Doctoral Thesis

博士論文

Mobile Phone Based Services for Household Adaptive Capacity Development
in Rural Africa: A case study of Makueni County, Kenya

（アフリカ農村部における家計の適応力開発のための携帯電話サービス：ケニア
共和国マクエニ郡における事例研究)

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ムアサ リリアン ムビニャ

(MUASA LILIAN MBINYA)

Graduate School of Frontier Sciences

The University of Tokyo

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DECLARATION

I hereby certify that this thesis is my own manuscript, and the sources of the materials used have been duly acknowledged. I declare that this work has not been submitted to any other institution for the award of any academic degree, diploma or certificate. Any part of this thesis shall not be reproduced without accurate acknowledgments.

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ABSTRACT

The energy crisis, rapid urban population, food insecurity, poverty, economic hardships, and climate change are some of the complex challenges experienced in the 21st century threatening the lives and livelihoods of millions in both developed and developing countries. In developing countries, the impacts are more pronounced to the rural population due to overreliance on environmental-based activities for food and livelihoods such as agriculture and fishing. In Sub-Saharan Africa (SSA), the rural population comprises households that rely on rain fed agriculture for livelihood and such households are vulnerable to climate related shocks that contribute to total crop and livestock failure.

In Kenya, one of the SSA countries, around 78% of the rural population rely on rain fed agriculture for livelihood. Such rural households frequently experience several shocks including droughts, floods, crop and livestock diseases, death of livestock, total crop failure, and water shortages. Since most of the households rely on their own resources to cope and adjust to the challenges as well sustain their standards of living, the severity and frequency of these shocks outweigh their limited resources bulging them into more risks. There is a need to develop their adaptive capacity to cope and adjust with both short and long term impacts. Previous studies have recognized adaptive capacity to be an essential component that encourages development at the household level. Information Communication and Technologies (ICTs) form a crucial part in adaptive capacity development through increasing resource accessibility. Although there is a wide range of developed ICTs, this study focus on the mobile phone, one of the dominant devices across ICTs which has many developed innovations targeting the rural population.

In order to ensure household adaptive capacity development of rural households in Kenya, the aim of this study is to assess the impact of mobile phone based services on household adaptive capacity with the purpose to aid household capacity development. This will ensure the sustainability of household development outcomes in rural Kenya. The study is divided into two parts; adaptive capacity assessment and adaptive capacity development and the following specific objectives were developed to answer the study aim; 1) analyze household adaptive capacity and identify resources that need to be developed, 2) assess households mobile phone usage and access to adaptive capacity resources, 3) evaluate the impact of mobile phone based services on household adaptive capacity, and 4) examine the influence of mobile phone based services on household networks to access and exchange resources that facilitate capacity development.

A mixed-method approach employing qualitative and quantitative methods, using both primary and secondary data collection were applied to achieve the aim of this study. First and foremost, an extensive literature

review was conducted to understand the adaptive capacity concept, estimation frameworks, adaptive capacity development, and current developed mobile phone based services targeting the rural population in Kenya. From the literature review, five resources including; financial resource, information resource, physical resource, human resource and diversity of livelihood from the Sustainable livelihood framework were adopted to estimate household adaptive capacity. A field survey was then conducted in Makueni County in which a total of 250 randomly selected households comprising of 125 users (use mobile phone based service to access adaptive capacity resources) and 125 non-users (do not use mobile phone based services to access adaptive capacity resources) from the 5 sub-counties in were surveyed by administering a household questionnaire. Also, a total of 25 key experts were interviewed and 10 focus group discussions conducted. Furthermore, an intervention session on mobile phone based services was conducted targeting the 125 non-user whereby 83 were treated and 42 untreated.

Analytical Hierarchy Process (AHP), a Multicriteria decision-making tool was used for adaptive capacity assessment in which weights were assigned on the five selected resources. The resource weightings were then aggregated to obtain a comprehensive household adaptive capacity index (HACI) value. A combination of Propensity Score Matching (PSM) and Difference in Difference (DD) methods were applied to match the treated and untreated households and to evaluate the impact of the provision of and training on mobile phone based services on household resource accessibility and adaptive capacity. To visualize household networks to exchange and access resources, Social Network Analysis (SNA) was applied to create visualization maps.

The research findings show that adaptive capacity varies across the household's and the average adaptive capacity of households is 0.3529 which is relatively low given the range of 0 to 1 HACI level. Most of the households were categorized in low (48%) and moderate (50%) adaptive capacity levels. Only 2% of households were categorized in high adaptive capacity levels. Resource accessibility and adaptive capacity levels of households vary based on the gender of the household head with the male-headed households registering higher accessibility and adaptive capacity level. Among the five resources assessed, information resource, financial resource and diversity of livelihood are the most important resources for household adaptive capacity development and contribute to a greater disparity in adaptive capacity across the households.

The mobile phone is a commonly used asset across households in Kenya with the penetration rate estimated to be 81% by the end of 2019. Although both users and non-users access information resource, the user household's accessibility was higher compared to non-user households due to the utilization of mobile phone based services to access the resources. Limited access to these resources was noted across the non-users. A

significant difference is noted on the users and non-users' adaptive capacity indexes, whereby most of the users were categorized in moderate (81.6%) and high (11.2%) adaptive capacity index levels while most of the non-users were categorized in low adaptive capacity index level (91.2%). The users registered a wider network to access and exchange information and financial services compared to non-users who registered fewer networks. Mobile phone based services increase networks to access and exchange adaptive capacity resources facilitating adaptive capacity development. This study proves that the use of mobile phone based services contributes to increased resource accessibility facilitating a higher adaptive capacity and livelihood diversification and increased social networks.

In conclusion, most of the households in rural Makueni County highly experience several shocks, have limited resources and low household adaptive capacity as clearly indicated in this study and therefore adaptive capacity should be increased significantly in order to help them cope and adjust to the impacts as well as sustain and achieve development outcomes. Mobile phone based services increase resource accessibility and generally facilitate adaptive capacity development as depicted by this study, therefore inclusion of mobile phone based services as a potential way to increase household resource accessibility and adaptive capacity should be considered in the current stakeholder adaptive capacity development interventions in rural areas to promote household adaptive capacity especially for the non-users.

(1108 Words)

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DEDICATION

To the entire Mr. and Mrs. Boniface Muasa family, Professor Emmanuel Mutisya family and to all my dear brothers and sisters, I dedicate this professional achievement to you all because without your love and support I would not have been able to successfully achieve my goal.

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LIST OF ABBREVIATIONS

AASR:	Africa Agriculture Status Report
AEZ:	Agri Ecological Zones
AHP:	Analytical Hierarchy Process
CARE:	Cooperative for Assistance and Relief Everywhere
CGIAR:	Consultative Group for International Agricultural Research
CIDP:	County Integrated Development Plan
COP:	Conference of the Parties
CSTI:	Centre for Science and Technology Innovations
DFID:	Department for International Development
FAO:	Food and Agriculture Organization
GDP:	Gross Domestic Product
GHG:	Green House Gases
GIS:	Geographic Information System
GSMA:	Global System Mobile Association
HACI:	Household Adaptive Capacity Index
IAPAD:	Integrated Approaches to Participatory Development
ICT:	Information, Communication, and Technology
IISD:	International Institute for Sustainable Development
IPCC:	Intergovernmental Panel on Climate Change
ISDR:	International Strategy for Disaster Reduction
ITU:	International Telecommunication Union
KACE:	Kenya Agricultural Commodity Exchange
KIHBS:	Kenya Integrated Household Budget Survey
KMD:	Kenya Meteorological Department
KNBS:	Kenya National Bureau of Statistics
KNBS:	Kenya National Bureau of Statistics
NGO:	Non-Governmental Organization
OECD:	Organization for Economic Co-operation and Development
PSM:	Propensity Score Matching
RCP:	Representative Concentration Pathway
SMS:	Short Message Services
SNA:	Social Network Analysis
SSA:	Sub-Saharan Africa

UN: United Nations

UNCTAD: United Nations Conference on Trade and Development

UNDP: United Nations Development Program

UN-HABITAT: United Nations Human Settlements Program

WHO: World Health Organization

WRI: World Resources Institute

CHAPTER 1

INTRODUCTION

1.1   Background

The energy crisis, rapid population, pollution, climate change, poverty, and food insecurity are some of the complex issues experienced in the 21st century with the inevitable impacts threatening lives and livelihoods of millions in both developed and developing countries, (UN, 2013; Kandachar, 2017 UN, 2013; Adger et al., 2012). Many studies indicate that these challenges are prominent and overwhelm the adaptive capacities of societies contributing to their destabilization hence leading to further risks in developing countries (IPCC, 2015; UN, 2013). In addition, the impacts associated with the challenges such as climate change, poverty, and food security are more pronounced in rural areas of developing countries and exert pressure on the limited resources which generally affect the household adaptive capacity (Aryes, 2007). Adaptive capacity has been proven to be an essential component in reducing the vulnerability[1] of the system to a particular shock and it is critical for achieving system development outcomes [2] (DFID, 1999; IPCC, 2007; Nelson et al 2007).   The adaptive capacity development is therefore imperative in increasing the ability of the rural vulnerable populations (Ospina et al, 2010; Muasa et al., 2019).

In Sub-Saharan Africa (SSA) context, the rural population comprises of households who solely rely on the environment for their livelihoods such as agriculture and are more vulnerable to environment-related challenges such as climate change and variability (World Bank, 2017; UN, 2018; Thompson et al., 2009; FAO, 2015). Approximately 80% of the SSA rural population relies on agriculture for livelihood (AASR, 2017; Alliance for Green revolution in Africa, 2017). Agriculture is entirely rain fed subjecting rural households to climate change and variability related shocks and other shocks affecting their livelihood and drive to food insecurity issues (Adger, 2012).

