizations by shifting their consciousness that includes overturning

limiting normative beliefs and expectations that keep women locked into situations of subordination and dependency, challenging restrictive cultural and social norms and contesting the institutions of everyday life that sustain inequality. SHGs, where women come together with other women to share experiences and offer solidarity, shifts the process in which they think of themselves and their entitlements not only as individuals but also as people who share something in common. Therefore, by targeting women's organizations, plays a vital role in supporting women's empowerment. A vital dimension of this role is the relationship of trust, loyalty, and that that often bind these organizations together and are part of a story of effectiveness.

iv. The use of mixed methods approach informed by the sustainable livelihoods framework as an analytical tool, and various theoretical models from different disciplines were achieved successfully in this study. The theories underpinning the theoretical models comprised of the SLF and INAM model, GAD, and Bourdieu's Theory of Class and Social capital. The research employed SEM to test hypotheses from empirical data for the quantitative strand of the study and thematic analysis for the qualitative data.

In summary, the research provided empirical evidence on the interconnection between ICT based climate information and better livelihoods in a context never studied for this, that is rural Kitui. It served its purpose as an illustration of the conceptual model and an empirical test of the framework.

7.5 Recommendations

The outcomes of this research yielded new knowledge that should benefit various actors, such as, policymakers, researchers, practitioners, and rural communities on how to promote better use of ICTs for climate information; and commission relevant studies in similar jurisdictions for they can make decisions from an informed position. The limitations highlighted in the study provide a basis for further studies. There are opportunities for more in-depth study to understand the various ICT tools that will allow timely climate information dissemination to achieve development objectives.

7.5.1 Recommendations for Practice

The engagement with practice was a key strength in the study, notably the collaboration with local staff from various institutions in the fieldwork. Drawing comparisons and contrasts with other projects already in place by intermeshing experiences from other studies into this research strengthened the understanding of the contextual issues. The findings of the research and the attendant recommendations may be replicable to other counties in Kenya because rural households depend on agriculture for their livelihood and this economic sector is not exempt to climate change and variability necessitating the need for local specific climate information. The findings may also benefit practitioners and policymakers on how best to package and disseminate valuable information for the benefit of rural populations in the country. Specifically, government agencies that deal with agricultural enhancement, poverty eradication, and meteorological services to reduce people's vulnerability to climate extremes. Other actors such as NGOs that operate in Kitui County and other ASAL areas, particularly for food and nutrition security. The specific area of recommendations to the various stakeholders are:

i. For practitioners and policymakers, the findings of this research include a clear indication of which local or national climate information is accessed via ICTs; and how useful the information has been in influencing livelihood strategies. The evidence from Kitui shows how to better package and disseminate climate information to rural farming communities. This study is therefore beneficial in highlighting factors to consider when deploying ICTs in rural areas too.
ii. The research findings will assist the local stakeholders on how to optimally benefit from the use of ICT tools in access to climate information. For example, in establishing contact with broader agricultural networks and experts and in exchanging technical information with local and external peers).
iii. For ICT service providers, such as mobile phone service providers and community radio stations, the research outcomes show the potential in boosting the client-base in rural areas. This can be achieved by introducing innovative packages, affordable bundles, and region-specific messages.
iv. Further, the findings of this study highlight the potential opportunities for rural farmers to start using ICTs in their demand for climate information instead of using ICTs for social

communication only. The business side to household ICTs will influence the quality of life that rural communities lead.

v. The findings from the research can potentially address the management of climate information and knowledge where:
    a. Access to a toll-free telephone number that people can call to access climate information promptly.
    b. Dissemination of climate information in the preferred local dialect.
    c. Voice-based activated climate information knowledge to address illiteracy.

vi. Partnerships with Industry (Mobile service providers) in the dissemination of climate information in USSD format for those who cannot afford smartphones and still have 2G phones.

vii. The Kenyan government has formulated the National Climate Change Response Strategy (NCCSR) and National Climate Change Action Plan (NCCAP) to guide adaptation planning in the country to minimize the negative impacts and optimize on the opportunities presented by climate change. However, for the proposed measures to be effective and widely adopted they have to be supported by ICT for development and incorporate gender issues, something that has been lacking in most National Adaptation Plans of Action (NAPAS) and other climate change adaptation policy documents in the region. Policymakers have the view that a general policy benefits all, and there is no such thing as a gender-blind ICT policy; therefore findings from this research can be used to inform climate change adaptation policies, plans and strategies in Kenya that integrates gender equality into ICT and climate change for sustainable development.

7.5.2 Recommendations for Further Research

While the research provided empirical evidence on the interconnection between ICT based climate information and the African gender perspectives in climate change and the potential women possess in transforming the climate change process, some knowledge gaps exist that future researcher can explore:

i. The researcher excluded any measurement of change in livelihood outcomes in the SLF because of time constraints that affect doctoral studies, and the longitudinal timeframe of such a project that was beyond the scope of this study. This did not affect the outcome of the

study and the contribution to knowledge, but research can further be extended to cover outcomes that will look at improved income, sustainable resource utilization, food security, and physical and emotional wellbeing.

ii. The specified structural model based on the modified SLF as a quantitative analysis tool formed the underlying structure for coding and analysis of data, findings and in the understanding of interactions between the constructs of the model. Its central tenet is the reinforcing relationships between ICT based climate information and the constructs in the model. There is a need for further validation of the modified SLF model by replicating to non-ASAL areas or other farming systems in other counties in Kenya, keeping in mind the social-cultural context of the area.

iii. On a related note, McOmber *et al.* (2013) have rightly noted, "Just as traditional methods of information sharing are gendered, and there are also gender factors to consider when analyzing usage of ICTs." More research is required to better understand how to support women's aspirations to be part of the solution to the challenges of climate change in Africa. It will aid those responsible for knowing how to make deliberate efforts to assist in the climate change debate and the factors that constrain women into being part of the voices of change in climate change issues in different areas. The issues from here are similar to other African countries where the patriarchal society persists but can be tailored to suit their environment.

iv. There is a need for research to go beyond gender sensitivity and inclusivity to gender-oriented action plans. Including women in societal decisions making processes on climate change alone is not enough. There is a need to turn what women say in meetings into action points, and this requires more research with governments, learning institutions and think tanks to address deep-rooted gender inequalities in Africa.

REFERENCES

Abdimajid N., N. J. Muthama, I. J. Mwalichi and J. Kinama, 2019. Comparative Analysis of the Role of Gender in Climate Change Adaptation between Kajiado and Kiambu County, Kenya. Vol 2, issue 1, pp. 28-37.https://doi.org/10.20987/jccs.3.03.20

Adera, E. O., Waema, T. M., May, J., Mascarenhas, O., and Diga, K. 2014. *ICT pathways to poverty reduction: Empirical evidence from East and Southern Africa*, Rubby, UK: Practical Action Publishing.

Africa, I., 2018. Use and communication of climate information to support uptake of adaptation actions in semi-arid regions in Africa and Asia.

African Science News, 2016. How Women in Kitui County Cope with Aftershocks of Climate Change. Clifford Akumu. Available at: https://africasciencenews.org/how-women-in-kitui-county-cope-with-aftershocks-of-climate-change/ [Accessed 17 July 2019]

Aguilar, L. 2009. Women and climate change: Vulnerabilities and adaptive capacities. State of the World: Climate Connections. 26th ed. Washington: World Watch Institute. pp. 59-62. Available at: <http://www.worldwatch.org/files/pdf/SOW09_CC_women.pdf> [Accessed 18 March 2016]

Aker, J. C. and Mbiti, I. M. 2010. Mobile Phones and Economic Development in Africa: CGD Working Paper 211. Washington, D.C.: Center for Global Development. [Online] Available at: <http://www.cgdev.org/content/publications/detail/1424175> [Accessed 18 March 2016]

Alampay, E., 2006. Analyzing socio-demographic differences in the access and use of ICTs in the Philippines using the capability approach. EJISDC, 27(5), pp, 1-39.

Anfara, A. V. and Mertz, T. N. (eds)., 2006. Theoretical frameworks in qualitative research. Thousand Oaks: Sage Publications Inc.

Apgar, M., Kniveton, D., Naess, L.O., Orindi, V., Abuya, N. and Bonaya, M., 2017. Improving the Impact of Climate Information Services in Kenya's Arid and Semi-Arid Lands.

Asare, K., 1997. Women find a shorter route to the classroom. [Online].Available at: <http://www.afronets.org/archive/199705/msg00009.php.>[Accessed 9 September 2015]

Ashley, C. and Carney, D., 1999. Sustainable livelihoods: Lessons from early experience. London: Department for International Development DFID. [Online]
Available at: <http://livelihoods.org/info/docs/nrcadc.pdf > [Accessed 5 January 2015]

Agricultural Sector Development Support Programme (ASDSP). 2014. Volume1: Household baseline Survey Report, Kitui County.

Aregu, L., Puskur, R., Renard, G., Hoekstra, D. and MacMillan, S. 2011. Gender—empowering women through value chain development: Good practices and lessons from IPMS experiences. Nairobi, Kenya: ILRI.