Climate change and variability are some of the extensively studied fields particularly in relation to the agriculture sector. The agriculture sector receives the largest known economic impacts associated with climate change and variability due to its size and sensitivity to changes in precipitation and temperature (IPCC, 2014; UN-Habitat, 2012). Through its inevitable direct and indirect impacts, climate change and variability are creating far-

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[1] Vulnerability is defined as the degree to which a system is affected adversely by a shock either directly or indirectly (IPCC, 2007)

[2] System development outcomes are the intended outputs or impacts that are achieved by a system after a development intervention (OECD, 2013). Examples of development outcomes include; increased income, risk management, etc.

reaching long term implications that affect thousands of people living in rural areas (UN-Habitat, 2012; Collier, 2014). The IPCC (2014) projections depict that agricultural productivity is expected to decline from 21% to 9% by 2080 due to climate change-related issues. Furthermore, it is expected that two-thirds of 600 million hectares of Africa's arable land will be lost by 2025 due to lack of rainfall and drought (Liliana, 2005). As a result, food insecurity and undernourishment are expected to increase, if nothing is done to develop the adaptive capacity of the rural population. The rural households rely on their available resources to cope with the shocks but the impacts outweigh the already scarce resources (Adger et al., 2012).

Kenya being one of SSA countries is not an exception. Over 80% of the country's rural population relies on rain fed agriculture and experience many shocks such as droughts, floods, diseases and death of livestock (KIHBS, 2017; Sherwood, 2013). More effort is needed to develop the rural household's adaptive capacity in order to increase the ability to manage the shocks and sustain their livelihood. In most African countries, Kenya included, the top-down approach is mostly applied to address the household level challenges, whereby resource allocation to households is based on the national level assessment (World Bank, 2014). As a result, what the household's need to address the challenge is not proportionately considered (World Bank, 2014; WRI, 2009). However, to address the challenges experienced by many rural households in Kenya, a wide range of mobile phone based services have been developed targeting rural populations to increase their agricultural productivity through providing them with relevant information and access to finances (CGIAR, 2014; Crandall, 2012). Although, many mobile phone based services exist currently, studies that quantify how these services are being utilized, how they benefit the household and how they contribute to their adaptive capacity development through the accessibility of resources barely exist in the current literature (Ospina et al., 2010; Nyamwanza, 2012). In addition, there are no studies that qualitatively or quantitatively visualize how the developed mobile phone based services influence the household social networks that increase the accessibility to resources and thus encourage general household adaptive capacity development (Ingold et al., 2010; Luthe et al., 2012; Rotberg, 2013).

1.2 Research aim and objectives

The principal aim of this research is to assess the impact of mobile phone based services on the household adaptive capacity to aid adaptive capacity development thus ensuring achievement and sustainability of development outcomes at the household level in rural Kenya. The study comprises of two parts, first, the household adaptive capacity assessment based on five selected resources from sustainable livelihood framework including; financial resource, information resource, human resource, physical resource and diversity of livelihood. The second part assesses how mobile phone based services can facilitate the accessibility of the resources to

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ensure general household adaptive capacity development. Furthermore, this study assesses how mobile phone based services have facilitated an increase in social networks to exchange and access resources between service providers and households and thus promoting adaptive capacity development of the household.

To achieve the main aim of this study, four specific objectives are generated;

1) To analyze household adaptive capacity and identify resources comprised in the household adaptive capacity that needs to be developed.
2) To assess households' mobile phone usage and access to adaptive capacity resources.
3) To evaluate the impact of mobile phone based services on household adaptive capacity.
4) To examine the influence of mobile phone based services on household social networks to access resources that facilitate adaptive capacity development

This research seeks to contribute to the current literature by addressing the outlined gaps through; 1) assessing adaptive capacity at the household level to identify the capacity needs of households, and 2) outline how the wide range of mobile phone based services contribute to household adaptive capacity development through increasing access to resources and social networks. Furthermore, this study provides an evidence-based study grounded on field-based qualitative and quantitative inquiries composed of selected households, community organizations and national government officials as well as relevant secondary materials to provide comprehensive documentation of mobile phone based services for rural household adaptive capacity development in Kenya. This is to achieve household development outcomes such as increased livelihood diversification, increase income and the ability to cope and adjust to shocks experienced at the household level. A study by IPCC (2014) and Chambers et al., (1992) show that the availability of resources in a household is important in determining the vulnerability of the household facing a shock.

Through rural household's adaptive capacity assessment, the challenges experienced by rural households and needs are identified. In addition, the importance of utilizing the available developed mobile phone based services is identified to ensure household adaptive capacity development, and the benefits accrued from utilizing these services and also the challenges that limit households to these services are outlined. All these will initiate delivery of the appropriate programs, resources, and services to the rural households to facilitate adaptive capacity development at the household level.

1.3   Structure of the thesis

Chapter 1 of this study provides background on challenges experienced in developing countries and the importance of household adaptive capacity development. The gaps that currently exist in the literature on adaptive capacity assessment and development through ICT are outlined. Also, the chapter outlines the challenges experienced by rural households in SSA and Kenya and depicts why adaptive capacity development is essential for households. The aim of this study is also discussed in this chapter with the specific objectives that were set to achieve it outlined.

Chapter 2 shares previous theoretical and empirical research of challenges experienced by the rural population in SSA and Kenya. The adaptive capacity concept is defined based on previous studies reviewed. It expounds on the adaptive capacity development process which comprises; adaptive capacity assessment and how ICT facilitates adaptive capacity development. It discusses the linkage between ICTs and adaptive capacity and how they facilitate an increase in accessibility to resources and social networks. The mobile phone statistics in Kenya are discussed and a wide range of services targeting the rural population. The existing gaps in the literature are identified which this study seeks to address.

Chapter 3 outlines the research methodology comprising; research design, study site, data collection methods, data analysis and justification of methods applied. The research design outlines the overall strategies that this study employs to integrate the different components of the study in a logical and coherent manner to effectively address the research problem and achieve the aim of this research. It constitutes the outline for data collection and analysis. Further, the overview of the study site (Makueni County) is discussed in detail. In this chapter, the data collection methods including questionnaire surveys, key expert interviews and focus group discussions are discussed in detail. The estimation methods used to analyze the data including; Analytical Hierarchy Process (AHP), Propensity Score Matching (PSM) and Social Network Analysis (SNA) are discussed intensively and justification of choice of these methods are outlined. The AHP is used to assess the household adaptive capacity based on the five resources discussed, the PSM is used to evaluate the impact of mobile phone based services on household adaptive capacity and SNA is used to visualize social networks facilitated by using mobile phone based.

Chapter 4 outlines the household socio-demographic characteristics and an overview of shocks experienced by the households in Makueni county. Furthermore, the chapter depicts the areas of the households affected by the shocks and adaptive strategies applied by the households.

Chapter 5 comprises of the household capacity assessment findings. It outlines the household adaptive capacity index (HACI) estimations for all the households based on the five resources. AHP method is applied to assign weights to the five resources. The households are then categorized into three levels; low, moderate and high adaptive capacity index to understand the state of adaptive capacity across the surveyed households. Further, the results on the important resources that need to be developed across the households including; financial, information and diversity of livelihood are outlined. An increase in accessibility and scale of the resources to be developed will ensure general adaptive capacity development of the households.

Chapter 6 provides mobile phone usage of surveyed households in Makueni County. These include; the mobile phone penetration rate, the type of mobile phone owned, the usage patterns and other ICT devices owned by the households. The surveyed households comprised of mobile phone based users and non-user, which facilitated comparison on the accessibility of the financial, information and diversity of livelihood. The users comprise of households that own mobile phone and use mobile phone based services to access the financial, information and diversity of livelihood while the non-users comprise of households that do not have a mobile phone and those that have a mobile phone but do not use the mobile phone based services to access the resources.

Chapter 7 outlines the findings of the impact of mobile phone based services on household adaptive capacity. The differences in HACI of households categorized in user and non-user groups are illustrated in detail. Further, the overall impacts of utilizing mobile phone based services are outlined and how they facilitate adaptive capacity development. In this chapter, the impact of the social experiment (provision of information and training in mobile phone based services to the non-user group) on household adaptive capacity in which the baseline and follow-up surveys are utilized to evaluate the impact is illustrated. Also in this chapter, the development outcomes that the households can achieve from developed household adaptive capacity and general benefits accrued from the mobile phone based services to the households are outlined.

Chapter 8 shares the social network visualization of the user and non-user in accessing financial and information resources of adaptive capacity. The network for the information and financial exchanges for the user and non-user are outlined. In this chapter, a statistical analysis hypothesizes whether the number of links to access information and financial resources contributes to higher HACI. This chapter shows how mobile phone based services can facilitate the expansion of networks that encourage adaptive capacity development.

Chapter 9 outlines the research conclusions and implications. This chapter involves; a summary of key findings and conclusions, the implications of the study, the limitations of the study and suggestions for future

work. Figure 1 shows the summary of chapter structures of this dissertation. This study comprises two important parts including adaptive capacity assessment and adaptive capacity development as indicated in Figure 1. The adaptive capacity assessment part is discussed in chapter 5 while the adaptive capacity development part is outlined in chapters 6,7 and 8.

Chapter 1

Introduction/problem statement/aim/objective/dissertation disposition

Chapter 2

Literature review

Chapter 3

Research methodology; study design, study site, data collection and analysis methods

Chapter 4

A descriptive analysis of household characteristics and shocks experienced

Part 1

Adaptive capacity assessment

Chapter 5

Household adaptive capacity assessment

Part 2

Adaptive capacity development

Chapter 6

Mobile phone use and access to adaptive capacity resources

Chapter 7

Impact of mobile phone based services on household adaptive capacity

Chapter 8

Influence of mobile phone based services and social networks

Chapter 9

Conclusion and implications

Figure 1 A summary structure of dissertation chapters

LITERATURE REVIEW

2.1   Adaptive capacity definition

The concept of adaptive capacity has been widely used and defined differently depending on the study context. In the context of biology, adaptive capacity is defined as the 'ability of species or organisms to become adapted to (or to be able to live and reproduce in) a certain range of environmental contingencies (Gallopin, 2006).