Archer, E.R., 2003. Identifying underserved end-user groups in the provision of climate information. Bulletin of the American Meteorological Society, 84(11), p.1525.

Ayieko, F., 2001. Worldspace radios link up the rural. [Online] Available at: <http//www.Kenya.ms.dk/partnernews/visartikel.asp?id=209> [Accessed 15 January 2014]

Babbie, E., 2004. The practice of social research. 10th ed. Belmont, CA: Wadsworth

Babbie, E. and Mouton, J., 2001. The practice of social research. (South African edition). Cape Town: Oxford University Press Southern Africa.

Ballantyne, P., Labelle, R. and Rudgard, S., 2000. Information and knowledge management: challenges for capacity builders. [Online] (Policy Management Brief No. 11).Maastricht: ECDPM. [Online] Available at: < http://www.chs.ubc.ca/lprv/PDF/lprv0075.pdf> [Accessed 2 October 2014]

Bandias, S.E., 2010. Building indigenous social capital in an online world. Platform: Journal of media and communication, (April 2010), pp.38-51.

Barret, S. and Ndegwa, W., 2016. Economic valuation of the Kenya meteorological department's decentralised provision. Kitui County, Kenya.

Behnke, R. and Muthami, D., 2011. The contribution of livestock to the Kenyan Economy: IGAD livestock policy initiative. Working Paper, pp. 1–62.

Bhavnani, A., Chiu, R.W.W., Janakiram, S., Silarszky, P. and Bhatia, D., 2008. The role of mobile phones in sustainable rural poverty reduction. [Online] Available at: https://www.share4dev.info/kb/documents/4266.pdf [Accessed 22 November 2016].

Boomsma, A., 1987. The robustness of maximum likelihood estimation in structural equation models. In Cuttance, P. & Ecob, R. [Eds.] Structural Modeling by Example: Applications in Educational, Sociological, and Behavioral Research. Cambridge University Press, 160–188.

Boserup, E., 1970. Women's role in economic development. New York: St. Martin's Press.

Bryman, A., 2004. Social research methods. 2nd ed. New York: Oxford University Press.

Bryman, A., 2006. Integrating quantitative and qualitative research: How it is done? Qualitative Research, 6, pp.97-113

Burrel, J., 2008. Livelihoods and the mobile phone in rural Uganda, Grameen Foundation USA.

Caine, A., Dorward, P., Clarkson, G., Evans, N., Canales, C., Stern, D. and Stern, R., 2015. Mobile applications for weather and climate information: their use and potential for smallholder farmers. CCAFS Working Paper no.150. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

Carney, D., 1998. Implementing the sustainable rural livelihoods approach. London: Department for International Development.

Caracelli, V. J. and Greene, J.C., 1993. Data analysis strategies for mixed-method evaluation designs. Educational evaluation and policy analysis, 15(2), pp.195-207.

Carr, E.R., Fleming, G. and Kalala, T., 2016. Understanding women's needs for weather and climate information in agrarian settings: The case of Ngetou Maleck, Senegal. *Weather, Climate, and Society*, *8*(3), pp.247-264

Carr, E. and Onzere, S.N., 2018. Really effective (for 15% of the men): Lessons in understanding and addressing user needs in climate services from Mali.

Chambers, R. and Conway, G. R., 1991. Sustainable rural livelihoods: Practical concepts for the 21st Century. [pdf] Brighton, UK: Institute for Development Studies. [Online]
Available at: <http://community.eldis.org/.59b4ab37/ dp296.pdf> [Accessed 19 September 2014].

Chambers, R. and Conway, G. R., 1992. Sustainable rural livelihoods: Practical concepts for the 21st Century. Discussion paper 296, Institute for Development Studies, University of Sussex, UK.

Chapman, R., Slaymaker, T. and Young, J., 2001. Livelihoods Approaches to Information and Communication in Support of Rural Poverty Elimination and Food Security. London, ODI, DFID &FAO.

Chapman, R. and Slaymaker, T., 2002. ICTs and rural development: Review of literature, current interventions, and opportunities for action. Working Paper 192. London: Overseas Development Institute.

Chapman, R., Slaymaker, T. and Young, J. (2004) Livelihoods approaches to information and communication in support of rural poverty elimination and food security: A literature update. Research Report. London: Overseas Development Institute

Chapman, R., Blench, R., Kranjac-Berisavljevic, G. and Zakariah, A.B.T., 2003. Rural radio in agricultural extension: the example of vernacular radio programs on soil and water conservation in N. Ghana. Agren Network Paper, 127, p.2.

Cherotich, V.K., Saidu, O. and Bebe, B.O., 2012. Access to climate change information and support services by the vulnerable groups in semi-arid Kenya for adaptive capacity development. African Crop Science Journal, 20, pp.169- 180.

Chaudhury, M., Kristjanson, P., Kyagazze, F., Naab, J.B. and Neelormi, S., 2012. Participatory gender-sensitive approaches for addressing key climate change-related research issues: Evidence from Bangladesh, Ghana, and Uganda.

Coltman, T., Devinney, T.M., Midgley, D.F. and Venaik, S., 2008. Formative versus reflective measurement models: Two applications of formative measurement. Journal of Business Research, 61(12), pp.1250-1262.

Cornwall, A., 2016. Women's empowerment: What works?. Journal of International Development, 28(3), pp.342-359.

County Integrated Development Plan (CIDP) for Kitui, 2018–2022. Government Publication, pp. 1–612.

Cramer, L., Förch, W., Mutie, I. and Thornton, P.K., 2016. Connecting women, connecting men: how communities and organizations interact to strengthen adaptive capacity and food security in the face of climate change. Gender, Technology and Development, 20(2), pp.169-199.

Craufurd, P.Q. and Balaji, V., 2014. Using information and communication technologies to disseminate and exchange agriculture-related climate information in the Indo-Gangetic Plains.

Creswell, J. W., 2003. Research design: Qualitative and quantitative approaches (2nd ed.). London: SAGE Publication.

Creswell. J. W., 2007. Qualitative inquiry and research design: Choosing among five approaches (3rd ed.). Thousand Oaks, CA: Sage.

Creswell, J. W., 2009. Research design: Qualitative and quantitative and mixed-method approaches (3rd ed.). London: SAGE Publication.

Creswell, J. W., and Clark, V. P., 2007. Designing and conducting mixed methods research. Thousand Oaks: Sage Publications Inc.

Creswell, J.W. and Plano Clark, V.L., 2008. The mixed methods reader. London: SAGE Publication

Creswell, J. W., and Plano Clark, V., 2011. Designing and conducting mixed methods research (2nd ed.). London: SAGE Publication

Creswell, J. W., and Garrett, A. L., 2008. The "movement" of mixed methods research and the role of educators. South African Journal of Education, 28(3), pp 321–333

Crotty, M., 2003. The foundations of social research: Meaning and perspective in the research process. London: Sage Publications.

Curtain, R., 2003. Information and communications technologies and development: Help or Hindrance? Curtain Consulting/ the Australian Agency for International Development: Melbourne, Australia.

Deacon, D., 2008. "Why Counting Counts." In Pickering, M. (Ed), Research Methods for Cultural Studies, Edinburgh UP, Edinburgh, pp, 89-104.

De Haan, L.J., 2000. Globalization, localization and sustainable livelihood.Sociologia Ruralis, 40(3), pp.339-365.

Deloitte, 2012. eTransform Africa: Agriculture sector study (Sector Assessment and Opportunities for ICT).Deloitte Consulting. [Online] Available at:<http://www.e-

agriculture.org/sites/default/files/uploads/ media/Complete-Report Agriculture_1.pdf.> [accessed 14 November 2014]

Denton, F., 2002. Climate change vulnerability, impacts, and adaptation: why does gender matter? Gender and Development, 10(2), pp. 10-20.

Denton, F., 2004. Gender and climate change: Giving the "latecomer" a "head start." Institute of Development Studies Bulletin, 14(3), pp. 42-49.

Dhingra, A. and Misra, D. C., 2004. Information Needs Assessment Model (INAM) for identifying the information needs of rural communities. Information Technologies and International Development, 2(2), pp. 77-78.

De Silva, H., and Ratnadiwakara, D., 2008. Using ICT to reduce transaction costs in agriculture through better communication: A case study from Sri Lanka. LIRNEasia. [Online] Available at: <http://www.lirneasia.net/wp content/uploads/2008/11/transactioncosts.> [accessed 16 September 2014]

DfID. 1999. Sustainable livelihood guidance sheets. Numbers 1–8, London: Department for International Development. [Online]. Available at www.livelihoods.org. [Accessed 16 September 2014]

DfID. 2005. The economic impact of telecommunications on rural livelihoods and poverty reduction: A study of rural communities in India (Gujarat), Mozambique and Tanzania. Report of DFID KaR Project 8347

DfID. 2009. Eliminating world poverty: Building our common future. London: DfID.

Duncombe, R., 2006. Analyzing ICT applications for poverty reduction via micro-enterprise using the livelihoods framework: Theorising ICT and development by applying a livelihoods approach, Working Paper Series Paper No. 27, Institute for Development Policy and Management, Manchester. [Online] Available at:<http://www.sed.manchester.ac.uk/idpm/research/publications/wp/di/documents/DIWkPpr27.pdf> [accessed 16 September 2014]

Duncombe, R., 2012. Understanding Mobile phone impact on livelihoods in developing countries: New Research Framework. Centre for Development Informatics, University of Manchester, UK.