In the climate change field where this concept is widely used, IPCC Fifth Assessment Report (2014) defines adaptive capacity as 'the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences'. Other definitions of adaptive capacity based on past studies in human-environmental systems and social-ecological systems are indicated in table 1.

Based on the past studies definitions outlined in Table 1, adaptive capacity can be defined using two important parts that are critically highlighted. First, most of the definitions from table 1 (Nelson et al., 2007; Moser, 2008; Walker et al., 2002; Luers et al., 2003) point out that adaptive capacity is the ability of a given system to better manage or adjust to some changing condition, disturbance or challenges (s)[3]. The second important part highlighted in these definitions (Adger et al., 2005; ISDR/UN, 2004; Gallopin, 2006) is that adaptive capacity is largely a function of resources or assets inherent in and accessible to a given system, see table 1. According to Nyamwanza (2012) and Defiesta et al. (2014), these resources defining adaptive capacity would be natural, physical, human, financial and social capital in a livelihood system that is adopted from the sustainable livelihood framework by Chambers and Conway (1992) and DFID (1999). Based on the two parts of adaptive capacity, a definition in this study is developed and defined as 'the ability of a given system (the system in this study is household) to better adjust to some changing conditions, disturbances or challenges given the resources available and accessible to the system'

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[3] The changing conditions, disturbances or challenges might be stresses such as general economic hardships, declining rainfall, diseases, poverty or shocks which is defined as the impacts which are unpredictable, sudden and traumatizing for instance, droughts, floods, and violence (Krantz, 2001).

Table 1 Adaptive capacity definitions

Source	Definition
Adger et al., (2005)	- Adaptive capacity is a vector of resources and assets that represent the asset base from which adaptation actions can be made
ISDR/UN (2004)	- Adaptive capacity is a combination of all the strengths and resources available within an entity (household, community, society) that can reduce the level of risk (or effects of a disaster)
Gallopin (2006)	- It is the capacity of any human system from the individual to humankind to increase the quality of the life of its individual members in a given environment or range of environments
Nelson et al (2007)	- Adaptive capacity is the way to describe the precondition necessary for a system to be able to adapt to disturbances and it is represented by the set of available resources and the ability of a system to respond to disturbances, including the capacity to design and implement effective adaptation strategies
Moser (2008)	- Adaptive capacity refers to the ability to make various changes, sometimes deep and structural, to help systems better align with long-term changes in their social and environmental spheres
Walker et al. (2002)	- Adaptive capacity is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions and development of generalized responses to broad classes of challenges
Luers et al. (2003)	- Adaptive capacity is the extent to which a system can modify its circumstances to move to a less vulnerable condition

Source: Adger et al., 2005; ISDR/UN, 2004; Gallopin, 2006; Nelson et al., 2007; Moser, 2008; Walker et al., 2002; Luers et al., 2003

2.2 Adaptive capacity development

Adaptive capacity is critical for the achievement of development outcomes, realize increased income, reduced vulnerability and increased food security of the system (DFID, 1999; IPCC, 2007; Nelson et al 2007; Ochola, 2009). Adaptive capacity facilitates both transitions and transformations that are the long-term adaptation directed to more desirable states (Adger et al., 2007), the greater the adaptive capacity the more the system will be able to wind up in a desirable situation in the face of a given shock. Lemos (2007) and Folke et al. (2010) argue that developing the household overall adaptive capacity may positively influence their ability to better take advantage of risk management mechanisms, for instance, identification of effective drought response.

According to UNDP (2008) and OECD (2002), adaptive capacity development takes several steps; adaptive capacity assessment, adaptive capacity development response and evaluation of adaptive capacity development as indicated in Figure 2. In this step, the adaptive capacity is assessed in order to identify areas and resources that need to be developed. In step two, the adaptive capacity development response is designed and implemented with the purpose to respond and develop the areas and resources identified during the adaptive capacity assessment. Evaluation of adaptive capacity development is then conducted after implementing the development response in order to understand the impact of the development response on adaptive capacity development.
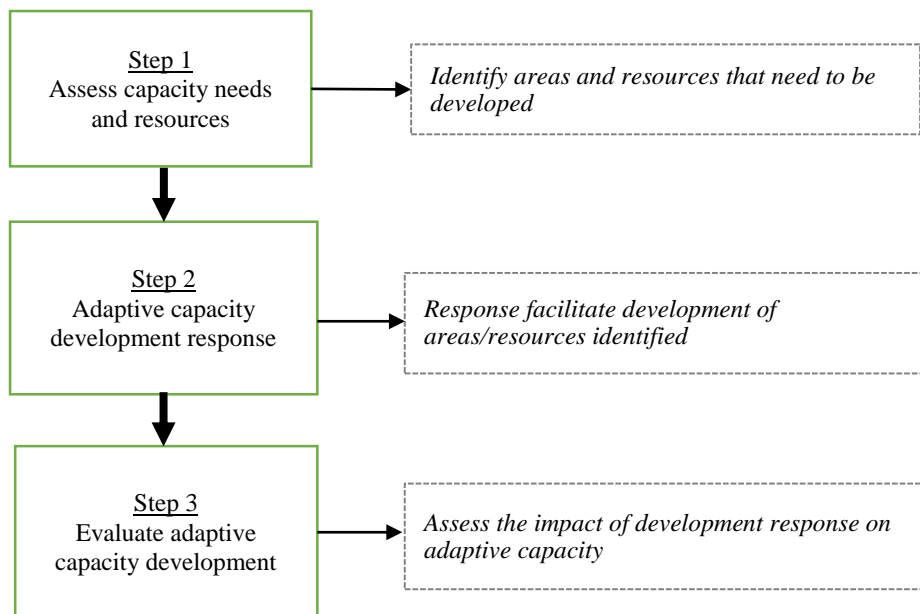
Figure 2 Adaptive capacity development process

Source: UNDP, 2008; OECD, 2002

2.2.1 Adaptive capacity assessment

According to UNDP (2008), adaptive capacity assessment is essential in identifying areas and resources that need to be developed, as the first step of adaptive capacity development, it facilitates in decision making on resource distribution. The adaptive capacity assessment helps to identify capacity gaps and provides insights to the service providers and policymakers to design and implement appropriate programs and services which will facilitate the ability to cope or adjust to challenges experienced (DIFD, 1999; Defiesta et al., 2014; UNDP, 2008, UNDP, 2014)).

Adaptive capacity can be estimated and understood at three levels: the micro (household level), the meso level (community level) and the macro-level (region or national level) (UNDP, 2008; Ospina et al., 2011; Ibarrarán et al., 2010; Stringer et al., 2009; Brouwer et al., 2007). Many studies on adaptive capacity assessment commonly focus at the national level and there are limited studies at community and household level (Thathsarani et al, 2018; Ospina et al., 2011; Muasa et al., 2016; Nelson et al., 2010; Tol et al., 2007; Vincent, 2007).

At the national level, the adaptive capacity assessment is function-based and qualitative. The assessment involves; assessment of vulnerability, coordination of different factors and management of information (WRI, 2009). In this case, most national adaptive capacity assessment is basically designed to compare countries for international financial support (WRI, 2009). In most African countries including Kenya, the resource allocation to households in rural areas is based on national level adaptive capacity assessment (WRI, 2009; World Bank,

2014). Therefore, what the households have and what they need is rarely considered in the face of a given challenge (WRI, 2009; World Bank, 2014). Therefore, there is a great need to assess and understand the adaptive capacity at the household level in order to identify the adaptive capacity needs of the households (Defiesta et al., 2014).

Previous studies depict a range of approaches for adaptive capacity assessment including inductive theory-driven approach by Pelling et al. (2008) and Gupta et al., (2010); adaptive capacity based on self-assessment process (Raymond et al., 2013; Brown et al., 2010); secondary data sources (Adger et al., 2005; Smit et al., 2006; Eriksen et al., 2007) and future modeling's by Bussey et al., (2012). The inductive theory-driven approach method, self-assessment approach and future modeling approach of adaptive capacity assessments are mostly conducted at institutional and national levels (Raymond et al., 2013). In addition, in the inductive theory-driven approach and self-assessment studies, the adaptive capacity assessment indicators are adopted often from the vulnerability and resilience literature, then the indicators are aggregated to determine the adaptive capacity (Schneiderbauer et al., 2013; Cabell et al., 2012; Schroter et al., 2005; Walker et al., 2004). The resources owned by the institution or nation are not considered in the adaptive capacity assessment in the inductive approach and self-assessment studies.

On the other hand, adaptive capacity assessment based on secondary sources is majorly determined using dimensions obtained from the rural livelihood frameworks (Ellis, 2000). These dimensions are resources including; financial, information, physical, human and diversity of livelihood obtained from sustainable livelihood framework (Chambers and Conway, 1992; DFID, 1999; UN, 2013). The resource-based adaptive capacity assessment has been advocated suitable for the household adaptive capacity assessment (Yohe and Tol, 2002) since it is widely used for development practice at the local context (DFID, 1999). Also, it is flexible to changes and applicable to different local contexts (Chamber and Conway, 1992). In addition, a resource-based framework conceptualizes how the people operate under a given vulnerability context that is shaped by different factors and it is suitable for understanding the livelihood of the rural low-income communities (Chambers and Conway, 1992).

Furthermore, through the resource-based approach, the five resources are estimated and through the aggregation of the resources an index is computed which estimates the adaptive capacity of the household (Raymond et al., 2013; Defiesta et al., 2014). The resource-based approach has been applied at the community level in Australia in which adaptive capacity assessment was based on secondary data obtained from the national statistics of the five resources; financial, information, physical, human resource and social resources (Raymond

et al., 2013; Nelson et al., 2007). In this study, the role of key experts and primary data to visualize the real situation at that period was not put into consideration. In another study on the resource-based approach to assessing adaptive capacity was conducted in the Philippines by Defiesta et al. (2014). In this study the adaptive capacity of rice farmers was assessed based on; financial, information, physical, human and diversity of livelihood, and the key experts and primary data was put into consideration to visualize adaptive capacity at the community level. Although a resource-based approach has been applied in discussed reviewed studies, adaptive capacity assessment at the household level is less explored.

Based on current literature there are limited resources based studies for adaptive capacity assessment at the household level in most developing countries especially in the African context (Nyamwanza, 2012; UNDP, 2014; Defiesta et al., 2014). This study focuses on bridging this gap by assessing adaptive capacity at the household level using the resource-based approach with resources adopted from the sustainable livelihood framework (Chambers and Conway, 1992; DFID, 1999).

2.2.1.1 Resource-based approach and adaptive capacity

Previous studies show that resources grant people the power to act, meet their needs as well as grant them the potential to confront given stresses or conditions (Chambers and Conway,1992; DFID, 1999; Bebbington,1999; Moser, 2011; Scoones, 1998). At the household level the more the resources the household has, the greater the capacity and less vulnerable to given stresses or challenges (Moser, 2011). The resource-based approach is suitable for assessing adaptive capacity at the household level as depicted in section 2.3.1 and it has strong links to the sustainable livelihood frameworks (SLF). Many previous studies have proven that the resource-based approach adopted 5 resources from the SLF (Financial resource, human resource, physical resource, diversity of livelihood and information resources) as direct indicators of adaptive capacity (Elasha et al., 2005; CARE, 2009; Deressa et al., 2008; Vincent, 2007; Adger et al., 2004). SLF is a concept that conceptualizes the development of programs and practices (Chambers and Conway, 1992). The SLF portrays that vulnerability has a direct impact on people's resources and livelihoods (Wright et al., 2013),. The shocks experienced by rural households can be conceptualized as an aspect of vulnerability context. Sustainable livelihood framework incorporates the skills, the approaches and resources (both material and social) which are used by the individuals, households or communities to survive and which help them to antagonize and overcome instants of stresses, conditions, disturbances or challenges (DFID, 1999; Chambers and Conway, 1992; UNDP, 2014). The availability of the resources in a household significantly define its potential to cope or adjust to changing conditions and challenges and these

resources comprise; Information, financial, diversity of livelihood, physical and human resource (DFID, 1999; Vincent, 2007; Defiesta et al., 2014; UNDP, 2014).

The importance of each of the five resources for adaptive capacity is discussed in detail in the following sub-sections.

2.2.1.1.1   Financial resource

A financial resource is the availability of cash that enables people to achieve a certain livelihood activity (DFID, 1999; Chambers and Conway, 1992; UNDP, 2014). The sources of financial resources in a livelihood is in two forms: 1) Available stocks which include savings that are held in several forms such as; bank deposits, cash in hand or liquid assets such as livestock or jewelry, it can also be obtained through credit providing institutions, and 2) the regular inflows of money which is the money received through earned income, remittances, pensions and other transfer's or subsidies from government or organization as regular inflows (DFID (1999).

From DFID (1999) and Chambers and Conway, (1992), the financial resource is the most versatile resource and is considered important across the five resources due to its ability to be converted into different degrees. It is one of the important resources which the households use to achieve livelihood outcomes. Although the financial resource is considered the most important resource, it is usually the most limited to get (DFID, 1999; Defiesta et al., 2014).

2.2.1.1.2   Physical resource

The physical resource comprises of basic infrastructure or producer goods that are needed to support the household. The infrastructure focus on the environment that affects communication and access to basic services such as vehicles, secure shelter, and buildings, roads, irrigation. Producer goods refer to the tools or equipment which facilitate productivity such as farming tools and land (DFID, 1999; DFID, 2000; Chambers and Conway, 1992). The physical resource through infrastructure and producer goods facilitate the provision of services that help households to acquire their basic needs and production capabilities (DFID, 2000). Many studies have proven that lack of access to physical resource deludes education, health services, and income generation (Chambers and Conway, 1992, Banuri, 2009; DFID, 1999).

2.2.1.1.3   Diversity of livelihoods

Diversification of livelihoods is recognized as an important strategy that decreases vulnerability and it is important for the population that derive part or all the livelihood from environment-related activities such as agriculture and fishing to engage on more than one livelihood activities in order to increases the ability of the

household to cope or adjust to a shock (Defiesta et al., 2014). Households construct an increasingly varied portfolio of activities and resources in order to survive and to improve their standards of living (Ellis, 2000).

2.2.1.1.4 Information resource

Information resource refers to the avenues by which households can derive pertinent information that strengthen their ability (Defiesta et al. 2014). The information can be accrued either directly from training or indirectly through interactions and knowledge sharing among households. High human resources at households mean more education level, long experience, and better health. These translate to more knowledge and skills that aid in making better decisions to adjust or cope with a given shock.

2.2.1.1.5 Human resource

The human resource includes the knowledge, skills, competences, and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being (OCED, 2001; Keeley, 2007). Accessibility to human resource defines the ability of the system to cope or adjust to the challenges that the system encounters (Chambers and Conway, 1992; Defiesta et al., 2014; DFID, 1999).

2.2.2 Adaptive capacity development response

A good adaptive capacity development response should facilitate existing adaptive capacity resources to address the adaptive capacity gaps that are identified through adaptive capacity assessment (UNDP, 2014). Previous studies indicate that most households focus on and prefer to play with their strengths based on available resources (World Bank, 2014; UNDP 2008, 2014). A good adaptive capacity development response can facilitate increasing accessibility and scale of adaptive capacity resources (Heeks et al., 2012; IAPAD, 2010; Nanda et al., 2009) and can expand social networks with service providers to increase access and exchange of adaptive capacity resources that facilitate general adaptive capacity development (Mehta et al., 2011). This study focuses on ICT as the adaptive development response since it plays an essential role in developing adaptive capacity through increasing access to resources and can facilitate household networks (Qiang et al., 2011; COP 21, 2015; Schramski et al., 2018; Rhodes, 2016).

2.2.2.1 Linking ICTs and adaptive capacity

The developing countries are particularly vulnerable to climate related impacts such as climate change and variability due to limited resources and capacities and nature of their livelihoods to respond to the changes (Ospina et al., 2011). In SSA countries, climate change and variability impacts are more pronounced to resource-dependent rural households (Adger, 2012; Thompson et al., 2009; FAO, 2015). It is within this context that the

development and use of ICTs are rapidly spreading in developing countries (UNCTAD, 2009; ITU, 2017; Lu, 2016). Heeks (1999) define ICTs as 'technologies that enable the users to receive, process, transmit or send information which may be in the form of voice, text or picture'. Generally, ICTs have been proven to increase efficiency, productivity and communication at national, community and household levels (Pant, 2011; Qiang 2015, ITU, 2019). Examples of ICTs include; computers, mobile phones, Geographic Information Systems (GIS), web space radios and television (ITU, 2019). ICTs play a crucial role in the development of adaptive capacity and they provide important development potentials especially for low-income households whose vulnerability is catalyzed by the effects of climate related disturbances (Pant et al. 2011; IPCC, 2014; Moser and Satterthwaite, 2008).

2.2.2.2   ICTs and resource accessibility/scale

ICTs facilitate access to household resources, such as information and knowledge which are important components of adaptive capacity (Ospina et al., 2011). A study by Nanda et al., (2009) depicted that use of ICTs increase information resource through weather forecasts and human resource through e-learning and telehealth of households in rural India and also increases the interaction between scientists, doctors, professors, and government officials in face of climate related events.

Through ICTs the scale (refers to the range of resources (Ospina et al., 2011)) of available resources can be increased by combining both household proximate and distance to the resources (Ospina et al., 2011). According to IAPAD (2010), through a community-based tool that merged local people's knowledge and GIS generated data, the information resource of people in the rural Philippines increased and thus facilitated the ability to cope to climate related shocks. Duncombe (2016) proves that ICTs play a role in strengthening the physical preparedness of a system for a shock through applications such as GIS. The use of ICTs has been proven to increase the availability of resources in such a way that there is excess or substitutability of the resources (Ospina et al., 2011). A study by Lightfoot et al., (2008) in Tanzania depicted that mobile phone usage and the internet increased farmers' participation in markets and information for increased productivity was provided. This generated extra income for the farmers which basically strengthened farmers' ability and preparedness to respond to climate related events.

Furthermore, ICTs have been shown to enable rapid access to adaptive capacity resources, for instance, financial resource. Through mobile banking and mobile finance, rural households are able to swiftly conduct transactions by receiving or sending finances efficiently. (Duncombe et al., 2009). In addition, ICTs increase

access to information resource (Mahan et. al, 2009). The information is imperative especially when an acute climate related event shock such as floods or landslides have occurred. According to Aziz et al., (2016), the speed of disaster warning, how to respond and recovery has recently been rapidly enhanced by mobile-based applications and networks which allow swift information flow to people. Although there are existing studies relating ICTs and adaptive capacity resources accessibility, adaptive capacity development remains least explored areas of analysis of ICTs potential especially in the Africa rural context (Ospina et al., 2010; Qiang et al., 2011). In addition, there are limited studies that quantify how the developed range of ICTs are being utilized to develop household adaptive capacity (Pant et al., 2011).