Easterby-Smith, M., Thorpe, R., and Lowe, A., 2003. Management research: An introduction (2nd ed.). London: SAGE Publication.

Ellis, F., 2000. Rural livelihoods and diversity in developing countries. Oxford, Oxford university press.

Esterhuysen, A., 2002. Networking for a purpose: African NGO's using ICTs. [Online]. Available at <http://www.piac.org/rowing_upstream/chapter1/ch1spectrum.html> [Accessed 13 January 2015]

FAO, 2011a. The State of Food and Agriculture (SOFA). Women in Agriculture: Closing the gender gap for development, FAO, Rome.

Finlay, A. and Adera, E., 2012. (eds) Application of ICTs for climate adaptation in the water sector: Developing country experiences and emerging research priorities. APC and IDRC: South Africa.

Gelo O., Braakmann D. and Benetka G., 2008. Quantitative and qualitative research: Beyond the debate. Integrative Psychological & Behavioral Science, 42, pp. 266-290

Gitelman, L., 2013. Raw data is an oxymoron. Harvard (US), Infrastructures Series, MIT Press,
Gioia, D., A. and Pitter, E., 1990. Multiparadigm perspectives on theory building. Academy of management review, 15(4), pp. 584-602.

GOK. 2010. National climate change response strategy. Nairobi, Kenya: Government of Kenya, Ministry of Environment and Mineral Resources.

GoK, 2013. National Climate Change Action Plan 2013- 2017. Republic of Kenya, Nairobi.

Greene, J.C., 2008. Is mixed methods social inquiry a distinctive methodology? Journal of mixed methods research, 2(1), pp.7-22.

Greenberg, A., 2005. ICTs for poverty alleviation: Basic tool and enabling sector, Swedish International Development Cooperation Agency (Sida)

Grigsby, B., 2013. Anthropology/Sociology 460: Women in poor countries. Eastern Oregon University.

Grimshaw, D. J. and Kala, S. (Ed), 2011. Strengthening rural livelihoods: The impact of information and communication technologies in Asia. Ottawa; International Development Research Centre.

GSMA, 2011. The GSMA mobile money for the unbanked team. GSMA Annual Report.

Guest, G., 2013. Describing mixed methods research: An alternative to typologies. Journal of Mixed Methods Research, 7(2), pp.141-151.

Gumucio, T., Hansen, J., Huyer, S. and van Huysen, T., 2018. Gender responsive rural climate services: A review of the literature. A learning Agenda for Climate Information Services in sub-Saharan Africa (USAID)

Gunasekera, D., 2004. Economic issues relating to meteorological services provision. BMRC Research Report N0. 102. Bureau of Meteorology. Research Centre: Melbourne Australia.

Gurumurthy, A., 2004. Gender and ICTs: Overview report. Brighton: Institute of Development Studies.

Haidar, M., 2009. Sustainable Livelihoods Approaches: The framework, lessons learned from practice and policy recommendations. UNDP

Hair, J., Black, W., Babin, B. and Anderson, R., 2010. Multivariate data analysis. Upper Saddle River, NJ: Prentice Hall.

Hansen, J.W., Baethgen W., Osgood D., Ceccato P and Ngugi R. K., 2007. Innovations in climate risk management: Protecting and building rural livelihoods in a variable and changing climate. Journal of Semi-Arid Tropical Agricultural Research, 4(1), pp.20-41.

Heeks, R., 2010. Do information and communication technologies (ICTs) contribute to development? Journal of International Development, 22(5), pp. 451-470.
Heeks, R., and Molla, A., 2009. Impact assessment of ICT-for-development projects: A compendium of approaches. Development Informatics. Working Paper Series. Paper No. 36. Development Informatics Group, University of Manchester: Manchester.

Heffernan, C., Lin, Y., and Thomson, K. I. M. 2012. Drawing from development : towards unifying theory and practice of ICT4D. Journal of International Development, (October). doi:10.1002/jid

Hooper, D., Coughlan, J., and Mullen, M.: Structural equation modelling: Guidelines for determining model fit. Electronic Journal of Business Research Methods, 6(1), 53-60

Hulme, M., R. Doherty, T. Ngara, and M. New., 2005. Global warming and African climate change: A reassessment. In P. S. Low, Climate change and Africa, ed. Cambridge, UK: Cambridge University Press.

InfoDev., 2012. Mobile Phone Usage at the Kenyan Base of the Pyramid. (InfoDev), Washington DC: World Bank.

Intergovernmental Panel on Climate Change (IPCC), 2001. Climate Change 2001: Impacts, Adaptations and Vulnerability, Report of working group II.

IPCC, 2007. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2014. Summary for Policy Makers. In Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.), Climate change 2014: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

International Telecommunications Union (ITU), 2005. ICTs for MDGs: ITU world summit on the information society: Geneva 2003-Tunis 2005.

ITU, 2008. ICTs for e-Environment Guidelines for Developing Countries, with a Focus on Climate Change (Vol. Final report). Geneva: International Telecommunication Union (ICT Applications and Cybersecurity Division).

ITU, 2009. Manual for Measuring ICT Access and Use by Households and Individuals. International Telecommunication Union.

ITU., 2010. World Telecommunication/ICT Development Report 2010- Monitoring the WSIS targets: A mid-term review. Geneva: International Telecommunication Union

ITU, 2012c. The coalition on ICT and climate change. Available at:
< http://www.itu.int/themes/climate/events/cop17/ICTcoalition.html.> [Accessed 3 October 2014].

ITU, 2014. ITU-T SG5: Environment and climate change. Available at:
<http://www.itu.int/en/ITU-T/studygroups/2013-2016/05/Pages/default.aspx>[Accessed 3 October 2014].

ITU. 2014. Resilient Pathways: The adaptation of the ICT sector to climate change. [Online] Available at:
<http://www.itu.int/en/ITU-T/climatechange/Documents/Publications/Resilient_Pathways-E.PDF>
[Accessed 3 October 2014].

Jaetzold, R., Schmidt, H., Hornet, Z.B. and Shisanya, C.A., 2007. Farm Management Handbook of Kenya. Natural Conditions and Farm Information, 2nd edition, Vol. 11/B. Ministry of agriculture/GTZ, Nairobi, Kenya (Eastern Province) Central Kenya.

Jebet, D., 2003. Empowering rural poor. [Online] Available at:
< http://216.185.134.103/archives/october/fri03102003> [Accessed 3 October 2014].

Kalas, P. P. and Finlay, A., 2009. Planting the knowledge seed: Adapting to climate change using ICTs. Building Communications Opportunities (BC) Alliance.
Available at: <http://www.bcoalliance.org/climate-change> [Accessed on 1 April 2016].

Karanasios, S., 2011. New and emergent ICTs and climate change in developing countries. Centre for Development Informatics Institute for Development Policy and Management, SED. University of Manchester. [Online] Available at: http://www.niccd.org/resourcepapers. [Accessed on 15th, November 2015].

Karanja, F and Kabubo-Mariara, J., 2007. The economic impact of climate change on Kenyan crop agriculture: A Ricardian approach. World Bank Development Research Group Sustainable Rural and Urban Development Team, pp. 1–40.

Kenya Food Security Steering Group (KFSSG) and Kitui County Steering Group. 2015. Kitui County 2015 long rains food security assessment report. Government Publication, pp. 1–20.

Kitui County, First County Integrated Development Plan. 2013-2017. [Online]. Available at: <http://www.kituicountyassembly.org/userfiles/KITUI%20COUNTY%20INTEGRATED%20DEVELOPMENT%20PLAN%20July%202014(1).pdf> [Accessed 16 January 2016]

Kituyi-Kwake, A. and Adigun, M.O., 2008. Analyzing ICT use and access amongst rural women in Kenya. International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2008, 4(4), pp. 127-147.

Kenya National Bureau of Statistics (KNBS), 2010. 2009 National demographics. Nairobi: Government of Kenya Publication.

Kenya National Bureau of Statistics (KNBS), 2015. Spatial Dimension of Well-Being in Kenya: Where are the Poor? Nairobi: KNBS.

Kollmair, M. and Gamper, S., 2002. The sustainable livelihoods approach. Input Paper for the Integrated Training Course of NCCR North-South Aeschiried, pp.9-20.

Kniveton, D.R., Smith, C.D. and Black, R., 2012. Emerging migration flows in a changing climate in dryland Africa. Nature Climate Change, **2**(6), pp.444-447.

Kwake, A. and Adigun, M., 2008. Analyzing ICT use and access amongst rural women in Kenya. International Journal of Education and Development using ICT, **4**(4).

Williams, L.J. and Holahan, P.J., 1994. Parsimony-based fit indices for multiple-indicator models: Do they work?. Structural Equation Modeling: A Multidisciplinary Journal, **1**(2), pp.161-189. doi:10.1080/10705519409539970

Lei, Pui-Wa and Wu, Qiong. (2007). Introduction to structural equation modeling: Issues and practical considerations. Educational Measurement: Issues and Practice, 26. 33 - 43.