2.2.2.3   ICTs and expanding household social networks

The level of household adaptive capacity is influenced by networks to institutions/policymakers and service providers since these networks help to structure, respond to impacts experienced by the household, access, and exchanges to resources (Jaja et al., 2017). These networks the household act as the conduit through which resources reach the households which facilitate adaptive capacity development (Agrawal, 2008). Networks help to understand the trust between the households and all the government and non-governmental actors (Adger et al., 2003; Pahl-wostl, 2009). In order to understand the influence that the institution has on the household adaptive capacity not only requires understanding the linkages that exist between the institutions, service providers and households but also analyzing the strengths of the individuals governing the institutions (Keskitalo, 2010).

A study by Jaja et al., (2017) shows that the ability of a system to successfully adapt to a given shock requires collective resources from different organizations operating from different scales. The strength of the vertical and horizontal integration of institutions helps in developing adaptive capacity and the households that are involved in these systems have a higher adaptive capacity (Ingold et al., 2010). This study tries to explore the impact of social network analysis as a concept to develop adaptive capacity at the household level to increase the ability to cope with different impacts experienced. There are limited studies at the household level on how social networks help to increase household access to adaptive capacity resources such as information, human and financial resources. In a study by Schramski et al. (2018), the rate of networks available in a given household increases access to adaptive capacity resources. In addition, a strong social tie allows greater access to resources and reduce the psychological stress caused by climatic disturbances through strengthening adaptive capacity (Smit and Wandel, 2006).

2.2.2.4   Why mobile phone across other ICTs

There is a wide range of developed ICTs designed to facilitate access to resources and expansion of networks such as GIS, television, radio, web platforms and mobile phones. Among these developed ICTs, the mobile phone is the most dominant technology (Pant, 2001; Qiang et al., 2011; Donner, 2008). It is the world's common way to transmit voice, data, and services in most developing countries (World Bank, 2012; Qiang et al., 2011, Baumuller, 2012). The mobile phone usage has been increasing in Africa with 671 million people owning a mobile phone by the end of 2018 due to increased affordability (World Bank, 2012; Qiang et al., 2011; CGIAR, 2014; Christine, 2009). Studies by Steinke et al. (2019) and Asongu (2016) have proven that many mobile phone based initiatives have been developed targeting households and farmers although there are no studies that quantify how these services impact resource accessibility at the household level. Therefore, this study focuses on the mobile phone as one of the promising ICTs tools, the wide range of mobile phone based services as the development response that facilitates access to adaptive capacity resources and how increased accessibility and scale of resources facilitate household adaptive capacity development in rural areas.

2.2.2.5   Mobile phone usage and statistics in Africa and Kenya

In many developing countries, the mobile phone uptake has significantly impacted economic initiatives which have led governments, private corporations, and non-governmental organizations in explaining the possibilities and imperativeness of using a mobile phone to communicate with citizens (Crandall, 2012). The International Technology Unions (ITU) report in 2017 shows that the world mobile phone subscriptions are more than the people. Furthermore, ITU indicates that mobile phone adoption in developing countries has increased from 96.3% in 2016 to 98.7% by the end of 2017 (ITU, 2017). The mobile phone has been depicted to have a greater impact on agricultural development through information accessibility, increase in agricultural extension outreach and financial accessibility through voice calls, SMS and mobile phone based applications (Lawal et al, 2010; Qiang et al., 2011; COP 21, 2015). Previous studies pointed out that mobile phone is not being used to its full potential while it is currently being used in ways that contribute to farm productivity, and thus farmers' capacity to use the provided services need to be improved (Mittal et al., 2012; Aker, 2016; Aker, 2010, Martin et al., 2011). In Kenya, the mobile phone penetration rate [4] increased from 76.8% in 2012 to 88.6% in 2018 and it is projected to rise to 96.3% by 2020 as indicated in Figure 3 (Communication Commission of Kenya, 2018).

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[4] The mobile phone penetration rate refers to the total mobile phone subscriptions over the total population of a certain country or region (ITU, 2017; World Bank, 2017). It measures the rate of active mobile phone users in a given region. Due to the multiple mobile phone ownership per individual, the mobile phone rate can exceed 100% (GSMA, 2018)
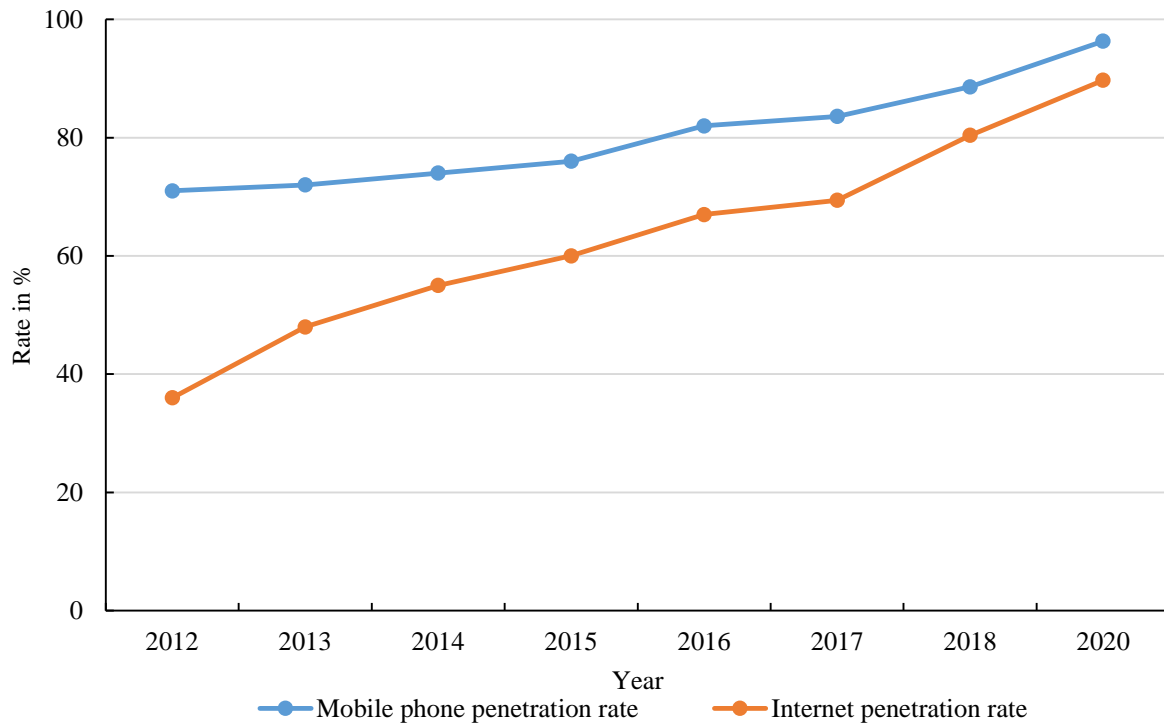
Figure 3 Mobile phone and internet penetration rate in Kenya

Source: Communication Commission of Kenya, 2018

This high mobile phone penetration rate indicates that mobile phone technology is a promising business opportunity as well as an indispensable tool for empowering the population, especially in rural areas. A study conducted at the household level in rural Kenya across all the 47 Kenya Counties shows that the ICTs owned by rural households include television, radio, mobile phone, computer and internet (KIHBS 2015/2016, 2017). According to KIHBS 2015/2016 (2017) and CAK (2018), approximately 75.6% of the rural population own radio, over 62% own a mobile phone, 33.7% own a television, 8.6% use the internet and 4.5% own a computer. The mobile phone is the second commonly owned ICT by rural households.

Approximately 30 million of Kenyan population (78.4%) in 2009 live in rural areas and largely rely on rain fed agriculture for livelihood (FAOSTAT, 2010; KNBS, 2009). Households in rural areas of Kenya are vulnerable to various types of risks including current weather events and projected climate change (Riziki and Maina, 2013; Herero, 2010). Due to climate variability and weather extremes which lead to disproportionality impacts of climate change, the rural population is more vulnerable (CGIAR, 2019; Glopolis, 2013) and access to both agricultural and climate information offer great potential to enable households to make informed decisions, take advantage of favorable climate conditions and adapt to changes. Currently in Kenya, a wide range of mobile

phone initiatives using voice calls, SMS and applications have been developed to provide information and financial services to rural households.

2.2.2.6   Agriculture and mobile phone based services targeting rural households in Kenya

In Kenya, the developed mobile phone based services target the rural population practicing agriculture by providing information and financial services through voice calls, SMS and installed applications on the mobile phone. The information provided is based on three themes; agricultural information, climate/weather information, and market information. Some of these information providers include Kenya Agricultural Commodity Exchange (KACE); a voice calling and SMS based information service in which the farmers can receive market information in Kenya (KACE, 2018), MFarm Ltd; an SMS based service which provides access to localized, current data on market and weather information (MFarm Kenya, 2018) and I-cow an SMS based service which provides dairy cow information. Some of the financial-based services are M-Pesa (Mobile money); a SMS based service which helps farmers receive and send money through the mobile phone (M-Pesa Kenya, 2018), M-Shwari is a SMS based service in which farmers can be able to access short term loans (M-Shwari Kenya, 2018) and M-Farmer funded by GMSA which provides rural households with financial advisory services in developing countries (GSMA, 2018). Table 2 shows a summary of a wide range of mobile phone based services that target households in rural areas in Kenya.

Table 2 Mobile phone based services targeting households in rural Kenya

Mobile phone based service	Service provider	Service offered	Category
Soko Hewani ('Super Market in the air")	- Kenya Agriculture Commodity Exchange (KACE) - SAFARICOM-Telecom operator	- Agricultural radio program accompanied by SMS and Voice calling	- Market Information
National Farmers Information Service (NAFIS)	- National agriculture and livestock extension program	- Allows farmers to access extension services through; internet, SMS and voice calling	- Agricultural information - Weather/climate information
Kilimo Salama (ACRE) 'Safe agriculture'	- Syngenta Foundation for Sustainable Agriculture - UAP Insurance company - Telecoms operator-SAFARICOM	- Insurance designed for Kenyan farmers so they may insure their farm inputs against drought and excess rain offered through money transfer (MPESA)	- Finance
Soko Pepe	- Kenya Meteorological - Department(KMD) - SAFARICOM	- Provides updates on weather/climate information	- Weather/climate information
I-cow	- Green Dreams TECH Ltd - SAFARICOM - USAID	- SMS application- helps farmers monitor their cows, provides agricultural information	- Agricultural information
Airtel Kilimo	- AIRTEL- telecom operator	- Provides market prices and weather information	- Market prices and weather/climate information
M-Pesa 'mobile-money'	- SAFARICOM- Telecoms Operator	- Helps farmers transfer and receive money, - Helps in saving	- Finance (Remittances, Save)
M-Shwari 'Mobile-safe'	- SAFARICOM- Telecoms Operator - Kenya Central Bank (KCB)	- Helps farmers access their bank accounts, save, access micro-credit product (loan)	- Finance(credit, save)
Shamba shape up	- The Media Company	- Tackle issues surrounding livestock, poultry, crops, soil fertility	- Agricultural information

Source: KACE, 2018; M-Farm, 2018, M-Pesa Kenya, 2018; M-Shwari Kenya, 2018; GMSA, 2018

CHAPTER 3

RESEARCH METHODOLOGY

3.1   Introduction

This chapter comprises of four parts; the research design, overview of the study area, data collection, and estimation methods. The data collection entails the household questionnaire survey, key expert interviews, and focus group discussions. The data estimation section comprises of Analytical Hierarchy Process Method (AHP), Propensity Score Matching (PSM) and Social Network Analysis (SNA) methods which are employed to estimate household adaptive capacity index (HACI), impact of mobile phone based services on household adaptive capacity and visualization of social networks used by households to access resources that encourage adaptive capacity development respectively.

3.2   Research design

This research involves two important parts; household adaptive capacity assessment and adaptive capacity development part. In the adaptive capacity assessment part, household adaptive capacity index (HACI) is computed based on five resources; financial, information, human, physical and diversity of livelihood. Also, the assessment identifies household adaptive capacity resources that need to be developed across households.

The adaptive capacity development part involves the development of the identified adaptive capacity resources. Furthermore, this study examines the potential of mobile phone based services, one of ICTs facilitate accessibility and scale of resources to ensure household adaptive capacity development. A visualization network map of the households is created to assess how mobile phone based services influence networks that increase access and exchange resources facilitating adaptive capacity development.

A mixed-method is applied by employing both qualitative and quantitative approaches that involve primary and secondary data collection methods. First and foremost, the initial stage of this study entails an extensive literature review to define the adaptive capacity concept, adaptive capacity assessment, and development as well as ICT/mobile phone statistics and mobile phone based services used in Kenya. For the adaptive capacity assessment, extensive literature was conducted to understand and facilitate the selection of theories/frameworks to analyze adaptive capacity at the household level. This stage forms the keystone of this study since the indicators for estimating adaptive capacity at the household level were selected to facilitate adaptive capacity assessment. Also, mobile phone based services targeting rural households in Kenya are outlined. The interviewed key experts

provided more statistical data regarding mobile phone based services utilized at the household level and also climate data of Makueni County.

The primary data collection encompassed the administration of semi-structured questionnaires to the selected households, key expert's interviews and focus group discussions. The primary data was collected with the purpose to obtain quantitative and qualitative data capturing household socio-demographic characteristics, adaptive capacity resources (financial, human, information, physical and diversity of livelihood), mobile phone statistics and how the households use the available mobile phone based services to access resources. Furthermore, the qualitative and quantitative data captured information regarding household networks and service providers to access and exchange adaptive capacity resources.

A multivariate analysis is conducted to cluster the collected data and determine the structure of the dataset. Since the obtained data of all adaptive capacity resource sub-indicators from the household survey were measured in different units, the minimum-maximum approach a normalization method was used to convert the data to values between zero and one. The weighting of adaptive capacity resources and resource sub-indicators was computed through the Analytical Hierarchy Process (AHP). Through a comprehensive composite index, both households and key expert's opinions are aggregated to develop one value of Household Adaptive Capacity Index (HACI) by summing weights of the five resources (financial, information, physical, human and diversity of livelihood). Based on the distribution of HACIs obtained, the households were then categorized into three levels; low, moderate and high adaptive capacities. The resources that need to be developed are then selected based on the distribution of the resources across the low, moderate and high levels. As a result, the resources initiating a greater disparity in HACI across low, moderate and high levels are selected. Therefore, to increase the accessibility and scale of resources identified, the potential of mobile phone based services as development response is evaluated in this study.

The surveyed households comprised of users defined as own a mobile phone and use the mobile phone based services to access the resources and non-users which is defined as comprises of households without mobile phone and households that own a mobile phone but do not use the mobile phone based services to access the resources. This facilitated comparison and evaluation of the impact of mobile phone based services on accessibility to resources and household adaptive capacity. In addition, a social experiment was conducted (intervention) targeting the non-users in which information and training on the available mobile phone based-services were provided. To

evaluate the impact of the provision of information on mobile phone based services on resources accessibility and household adaptive capacity, a baseline and follow up surveys are conducted.

A combination of Propensity score matching (PSM) and Difference in Difference (DD) methods are applied to determine the impact of the social experiment on the accessibility and scale of resources to be developed across the non-users. Social networks increase accessibility and exchange of resources between households and service providers. Therefore, to visualize the household networks to exchange and access resources, Social Network Analysis (SNA) is used to create visualization maps. Network visualizations for the users and non-users are created which facilitate comparison to depict the influence of mobile phone based services on social networks.

3.3 Overview of study site - Makueni County

3.3.1 Location, size, and dynamics of Makueni County

Makueni County is one of the 47 counties in Kenya situated in the South-Eastern part of the country. It lies in Latitude 1º 35´ and 3° 00´ South and Longitude 37º10´ and 38º 30´ East and it covers an area of 8,008.7km^2 comprising of 594 km^2 urban areas and around 7441 Km^2 rural areas for agriculture and other activities (KNBS, 2010). Makueni County borders Machakos County to the north, Kitui County to the East and Taita taveta to the south and Kajiado to the west. The County is currently divided into six sub-counties which include; Kaiti, Makueni, Kibwezi East, Kibwezi west, Mbooni, and Kilome. Figure 4 shows the sub-counties in Makueni County and its location in Kenya and Africa.
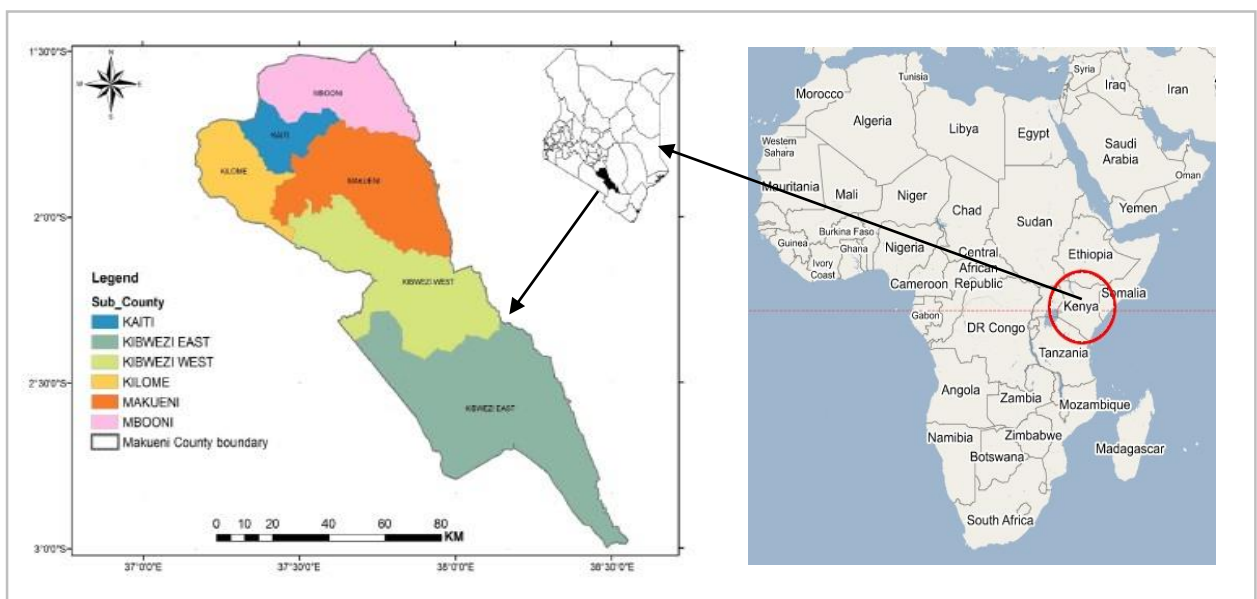
Figure 4 Sub-counties in Makueni County and its location in Kenya and Africa
Source: Cheruto et al., 2016; Wiki travel, 2018

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The projected population in Makueni County for 2018 based on the 2009 census is estimated to be 1,002,979 people, composed of 488,378 males and 514,601 females (KNBS, 2010). The County has a population density of 125 persons per km^2. The County is largely arid and semi-arid and is usually prone to frequent droughts. The County terrain is generally low-lying from 600m above sea level in the Tsavo at the southern end of the County. Makueni County has one main perennial river called Athi River which is mainly fed by few inland distribution rivers. Most of the rivers in Makueni County have changed from permanent to seasonal due to the continued decline of the amount of rainfall received (CIPD Makueni, 2016).