Levy, P. and Lemeshow, S. (2013). Sampling of populations: methods and applications. Hoboken, John Wiley and Sons.

Mallalieu, K. and Rocke, S., 2007. Selecting Sustainable ICT Solutions for Pro-Poor Intervention. In H. Galperin and J. Mariscal, Digital Poverty: Latin America and Caribbean Perspective, Intermediate Technology Publications Ltd., and the International Development Research Centre, Warwickshire, UK, pp. 119-140.

Manfre, C. and Nordehn, C., 2013. Exploring the promise of information and communication technologies for women farmers in Kenya. *Cultural practice, LLC, MEAS Case Study*, *4*.

Marchand, M.H. and Parpart, J.L. (Eds.), 2003. Feminism/Postmodernism/Development. London: Routledge

May, J., 2010. Digital and other poverties: Exploring the connection in four East African countries. Mimeo, University of KwaZulu-Natal, South Africa

May, J., Waema, T., and Bjastad, E., 2014. Introduction: The ICT/poverty nexus in Africa. In E. Adera et al. (eds.) ICT Pathways to Poverty Reduction: Empirical evidence from East and Southern Africa. Ottawa: Practical Action Publishing. pp. 1 – 31.

Meinke, H. and Stone, R.C., 2005. Seasonal and inter-annual climate forecasting: the new tool for increasing preparedness to climate variability and change in agricultural planning and operations. Climatic Change, 70(1-2), pp.221-253.

McNamara, K., 2003. Information and communication technologies, poverty and development: learning from experience, framework for thinking about ICTs, poverty, and development. Washington, DC: Information for Development Program (InfoDev), World Bank.

McOmber, C., Panikowski, A., McKune, S., Bertels, W. and Russo, S., 2013. Investigating climate information services through a gendered lens. CCAFS Working Paper No. 42. [Online]
Available at: < www.ccafs.cgiar.org >[Accessed 20 February 2014]

Miles, M.B. and Huberman, A.M., 1994. Qualitative data analysis: An expanded sourcebook, 2nd ed., Sage Publications, Newbury Park, CA.

Mittal, S., Gandhi, S. and Tripathi, G., 2010. Socio-economic impact of mobile phones on Indian agriculture (p. 53). New Delhi: Indian Council for Research on International Economic Relations.

Momsen, J. H., 2004. Gender and development. New York: Routledge Perspectives on Development.

Mugenda, O.L. and Mugenda, A.G., 1999. Research methods: quantitative and qualitative approaches. Nairobi: African Centre for Technology studies.

Mugenda, O.M and Mugenda, A.G., 2003. Social sciences research. Revised Edition. Nairobi, Acts Press.

Munyua, H. 2000. Application of ICTs in Africa's agricultural sector: a gender perspective. In E. M. Rathgeber, and E. O. Adera (Eds.), Gender and the Information Revolution in Africa. Ottawa: International Development Research Centre

Munyua, H. and Adupa, J., 2002. Improving rural livelihoods through community telecentres: the case of Uganda. Presentation given at Kenya College of Communications Technologies (KCCI) in June 2002.

Munyua, H., 2007. ICTS and small-scale agriculture in Africa: A scoping study. Ottawa: IDRC.

Mutimba, S. Mayieko, S. Olum, P and Wanyama, K. (2010) Climate change vulnerability and adaptation preparedness in Kenya. Heinrich Boll Stiftung, East Africa, pp. 1–61.

Musiyiwa, K., Leal Filho, W., Nyamangara, J. and Harris, D., 2015. An Assessment of Gender Sensitive Adaptation Options to Climate Change in Smallholder Areas of Zimbabwe, Using Climate Analogue Analysis. In Adapting African Agriculture to Climate Change pp. 109-117. Springer, Cham.

Myers, M. (2008) Radio and development in Africa: A Concept Paper Prepared for the International Development, Research Centre (IDRC) of Canada.

Nagel T., 1986. The view from nowhere. New York, NY: Oxford University Press.

Neuman, W., 2005. Social research methods: Quantitative and qualitative approaches. Boston, MA: Allyn and Bacon.

Nevin, E., Behan, A., Duffy, G., Farrell, S., Harding, R., Howard, R., Mac Raighne, A., and Bowe, B., 2015. Assessing the validity and reliability of dichotomous test results using Item Response Theory on a group of first-year engineering students. The 6th Research in Engineering Education Symposium (REES 2015), Dublin, Ireland, July 13-15.

Ngigi, S. (2009). Climate change adaptation strategies. Water Resources Management Options for Smallholder Farming Systems in Sub-Saharan Africa, pp. 1–189.

Obuya, C., 2003. Horn of Africa Regional Women's Knowledge Network (HAWKNet): Bringing African women's voices. [Online] Available at: <www.globalknowledge.org/gkps_portal/view_file.cfm?fileid=1137> [Accessed 20 February 2014]

Odame, H., 2005. Gender and ICTs for development: setting the context. In: Gender and ICTs for development. [Online] Available at: <http://smartsite.kit.nl/net/KIT_Publicaties_output/showfile.aspx?a=tblFilesandb=FileIDandc=File Nameandd=TheFileande=820> [Accessed 20 November 2014]

Odhiambo C. J., 2007. Reading FM Radio Stations in Kenya opening a pandora's box. In Kimani Njogu and G. Oluoth Olunya (eds). Cultural Production and Social Change in Kenya: Building Bridges. Nairobi: Twaweza Communications, pp. 151-166.

Okinda, O. and Adera, E., 2014. "Political Economy of ICTs and their Effect on Poverty" in Edith Ofwona Adera et al. (eds.) ICT Pathways to Poverty Reduction: Empirical evidence from East and Southern Africa. Ottawa: Practical Action Publishing. pp. 53 – 76.

Oluoko-Odingo A. A., 2019. Gender Mainstreaming for the Adaptation to Weather and Climate Extremes in African Cities. Vol 2, issue 1, pp. 15-27. https://doi.org/10.20987/jccs.2.02.2019

Onwuegbuzie, A. J. and Leech, N. L., 2006. Linking research questions to mixed methods data analysis procedures. The Qualitative Report, 11(3), pp.474-498.

Opala, K., 2004. Kenyan farmers discover the Internet. [Online]. Available at: <http://web.idrc.ca/en/ev-47033-201-1-DO_TOPIC.html> [accessed 2 June 2014] [Accessed 20 February 2014]

Oremo, F., 2013. Small-scale farmers perceptions and adaptation measures to climate change in Kitui County: Kenya, College of Humanities and Social Sciences (CHSS); University of Nairobi digital repository.

Ospina, V. A. and Heeks, R., 2012. ICT-enabled responses to climate change in rural agricultural communities. Strategy Brief, 2, pp. 1 – 15.

Ospina, A. V., Heeks, R., and Adera, E., 2012. The ICTs, Climate Change Adaptation, and Water Project Value Chain: A conceptual tool for practitioners. In Finlay A and Adera E (eds). Application of ICT s for Climate Change Adaptation in the Water Sector: Developing country experiences and emerging research priorities. Association for Progressive Communications (APC) and the International Development Research Centre (IDRC), South Africa.

Ospina, A. V. and Heeks, R., 2010a. Unveiling the links between ICTs & climate change in developing countries: A scoping study. Manchester: Centre for Development Informatics, Institute for Development Policy and Management, SED University of Manchester.

Ospina, A. V. and Heeks, R., 2010b. Linking ICTs and climate change adaptation: A conceptual framework for e-Resilience and e-Adaptation. Manchester, UK: Centre for Development Informatics Institute for Development Policy and Management, University of Manchester.

Owusu, A.B., Yankson, P.W. and Frimpong, S., 2018. Smallholder farmers' knowledge of mobile telephone use: Gender perspectives and implications for agricultural market development. Progress in Development Studies, 18(1), pp.36-51.

Panchard, J., Rao, S., Prabhakar, T.V., Hubaux, J.P. and Jamadagni, H.S., 2007. Commonsense net: A wireless sensor network for resource-poor agriculture in the semiarid areas of developing countries. Information Technologies and International Development, 4(LCA-ARTICLE-2008-024), pp.51-67.

Parpart, J., Connelly, P., and Barriteau, V. (Eds.). 2000. Theoretical perspectives on gender and development. Ottawa: International Development Research Centre (IDRC).

Parkinson, S. and Ramírez, R., 2006. Using a Sustainable Livelihoods approach to assessing the impact of ICTs in development. Community Informatics, 2(3), Special Issue Telecentres

Patt, A. and C. Gwata., 2002. Effective seasonal climate forecast applications: examining constraints for subsistence farmers in Zimbabwe. Global Environmental Change, 12(3): pp.185–195.

Piot, S., Bates, P., Edmunson K. and Tchoukriel-Thébaud, L., 2017. Telecommunication Competition Market study in Kenya. For Communication Authority of Kenya (CA).

Payne, G. and Payne, J., 2004. Key concepts in social research. London: Sage.