3.3.2   Livelihood activities in Makueni County

Agriculture is the predominant economic activity and employs the highest number of Makueni County residents with around 78% relying on it for livelihood. In the County, the major agricultural products include; green grams, mango, dairy farming, and local poultry and they support income generation, production and food security in the county (CIPD Makueni, 2016). The county receives scanty rainfall of 800-1200 per annum and high temperatures of 35.8^{0}C are experienced. Makueni County receives two rainy seasons, the long rains which occur between January and June while the short rain season occurs between July and December (KMD, 2017). The depressed rains in the county can hardly sustain farming of the major staple food of maize and beans due to frequent droughts and other climatic related impacts resulting in total crop failure and an increase in food insecurity across households (Makueni CIDP, 2013; Bukania et al, 2014). The county has frequently experienced insufficient rains and prolonged dry spells which has resulted to crop failure and high water scarcity (Makueni CIDP 2013). As a result, Makueni residents have turned into poverty coping strategies such as charcoal burning and sand harvesting which highly contribute to environmental degradation (Kenya vision 2030, 2008).

3.3.3   Land and climatic conditions

The land is the main natural resource in Makueni county and due to poor and unpredictable rainfall, the county prosperity is limited (Makueni CIPD, 2013). The arid and semi-arid characteristic of Makueni County makes it prone to extreme rainfall variability which results in prolonged droughts. The county has 3 Agri-ecological zones (AEZ); upper zone, central zone, and lower zone. The upland zone has 3 sub-counties which include; Kilome, Kaiti, and Mbooni. In the upper zone, most of the households rely on rain fed agriculture, highly practice food crop farming combined with some dairy farming and experience moderate probability of dry spells. The central zone constitutes only of Makueni Sub County and in this zone, most of the households highly rely on rain fed agriculture and the region has a higher probability of dry spells with around 30% crop failure. Due to this, the households highly practice both crop and livestock farming. Kibwezi Sub County is located on the lower zone

and it is highly prone to dry spells, it experiences around 46% of crop failure and due to this, most of the households practice livestock farming. Generally, all three zones in Makueni frequently experience dry spells which result in crop failure and also affect livestock keeping and this affects the livelihood of most households in Makueni County (Makueni CIPD, 2013).

Climate change and variability remain one of the largest threats to the agricultural sector in Makueni County. Since 1994, maize production has been declining and in 2013, 2015 and 2016, there has been a 70-90% crop failure in the county with the major crops like maize, green gram and cowpea registering more than 50% decline in productivity and as a result of more than 60,000 people subjected to food shortage thus left dependent on food assistance (Makueni County Vision 2025, 2016). The climatic hazards experienced in the county include drought, heat stress, reduced precipitation and increased temperatures (KMD, 2018). Analysis of past climatic events and future projections in Makueni County shows that the frequency and intensity of these events are increasing as indicated in Figure 5.
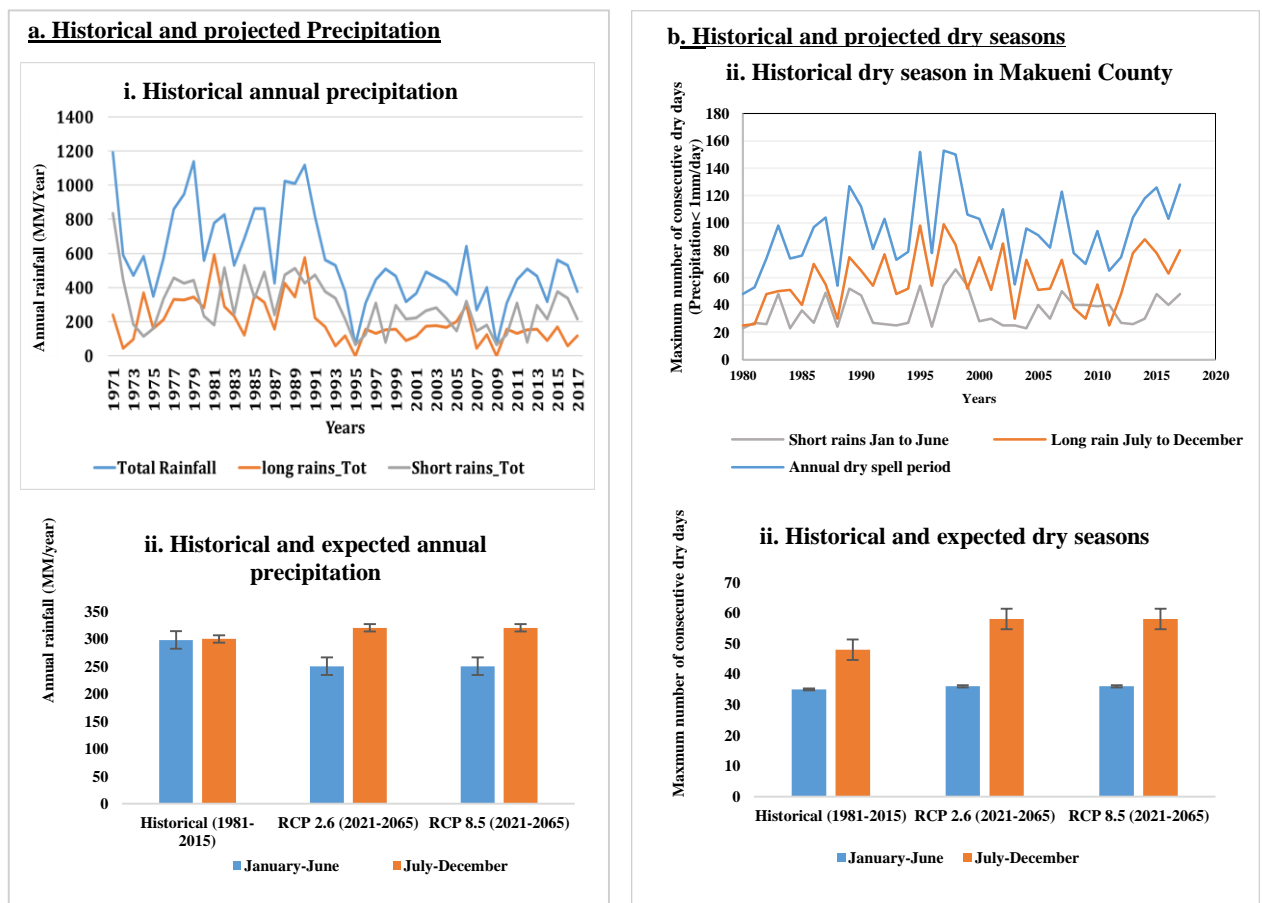
Figure 5 Past climatic conditions and future projections in Makueni County

Source: KMD, 2017; IPCC, 2014; modified by author

Figure 5a (i), shows that the total annual precipitation has been fluctuating and declining since 1971 with the years 1995 and 2009 experiencing a severe decline. In addition, the rainfall has been declining in both short and long seasons. Although planting occurs in both seasons, most farmers expect high productivity during the short season and therefore a decline translates to a decrease in agricultural productivity. The same notation is experienced for the amount of precipitation received in Makueni County as echoed by projections by the Representative Concentration Pathway[5] (RCP) scenarios 2.6 and 8.5 as indicated in figure 5a (ii). A decline in the amount of precipitation received in both short and long rain seasons in Makueni County between 2021 and 2065 is projected (IPCC, 2014). On the other hand, the dry spells per annum have been fluctuating since 1980 with an increase in the number of days without rainfall during the long rain season expected to increase by 2020 as indicated in 5b (i). The same situation is confirmed by the projections by the RCP that the temperatures in Makueni County are expected to increase between 2021 and 2065 as indicated in 5b (ii).

The arid and semi-arid characteristic of the county makes the situation worse and more prone to climate related extreme events such as droughts (Makueni CIPD, 2013). In addition, the households in Makueni county experience resource decline or demise of livelihood associated with agriculture due to changes in climate change and vulnerability.

3.3.4   Environment and food security in Makueni County

Households in Makueni County experience frequent food shortages leading to perpetual reliance on food donations from the government and other donors which unfortunately is not enough to cater to the large families. Also, the distribution of relief food is done unfairly due to corruption hence the targeted needy people are not reached. The county has been relying on food and non-food aid continuously for several years because of vulnerable livelihood systems. This has created a dependency syndrome within the community, hindering innovativeness and participation in development initiatives (Kenya Food Security Organization, 2011). Its food security situation has been caused by five consecutive partials to total crop failures (Gachuki, 2011; CSTI, 2009). Fight against hunger and poverty has been largely beset by unreliable rainfall resulting in drought and famines. A study by Mwaniki.A (2009) proves that food insecurity in Makueni County is also due to underdevelopment in the agricultural sector that is characterized by over-reliance on primary agriculture, low fertility soils, minimal use of external farm inputs and environmental degradation that remains a major dilemma until today. The

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[5] Representative Concentration pathways refers to the scenarios that are based on time series of emissions and concentrations of greenhouse gas emissions and aerosols (Moss et al., 2008). It is a concentration pathway extending up to 2100, they are used by the IPCC assessments as a basis for the climate predictions and projections

environment is at risk of severe degradation due to the unabated felling of trees for charcoal burning and firewood. This has exposed huge tracts of land to continued water and soil erosion. If these degradation trends are not arrested, then the livelihoods in the region will continue to be at threat.

3.4 Data collection methods

This study involves both qualitative and quantitative data collection in which a mixed approach is employed. data. The techniques to collect the primary data from the field survey included; household questionnaires, focus group discussions and key expert interviews.

3.4.1 Household questionnaire surveys

The data collection of this study involves the following phases; Master thesis (2016), pilot survey (February-March 2017), baseline survey/intervention (January-March, 2018) and a follow-up survey (August-September 2018), see study timeline in figure 6.