Post Disaster Needs Assessment (PDNA), 2012. 2008–2011 Drought. Kenya post-disaster needs assessment report. Government of Kenya, United Nations and World Bank, pp. 1–192.

Rao K.P.C., Ndegwa W.G., Kizito K. and Oyoo A., 2011. Climate variability and change: farmer perceptions and understanding of intra-seasonal variability in rainfall and associated risk in semi-arid Kenya. Expl Agric, **47**(2), pp. 267–291 C, Cambridge University Press 2011 doi:10.1017/S0014479710000918

Rathgeber, E. M., 2000. Women, men, and ICTs in Africa: why gender is an issue. In E. M. Rathgeber, and E. O. Adera (Eds.), Gender and the Information Revolution in Africa. Ottawa: International Development Research Centre.

Roncoli, C., Ingram, K. and Kirshen, P., 2002. Reading the rains: Local knowledge and rainfall forecasting among farmers of Burkina Faso. Society and Natural Resources, 15, pp. 411–430.

Rosenzweig, M.R. and Binswanger, H.P., 1993. Wealth, weather risk and the composition and profitability of agricultural investments. The Economic Journal, 103(416), pp 56-78.

Saunders, M.N.K., Lewis, P. and Thornhill, A., 2009. Research methods for business students (5th ed.). Harlow, UK: FT Prentice Hall.

Sen, A., 1999. Development as freedom. New York, NY: Anchor Books.

Scoones, I., 1998. Sustainable rural livelihoods: A framework for analysis. IDS, Working Paper 72, IDS, Brighton, UK, June 1998.

Scoones, I., 2009. Livelihoods perspectives and rural development. The Journal of Peasant Studies, **36**(1), pp.171-196.

Shook, C. L., Ketchen, D. J., Hult, G. T. M., and Kacmar, K. M., 2004. An assessment of the use of structural equation modeling in strategic management research. Strategic Management Journal, **25**(4), 397-404

Skinner, E., 2011. Gender and climate change: Overview report. BRIDGE: Development Gender, Institute of Development Studies, p 91.

Sife, A.S., Kiondo, E. and Lyimo-Macha, J.G., 2010. Contribution of Mobile Phones to Rural Livelihoods and Poverty Reduction in Morogoro Region, Tanzania. The Electronic Journal of Information Systems in Developing Countries, **42**(0).

Singh, M., Molla, A., Karanasios, S. and Sargent, J., 2008. Exploring the impact of government ICT initiatives on the livelihood of Australian rural communities. BLED 2008 Proceedings, p.11.

Soriano, C.R.R., 2007. Exploring the ICT and rural poverty reduction link: Community telecenters and rural livelihoods in Wu'an, China. The Electronic Journal of Information Systems in Developing Countries, 32.

Swift, J., Hamilton, K., Devereux, S. and Maxwell, S., 2001. Household food and livelihood security. In: S. Devereux & S. Maxwell (Eds.) Food security in Sub-Saharan Africa. London: ITDG Publishing, pp. 67-92.

Tall, A., J.A, and Hansen J. 2013. Scaling up climate services for farmers in Africa and South Asia workshop report. CCAFS working paper no. 40. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Tall, A., Davis, A., and Guntunku, D., 2014a. Reaching the last mile: best practices in leveraging the power of ICTs to communicate climate services to farmers at scale. CCAFS Working paper no.70.(CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Tall, A., Kristjanson, P.M., Chaudhury, M., McKune, S. and Zougmoré, R.B., 2014c. Who gets the Information? Gender, power and equity considerations in the design of climate services for farmers. CCAFS Working paper no.89. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Tashakkori, A. and Teddlie, C., 1998. Mixed methodology: combining qualitative and quantitative approaches, Thousand Oaks, CA: Sage.

Tashakkori, A. and Teddlie, C. eds., 2003. Handbook of Mixed Methods in the Social and Behavioral Sciences. Thousand Oaks, CA: Sage

Tashakkori, A. and Teddlie, C. eds., 2010.Sage handbook of mixed methods in social & behavioral research. Thousand Oaks, CA: Sage.

Teddlie, C. and Tashakkori, A., 2006. A general typology of research designs featuring mixed methods. Research in the Schools, 13(1), pp.12-28.

Teddlie, C. and Tashakkori, A., 2009. Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences. Thousand Oaks, CA: Sage.

Toomela A., 2008. Variables in psychology: A critique of quantitative psychology. Integrative Psychological & Behavioral Science, 42, pp. 245-265.

UNEP (United Nation Environment Programme), 2009.Climate Information and Capacity needs for Ecosystems management under a changing climate. Nairobi Kenya. [Online]. Available at: <http://www.unep.org/ecosystemmanagement/Portals/7/Documents/policy_brief_EM-CC-info-needs.pdf>[Accessed 8th January 2014]

Vogel, C. and O'Brien K., 2006. Who can eat information? Examining the effectiveness of seasonal climate forecasts and regional climate–risk management strategies. Climate Research 33: pp. 111–122.

Waema, T. M. and Okinda, O., 2014. Access to and use of ICT and its contribution to poverty reduction in Kenya. In E., O. Adera et al. (eds.) ICT Pathways to Poverty Reduction: Empirical evidence from East and Southern Africa. Ottawa: Practical Action Publishing. pp. 101-131.

Waema, M.T.and Nd'ung'u, N.M., 2013. Understanding what is happening in ICT in Kenya-A supply-and-demand side analysis of the ICT sector. Research ICT Africa. Policy Paper, 9, p.2012.

Waema, T. M. and Okinda, O., 2011. Policy implications for the relationship between ICT Access and Usage and Well-being: A case study of Kenya. African Journal of Science, Technology, Innovation, and Development, 3(2), pp. 30-56.

Wamalwa, I. W., Mburu, B. K. and Manguru, D. G., 2016. Agro climate and weather information dissemination and its influence on adoption of climate-smart practices among small-scale farmers of Kisii county, Kenya. Journal of Biology, Agriculture and Healthcare, 6(10).

West, J.J., Daly, M. and Yanda, P., 2018. Evaluating User Satisfaction with Climate Services in Tanzania 2014-2016: Summary Report to the Global Framework for Climate Services Adaptation Programme in Africa. *CIC*

Weston, R. and Gore Jr, P.A., 2006. A brief guide to structural equation modeling. The counseling psychologist, 34(5), pp.719-751.

Wheaton, B., Muthen, B., Alwin, D., F., and Summers, G. (1977), "Assessing Reliability and Stability in Panel Models," Sociological Methodology, 8(1), 84-136.

Winther, T., Ulsrud, K. and Saini, A., 2018. Solar powered electricity access: Implications for women's empowerment in rural Kenya. Energy research & social science, 44, pp.61-74.

World Bank Independent Evaluation Group (IEG), 2011. Capturing Technology for development: an evaluation of world bank group activities in information and communication technologies. Washington, DC: Independent Evaluation Group, the World Bank Group.

World Bank. 2011. ICT in agriculture: Connecting smallholders to knowledge, networks, and institutions. (e - Sourcebook). Report Number 64605. The World Bank, Washington, DC.

Wu, J., Guo, S., Huang, H., Liu, W. and Xiang, Y., 2018. Information and communications technologies for sustainable development goals: State-of-the-art, needs and perspectives. IEEE Communications Surveys & Tutorials.

Wyche, S. and Olson, J., 2018. Gender, Mobile, and Mobile Internet| Kenyan Women's Rural Realities, Mobile Internet Access, and "Africa Rising." Information Technologies & International Development, 14, p.15.

Yohannis, M.A., Waema, T.M. and Wausi, A.N., 2016, May. Provisional findings on linking climate information to livelihood strategies through ICTs among rural women in Kitui County, Kenya. In IST-Africa Week Conference, 2016 (pp. 1-7). IIMC.

Ziervogel, G. and Calder, R., 2003. Climate variability and rural livelihoods: assessing the impact of seasonal climate forecasts in Lesotho. Area, 35(4), pp.403-417.

Ziervogel, G., Bithell, M., Washington, R. and Downing, T., 2005. Agent-based social simulation: A method for assessing the impact of seasonal climate forecasts among smallholder farmers. Agricultural Systems 83(1), pp. 1–26.

APPENDICES

Appendix 1: General Household Survey Questionnaire

Dear Respondent,

My name is Michaelina Almaz Yohannis. I am a Ph.D. candidate at the School of Computing and Informatics, University of Nairobi. I am currently researching on "Mainstreaming ICT-based Climate Information to Livelihood Strategies among Rural communities in Kitui County, Kenya." You have been identified as one of the respondents whose answers will go a long way in collecting data to feed into Vision 2030 and the Sustainable Development Goals (SDGs) in Kenya. The responses that you give shall be used exclusively for this academic research, and for no other purpose. The information you share with the research team will be treated with utmost confidence. We are therefore requesting that you kindly agree to answer the questions in the questionnaire as objectively as possible. The exercise will take less than 30 minutes of your time. Thank you.

Interviewer name: _____ **Interviewee name**: _____

Study Area

I. Sub-County ……..
II. Ward ……..
III. Village ……..
IV. AEZ ……..

A. DEMOGRAPHIC INFORMATION

Respondents should be 18 years and above and willing to participate in the study.

This section seeks information on the demographic details of the respondents. For each of the question, please use the numerical numbers provided to indicate in the provided spaces the option that correctly captures your answer. For example, in question one, indicate 1 for male, and 2 for female.

	Question	Options	Response
1.	Gender	1=Male 2=Female	
2.	Age (in years)	1=18-30 years 2 =31- 45 years 3=46-60 years 4 =Above 60 years	

3.	Marital Status	1= Never married with no children 2= Never married with children 3 = Married living together 4 = Married living apart 5=Divorced/separated/widowed	
4.	Religious affiliation	1=Christian 2= Muslim 3 =Other 4 =None	
5.	Household Size	1= One member 2 =2-4 members 3 =5-7 members 4 =8-10 members 5 = More than 10 members	
6.	I can read	1=Yes 2=No	
	I can write	1=Yes 2=No	
7.	My highest level of education is:	1=None 2 =Primary 3 =Secondary 4 = College 5 = University	

B. ICT SYSTEM

This section seeks information on **ownership** and **use** of ICT tools and the accessibility, availability, and affordability (**Digital Capital**) of the same tools in your daily life. For each of the question, please use the numerical numbers provided to indicate in the provided spaces the option that correctly captures your answer. For example, if you own a radio, indicate 1, and if you do not, indicate 2. For the rest of the questions, indicate using a tick which best options describe your response.

8. **ICT Tools**

8.1. **Ownership** of ICT Tools

ICT Tool	i. Do you **own**/the following ICT Tool? **1 = Yes** **2=No**
1. Radio	
2. Mobile Phone	
3. Television	
4. Computer	

8.2. **Digital Capital**

a) How else do you **access** the ICT tools that you do not own (Accessibility)

ICT Tool	i. Neighbors/Friends	ii. Payphone/ Simu ya Jamii	iii. Cyber Cafe	iv. Community center
1. Radio				
2. Mobile Phone				
3. Television				
4. Computer				

b) I can **operate** the following ICT tools (Accessibility in skills and use of ICT tools)

i)

ICT Tool	i. Strongly Agree	ii. Agree	iii. Neutral	iv. Disagree	v. Strongly disagree
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer					

ii) Who **assists** you when you are unable to operate the ICT tools (Accessibility)

ICT Tool	i. Spouse	ii. Child	iii. Relative	iv. Local Teacher	v. Chief	vi. Cyber Cafe	vii. Other
1. Radio							
2. Mobile Phone							
3. Television							
4. Computer							

c) I can **understand** the technical information relayed in the following ICT tools (Accessibility)

i)

ICT Tool	i. Strongly Agree	ii. Agree	iii. Neutral	iv. Disagree	v. Strongly disagree
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer					

ii) Who gives you **support** if you are not able to understand the technical information received above?

`	i. Spouse	ii. Child	iii. Relative	iv. Local Teacher	v. Chief	vi. Cyber Cafe

iii) In what f**ormat** would you prefer to receive the technical information on the ICT Tool

ICT Tool	i. English	ii. Kikamba	iii. Kiswahili	iv. Other

d) I **charge** the ICT tools that I own, mainly using the following: (Availability)

i)

ICT Tool	i. Electricity	ii. Solar	iii. Battery	iv. Neighbors	v. Cyber Cafe	vi. Community Center
1. Radio						
2. Mobile Phone						
3. Television						
4. Computer/						

ii) How **frequently** do you use each of the following ICT tools: (Availability)

ICT Tool	i. Daily	ii. Sometimes	iii. Not sure	iv. Rarely	v. Never
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer/Internet Connectivity					

e) I can **afford** to sustain the use of the following ICT tools with (Affordability)

ICT Tool	i. Strongly Agree	ii. Agree	iii. Not sure	iv. Disagree	v. Strongly disagree
1. Radio a. Electricity					
b. Solar					
c. Battery					
2. Mobile Phone a. Electricity					
b. Solar					
c. Battery					
d. Airtime					
e. Internet/bundles					
3. Television a. TV connectivity box					
b. Monthly charges					
4. Computer/Internet Connectivity a. Purchase of internet					
b. Printing & photocopies					

C. Climate Information

This section seeks information on your awareness, access to and use of climate information (CI). For each of the questions, indicate using a tick the option that correctly captures your answer.

9. **Awareness and Use of CI**

a) How do you personally evaluate the **importance** of the following aspects of CI?

How important is?	i. Very important	ii. Important	iii. Neutral	iv. Less important	v. Not important
1. Daily weather forecast					
2. Weekly forecast					
3. Onset & cessation of the rainy season					
4. Length of rainy season					
5. The intensity of rainy season					
6. Seasonal forecast					
7. Early warning of extreme weather events (drought, floods, pests)					
8. Climate Change information (future forecast)					

b) I **frequently** use the following ICT tools to access CI

ICT Tool	i. Always	ii. Sometimes	iii. Neutral	i. Rarely	ii. Never
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer					

c) The following CI that I get on the ICT tool is usually what I **need**. (Relevance)

Climate Information	i. Strongly Agree	ii. Agree	iii. Undecided	iv. Disagree	v. Strongly Disagree
1. Daily weather forecast					
2. Weekly forecast					
3. Onset and cessation of the rainy season					
4. Length of rainy season					
5. The intensity of rainy season					
6. Seasonal forecast					
7. Early warning of extreme weather events (drought, floods, pests)					

8. Climate Change information (future forecast)					

d) The CI that I get from the following ICT tools comes when I **need it the most** (Timeliness)

ICT Tool	i. Strongly Agree	ii. Agree	iii. Undecided	iv. Disagree	v. Strongly Disagree
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer					

e) The CI that I get from the following ICT tools is reliable (Accuracy)

ICT Tool	i. Strongly Agree	ii. Agree	iii. Undecided	iv. Disagree	v. Strongly Disagree
1. Radio					
2. Mobile Phone					
3. Television					
4. Computer					

f) Are you willing to **pay extra** for the CI service that you get If the CI is Relevant, Timely & Accurate,

ICT Tool	i. Strongly Agree	ii. Agree	iii. Undecided	iv. Disagree	v. Strongly Disagree

D. LIVELIHOOD ASSETS

This section seeks information on how ICT-Based-Climate Information influences rural communities in the maximization of the livelihood assets that they utilize. For each of the question, please indicate in the provided spaces the option that correctly captures your answer.

10.

a) Natural Capital	i. Self	ii. Spouse	iii. Jointly	iv. Parents	v. Rented
1. The land we cultivate is owned by					

2. The size of the land (in acres) we cultivate is:	i. < 2	ii. 2-5	iii. 5-8	iv. 8-10	v. >10

3. I have ready access to the following sources of water for consumption and farming	i. Always	ii. Sometimes	iii. Neutral	iv. Rarely	v. Never
a. Rain-fed					
b. Borehole					

c. River					
d. Well					
e. Kiosk					
f. Piped water					
b) **Physical Capital**	i. Always	ii. Sometimes	iii. Neutral	iv. Rarely	v. Never
2. I have mechanized tools for farming activities (Tractor, plow, mattock)					
3. I have storage facilities for my crop					
4. I have shelter for my animals					
5. I have to travel the following distances to the Local Market					
a. Less than 1km					
b. 1-5km					
c. 5-9km					
d. More than 9Km					
6. My main mode of transport is					
a. My Car					
b. Public transport					
c. Bicycle					
d. Motorbike					
e. Animal Cart (Donkey/Cow)					
f. On foot					

7. The type of house we live in is a:	i. Mud-walled hut	ii. Brick walled house	iii. Grass thatched roof	iv. Iron sheet roof
Tick all that apply				

c) Human Capital	i. Self	ii. Spouse	iii. Children	iv. Community	v. Hired labor
1. Who is your primary source of farm labor					
d) Financial Capital	i. Always	ii. Sometimes	iii. Neutral	iv. Rarely	v. Never
1. I have access to the following					
a. Savings					
b. Credit					
c. Remittances					

2. I own the following Assets	i. List no.
a. Cow	
b. Donkey	
c. Sheep	
d. Chicken	
e. Goat	

e) **Social Capital (LA-SC)**	i. Regular Member	ii. Chairperson	iii. Secretary	iv. Treasurer	v. Governing official
1) I am a member & hold the following position in the groups					
a. Farmers Group					
b. Self-help groups					
c. Religious Organizations					
d. Savings group (Chama's)					
e. Community-based Org					
f. Other (specify)					

11. Since I started accessing ICT-based CI (Maximization of Livelihood Assets)

a) Natural (LA-NC)	i. Always	ii. Sometimes	iii. Neutral	iv. Rarely	v. Never
1. I have increased the size of land that I cultivate					
2. I know when and where to access water for both home and farming use					
b) Human Capital (LA-HC**)**					
1) I can afford to hire more labor					
2) I am more knowledgeable in the preparation of farming activities					
3) I have connections to the right market and market prices					
c) Physical Capital (LA-PC)					
1. I have increased ownership and assets to adequate farming implements					
2. The methods that I use for farming operations are more mechanized (use of the tractor, donkey/cow plow, etc.)					
3. I have build a better housing structure					
4. I have build food storage facilities					

5. I have purchased transport means, or I can access transport easily					
d) Financial Capital (LA-FC)					
1. Increased income from agricultural farming and hence:					
a. Capable of paying school fees					
b. Able to continue with education					
c. Able to pay medical bills					
d. Able to buy nutritional foods for the family					
e. Able to purchase more livestock /Seeds					
2. Increased Savings					
3. Reduced credits					

e) Social Capital

I have benefited from being a member of these groups. For each of the questions, indicate using a tick the option that correctly captures your answer. (LA-SC)

Social Groups	i. Leadership position	ii. Networking	iii. Visibility	iv. Decision-making	v. Respect
1. Farmer's Groups					
2. Self-help groups (Chama's)					
3. Religious Organizations					
4. Savings Groups/Table banking					
5. Community-based organizations (CBO)					
6. Other groups					

E. ICT- based- CI and Livelihood Strategies

This section seeks information on your livelihood strategies in the context of your access to and use of ICT-based-CI. For each of the questions, indicate using a tick the option that correctly captures your answer.

12. I use ICT- based-CI to make the following livelihood strategies

	i. Very Often	ii. Often	iii. Sometimes	iv. Rarely	v. Not at all
a) Natural Capital					

	i. Very Often	ii. Often	iii. Sometimes	iv. Rarely	v. Not at all
1. **Land- management such as:**					
a. Soil conservation					
b. How to prepare land (Tillage/spacing/Weeding)					
c. The percentage of land I use for planting crops					
2. **Water management such as:**					
a. Conservation of water (use water well)					
b. Recycling and treating water					
c. Harvesting water					
d. The use of irrigation on the farm					
b) Human Capital					
1. **Skills and knowledge learned**					
a. Where to source for farm inputs (seeds, fertilizer, farm machinery)					
b. When and how to use farm fertilizer and manure					
c. What improved high yielding seeds to use					
d. When to plant Indigenous and drought-tolerant crops					
e. Timely planting					
f. Crop and Animal diversification					
g. Agricultural technological intensification (tree planting, multi/intercropping					
h. How to manage pests and disease outbreak					
i. When to stock and destock livestock					
j. How and when to preserve food					
k. Value addition to crops (flour, dried products, e.g., fruits) and livestock (yogurt, butter, cakes)					
c) Social Capital					
1. Networks: Improved access to					
a. Skills and knowledge					
b. Financial services/Loan/KREP, KWFT					

	i. Very Often	ii. Often	iii. Sometimes	iv. Rarely	v. Not at all
2. Membership groups					
a. Better coordination of activities					
b. Communal benefit					
c. Participation in decision-making					
d. Resource sharing					
e. Support of each other					
3. Trust:					
a. Conflict resolution					
b. Trust among community members					
4. Alternative/non-agricultural activities					

F. Structures and Processes

This section seeks information on the various aspects of the administrative, social, and cultural process and structures that influence your ICT-based-CI livelihood strategy. For each of the questions, indicate using a tick the option that correctly captures your answer.

13. I get assistance and guidance from the following in making ICT-based-Cl livelihood strategy:(**Structures**)

	i. Very Often	ii. Often	iii. Rarely	iv. Very Rarely	**v.** Not at all
1. National government extension agents (e.g., Kenya Met services, Agricultural extension agents, etc.)					
2. Non-Government Organizations (e.g., Caritas, ADSA, Red Cross, etc.)					
3. County Government Institutions					
4. Community-Based Organizations					
5. Agro-Vets					
6. Others (Specify)					

14. The following decision-making aspects **affect** my ICT-based-CI Livelihood strategy: (**Processes**)

	i. Very Often	ii. Often	iii. Rarely	iv. Very Rarely	v. Not at all
1. My participation in the National Government Policies decisions (e.g., Climate change Policy, Gender Policy, ICT Policy)					

2. Decision-making dynamics in the household					
a. I am not able to make decisions on farm activities without asking my spouse/parent					
b. The time I take sourcing for water and food					
c. The control of income earned					
d. The lack of finances/collateral (Title deed, car)					
e. Access to extension services					
3. My cultural practices and beliefs:					
a. Being in a polygamous marriage /Concubine					
b. Girls help out in household duties					
c. The extra work of raising children, housework and at the same time tend to the farm activities					

Appendix 2: Focus Group Discussions

Dear Respondent,

My name is Michaelina Almaz Yohannis. I am a Ph.D. candidate at the School of Computing and Informatics, University of Nairobi. I am currently researching on "Mainstreaming ICT-based Climate Information to Livelihood Strategies among Rural communities in Kitui County, Kenya." You have been identified as one of the respondents whose answers will go a long way in collecting data to feed into Vision 2030 and the Sustainable Development Goals (SDGs) in Kenya. The responses that you give shall be used exclusively for this academic research, and for no other purpose. The information you share with the research team will be treated with utmost confidence. We are therefore requesting that you kindly agree to answer the questions in the questionnaire as objectively as possible. The exercise will take less than 30 minutes of your time. Thank you.

Interviewer name: _____

STUDY AREA

I.	Sub County	……..
II.	Ward	……..
III.	Village	……..
IV.	AEZ	……..

1. Introductions: Name
2. Access and Use of ICT Tools (Radio, Mobile/bundles, Television, Computer /internet, Video)
    a. Which ICT tools do you own and use most frequently
    b. What are the challenges you face in the access and use of the ICT tools in regards to?
        i. Accessibility (can effectively operate, understand information relayed)
        ii. Availability and (travel far to access, basic infrastructure not in place intermittent connectivity)
        iii. Affordability (I do not have money to buy airtime, we have to share)
3. Are you aware of Climate Information (CI) that is circulated or broadcast in your area? If yes, which ones (daily weather, weekly, seasonal, future forecasts, onset &cessation of rain, the intensity of rainfall)
4. What ICT tool do you use to access Cl?
    a. Do you work with an organization(s) that disseminate these CI? If Yes list them
    b. For how long have you worked with this/these organization(s)?

c. How often do you receive these CI?

d. How do you/group members use this information?

e. Do you share this information with other community members who are not members of your social circle?

5. What is your view on the following in regards to the CI you receive through the ICT tools
   a. Relevance (Information that I need)

   b. Timeliness (in good time)

   c. Accuracy (reliable)

   d. Affordability (can afford to get CI)

   e. Clarity (easy to understand)

6. Do you belong in any social groups and if so how have you benefited from the membership?

7. What changes have you experienced in livelihood assets since you started receiving CI?

8. Are there organizations that have facilitated the process of you receiving CI? (National government extension agents, NGO's CBOs, Caritas, Agro-vets, etc.)

9. Are there inter-household decision-making dynamics that affect your access to ICT-based-CI?

10. Are there cultural challenges to the access and use of ICT-based-CI?

11. Have you witnessed changes in agricultural practices and subsequently crop yields since you started receiving CI?

12. What is your evaluation on your livelihood (food security and water harvesting practices) since you started receiving ICT-based-CI?

Appendix 3: Key Informant Interview (KII) Guide

Dear Respondent,

My name is Michaelina Almaz Yohannis. I am a Ph.D. candidate at the School of Computing and Informatics, University of Nairobi. I am currently researching on " Mainstreaming ICT-based Climate Information to Livelihood Strategies among Rural communities in Kitui County, Kenya." You have been identified as one of the respondents whose answers will go a long way in collecting data to feed into Vision 2030 and the Sustainable Development Goals (SDGs) in Kenya. The responses that you give shall be used exclusively for this academic research and for no other purpose. The information you share with the research team will be treated with utmost confidence. We are therefore requesting that you kindly agree to answer the questions in the questionnaire as objectively as possible. The exercise will take less than 30 minutes of your time. Thank you.

1. Introduction
    a. Name
    b. Organization
    c. Position/Title/Designation
    d. Length in that position
    e. Ward /Village/ Agricultural Ecological Zone (AEZ)

2. Access and Use of ICT Tools (Radio, Mobile, Television, Computer /internet, Video)
    a. What are some of the most commonly available ICT tools in your area?

    b. What is your view on the following in regards to the ICT Tools in your organization?
        i. Accessibility (can effectively operate, understand information relayed)

        ii. Availability and (travel far to access, basic infrastructure not in place, intermittent connectivity)

        iii. Affordability (I do not have money to buy airtime, we have to share)

3. Are you aware of Climate Information (CI) that is circulated or broadcast in your area? If yes, which ones (daily weather, weekly, seasonal, future forecasts, onset &cessation of rain, intensity)

4. What mode does your organization use to share CI? Why does your organization choose to use that mode?
    a. Which regions does it cover?

    b. How often does the organization disseminate this climate information?

c. Who are the recipients of this information (agricultural stakeholders/general public?)

d. Which social network groups /networks if any do you use to disseminate this climate information?

e. What are the benefits or challenges of using the social network groups

f. Is there a cost to the end-user/farmer? If yes, please explain

5. Do you partner with any other government agencies or NGOs to provide ICT-based-CI? If yes, please list them

6. What changes have you experienced in the communities livelihood assets since you started disseminating ICT-based CI?

7. Are there cultural challenges in the community to the use of ICT-based-CI?

8. What is your view on the following in regards to the success rate in disseminating ICT-based-CI?
   a. Relevance (Information that is needed)

   b. Timeliness (in good time)

   c. Accuracy (reliable)

   d. Affordability (can afford to get CI)

   e. Clarity (easy to understand)

9. Is there anything that you think your organization can do differently in sharing ICT-based-CI?

10. Have you witnessed changes in agricultural practices and subsequently crop yields in the community since disseminating ICT-based CI (Livelihood Strategies).

11. What is your evaluation of the communities' livelihood (food security and water harvesting practices) since you started disseminating ICT-based-CI?

Appendix 4: Univariate Normality Table

Construct	Indicator variable	N	Min.	Max.	Mean	Std. Dev	Skewness	Kurtosis
Digital Capital	KS	419	1.00	5.00	2.902	0.862	-0.023	0.179
	TU	419	1.00	5.00	2.797	0.941	0.294	-0.122
	AV	412	1.00	5.00	3.441	0.964	0.178	-0.667
	AF	409	1.00	5.00	2.915	1.202	0.580	-0.920
Climate Information	AW	419	1.00	5.00	4.167	0.905	-1.194	1.215
	FR	419	1.00	5.00	2.774	0.821	-0.010	-0.130
	RV	417	1.00	5.00	4.076	0.830	-0.948	0.978
	TM	410	1.00	5.00	3.240	0.884	0.029	-0.038
	RA	410	1.00	5.00	3.159	0.917	0.020	-0.079
Livelihood Assets	LANC	419	1.00	5.00	2.823	0.609	0.827	0.646
	LAHC	419	1.00	5.00	3.833	0.856	-0.901	0.910
	LAPC	419	1.00	5.00	3.675	0.860	-0.816	0.707
	LAFC	419	1.00	5.00	3.321	0.879	-0.400	-0.164
	LASC	419	0.00	1.00	0.165	0.168	1.591	3.878
Structures &Processes	ST	419	1.00	5.00	2.894	1.137	-0.052	-1.154
	DM	419	1.00	5.00	3.579	0.756	-0.711	0.991
	PB	419	1.00	5.00	3.375	1.069	-0.539	-0.367
	PC	419	1.00	5.00	3.570	1.408	-0.819	-0.638
Livelihood Strategies	LSNC	419	1.00	5.00	3.569	0.701	-0.427	0.530
	LSHC	419	1.00	5.00	3.603	0.795	-0.579	0.505
	LSSC	419	1.00	5.00	3.667	1.054	-0.759	-0.081
	LSFC	419	1.00	5.00	3.379	1.090	-0.507	-0.789

Appendix 5: Standardized Regression Weights for Measurement Model Table

Indicator Variable	Relation	Construct Variable	Estimate/ Factor Loadings
R	<---	ICT Tool	0.912
C	<---	ICT Tool	0.750
M	<---	ICT Tool	0.804
T	<---	ICT Tool	**0.473**
AF	<---	DC	0.670
AV	<---	DC	0.770
TU	<---	DC	0.958
KS	<---	DC	0.980
TM	<---	CI	0.940
RV	<---	CI	0.608
FR	<---	CI	0.547
AW	<---	CI	0.587
RA	<---	CI	0.949
LANC	<---	LA	0.834
LAFC	<---	LA	0.869
LAPC	<---	LA	0.862
LAHC	<---	LA	0.858
LASC	<---	LA	0.653
PC	<---	STPR	0.695
PB	<---	STPR	**0.318**
DM	<---	STPR	0.500
ST	<---	STPR	0.692
LSFC	<---	LS	0.751
LSNC	<---	LS	0.896
LSSC	<---	LS	0.764
LSHC	<---	LS	0.899

Appendix 6: Modification Indices and Model Fitness Results

First Model Fitness without Modification

Chi-square = 2822.1				
Degrees of Freedom (df) = 290				
Measure	**Fit Index**	**Expected**	**Result**	**Comments**
Goodness of Fit	Goodness of Fit (GFI)	> 0.9	0.59	Unacceptable
	Root Mean Squared Error of Approximation (RMSEA)	0.03 < x < 0.08	0.145	Unacceptable
	Root Mean Residual (RMR)	-4 < x < 4	9.45	Unacceptable
	Normed Chi-square (χ^2:df)	< 1:3 (ratio)	1:5	Unacceptable
Incremental Fit Indices	Comparative Fit Index (CFI)	> 0.95	0.503	Unacceptable
	Tucker-Lewis Index (TLI)	> 0.95	0.399	Unacceptable
Parsimony Fit Indices	Adjusted Goodness of Fit (AGFI)	0-1	0.826	Acceptable
	Parsimony Normed Fit Index (PNFI)	0-1	0.398	Acceptable

First Modification Indices

Correlated Error Terms			MI2	Par Change
e32	<-->	e33	9.055	.006
e31	<-->	e30	6.924	-.012
e26	<-->	e29	4.145	.007
e21	<-->	e31	7.174	-.018
e20	<-->	e26	16.657	-.022
e1	<-->	e19	7.969	-.044
e2	<-->	e18	4.411	-.033
e5	<-->	e13	5.249	.057
e8	<-->	e10	6.655	.059
e1	<-->	e4	13.838	-.066
e10	<-->	e3	4.110	-.034
e9	<-->	e2	12.646	-.056

Second Model Fitness

Chi-square = 1123.9				
Degrees of freedom = 247				
Measure	**Fit Index**	**Expected**	**Result**	**Comments**
Absolute Fit Measures	Goodness of Fit (GFI)	> 0.9	0.523	Unacceptable
	Root Mean Squared Error of Approximation (RMSEA)	0.03 < x < 0.08	0.103	Unacceptable
	Root Mean Residual (RMR)	-4 < x < +4	5.419	Ratio Unacceptable
Incremental Fit Indices	Comparative Fit Index (CFI)	> 0.95	0.783	Not Acceptable
	Tucker-Lewis Index (TLI)	> 0.95	0.717	Unacceptable
Parsimony Fit Indices	Adjusted Goodness of Fit (AGFI)	0-1	0.766	Acceptable
	Parsimony Normed Fit Index (PNFI)	0-1	0.575	Acceptable

Appendix 7: Weather Report

REPUBLIC OF KENYA
MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES
KENYA METEOROLOGICAL DEPARTMENT
Dagoretti Corner, Ngong Road, P. O. Box 30259, 00100 GPO, Nairobi, Kenya
Telephone: 254 (0) 20 3867880-7, Fax: 254 (0) 20 3876955/3877373/3867888,
e-mail: director@meteo.go.ke, info@meteo.go.ke Website: http://www.meteo.go.ke

DAILY WEATHER REPORT

Issued on 6th November 2017, 3.00 P.M

(Valid from 9.00 pm tonight to 9.00 pm tomorrow 7th November, 2017)

This is the weather forecast for Makueni, Machakos and Kitui Counties issued on Mon 6th Nov 2017.

Light showers expected over few places tonight across all Counties.

Light rains expected over few places in the morning across all counties, giving way to sunny intervals.

Sunny intervals expected across all counties in the afternoon.

Minimum temperature is expected to be 17 degrees in Makueni, 18 degrees in Kitui and 15 degrees in Machakos.

Day time temperatures are expected to rise to highs of 26 degrees in Makueni, 27 degrees in Kitui and 24 degrees in Machakos.

Gentle Easterly winds expected to blow across Machakos County. The strength of this wind may constantly move leaves and small twigs and also extend light flags. Light Easterly winds expected to blow over Makueni and Kitui Counties. The strength of this wind may be felt on face, cause leaves to rustle and begin to move vanes.

This forecast is prepared by Kenya Meteorological Department.

For further details please contact;

Machakos County Director of Meteorology
Tel: 0721 384681
Email: cdmmachakos@meteo.go.ke

Kitui County Director of Meteorology
Tel: 0722 324 161
Email: cdmkitui@meteo.go.ke

Makueni County Director of Meteorology
Tel: 0729 262 285
Email: cdmmakueni@meteo.go.ke

Appendix 8: Authorization Letter from the University of Nairobi

UNIVERSITY OF NAIROBI
COLLEGE OF BIOLOGICAL AND PHYSICAL SCIENCES
SCHOOL OF COMPUTING AND INFORMATICS

Telephone: 4447870/4444919/4446544
Telegrams: "Varsity" Nairobi
Telefax: 254-20-4447870

P. O. Box 30197
Nairobi
Kenya

Ref: UON/CBPS/SCI/PHD/IS/2013

7 November 2016

To Whom It May Concern

Dear Sir/Madam

RE: MICHAELINA ALMAZ YOHANNIS – REG. NO. P80/90262/2013

This is to certify that the above named is a bona fide student of the University of Nairobi, School of Computing and Informatics.

She is pursuing a Ph.D course in Information Systems. She is in now doing her research.

Any assistance accorded to her will be highly appreciated.

Yours faithfully

School of Computing & Informatics
University of NAIROBI
P. O. Box 30197
NAIROBI

DOROTHY M. ISEU
FOR: DIRECTOR
SCHOOL OF COMPUTING & INFORMATICS