In the pilot survey phase, a preliminary survey of the Makueni County was undertaken in February 2017. The purpose of the survey was to familiarize with the study area, meet with the selected key experts from Kenya Meteorological Department (KMD), Kenya Agriculture Research Institute (KARI), Extension officers, peer farmers, farmers organization leaders, Department of agriculture, livestock and fisheries, Kenya Agriculture Commodity Exchange (KACE), Safaricom and Airtel to help in choosing, ranking and rating of the adaptive capacity resources and sub-indicators that were used to assess household adaptive capacity. The key experts did the rating and judgments of the adaptive capacity resources and resource sub-indicators based on the pairwise comparison method suggested by Saaty (2009) to indicate the importance of resources on household adaptive capacity.
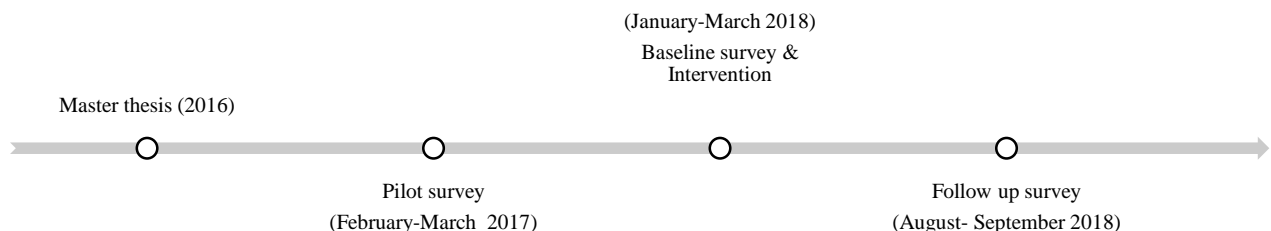
Figure 6 Field survey timeline

Source: Field survey 2017/2018

In addition, more secondary data was obtained from the key experts especially from Kenya Meteorological Department who provided data on rainfall and temperature from 1940 to 2018. This data was used to highlight the long-term change of rainfall and temperatures in Makueni County. The second field survey phase comprised a baseline survey conducted in February 2018. During the baseline survey, a semi-structured questionnaires was administered to collect explorative data on household socio-demographic characteristics such as; age, gender, household income and size of the household, data on adaptive capacity based on the five resources and sub-indicators, information on mobile phone statistics and how the households use mobile phone based services to access the adaptive capacity resources. Furthermore, information on household networks that facilitate access to adaptive capacity was collected.

A total of 250 households were sampled from the 11 selected villages in the 5 sub-counties in Makueni County, see Table 3. Two villages we selected in Kilome, Kaiti, Mbooni and Kibwezi sub-counties while three villages in Makueni sub-county since it has a higher population. To sample the households within the selected villages, google map facilitated in dividing each village into 4 segments by using identifiable features including the main road, paths, and rivers to demarcate the segments. In each segment, every third household was picked and interviewed. As indicated in Table 3, approximately 50 questionnaires were administered in each of the 5 sub-counties in Makueni County thus achieving a total of 250 questionnaires. Figure 7 shows the location of the study sites in the 5 sub-counties in Makueni County.

Table 3 Study sites and sampling

Sub-counties	Agri-climatic zones	Study sites (Villages)	Sample size
Kilome		- Kiima Kiu, Kasikeu	50
Kaiti	Upland zone	- Kilungu, Ilima	50
Mbooni		- Mbooni East, Kalawa	50
Makueni	Central zone	- Wote, Kathonzweni, Nzaui	50
Kibwezi	Lower zone	- Emali, Makindu	50
Total Sample size			250

Source: Field Survey, 2017/2018
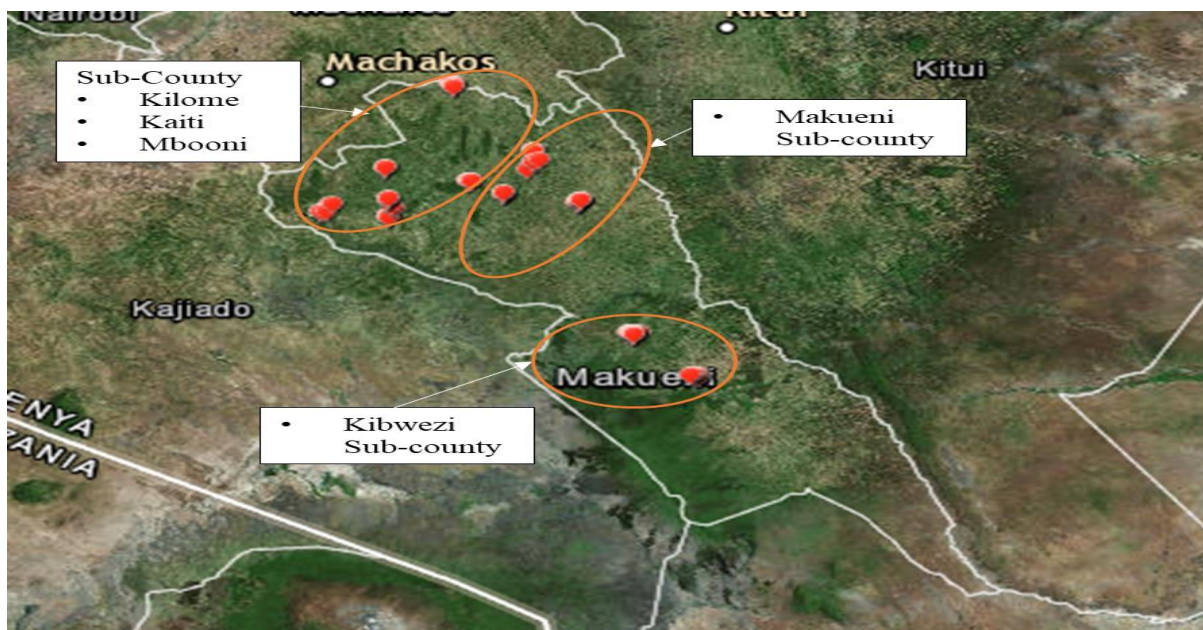
Figure 7 Location of study sites in the 5 sub-counties in Makueni County

Source: Google map, 2018; Field Survey, 2017/2018

The household questionnaires were administered with an aid of two technical enumerators, selected and given two-day training. The enumerators are acquainted with Makueni County in terms of the locations of the study site and household distribution and thus were instrumental in sampling. Though this can introduce sampling and response errors, it was a suitable approach to get information from the households. The questionnaires were first pretested on some households outside the sampled population, then adjusted, and directly administered to the respondents in the selected study sites. The household questionnaire survey targeted household head as the key respondent and in absentia of the household head, the wife was interviewed or an adult who is acquainted with the household information.

Out of the 250 interviewed households, 125 were users and 125 non-users. Users are households that have a mobile phone and they use mobile phone based services to access adaptive capacity resources. Non-users, on the other hand, comprises of households with a mobile phone and do not use it to access adaptive capacity resources and also households without a mobile phone as shown in Figure 8.
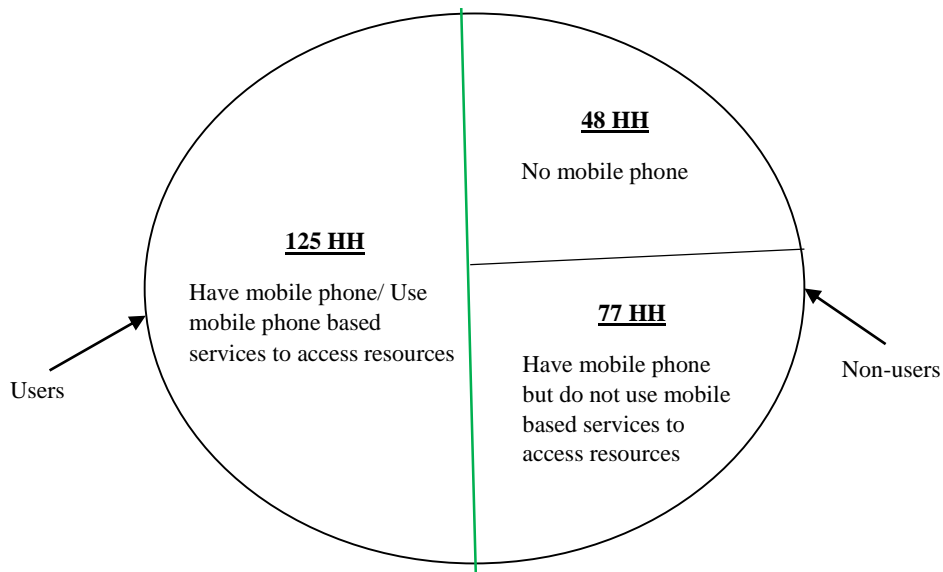
Figure 8 Illustrates the Users and Non-users

Source: Field survey 2017/2018

3.4.2 Intervention and monitoring

This research targeted the users and non-users to evaluate the impact of the mobile phone based services on household adaptive capacity development through. First and foremost, a baseline survey was conducted for all households and then an intervention conducted in January-March 2018, see the survey timeline in Figure 6.

The intervention targeted the non-user, information, and training on mobile phone based services to access resources were provided. No specific criteria for choosing the participants of the intervention collaborative session since all the 125 non-users were prior informed about the intervention session during the baseline questionnaire survey. As a result, the number of participants could not be controlled.

The mobile phone based services are provided by different service providers targeting the rural households and this study focused on collaborating with some of the experts in the intervention session. Mobile phone service providers from Safaricom and Airtel, Makueni County government including extension officers and climate change technical team, Kenya Meteorological Department in Makueni County provided support during the intervention session in which essential information and training regarding the available mobile phone based services were provided to the participants. Out of 125 targeted non-user, 83 households participated in the intervention session and 42 did not participate, see Table 4.

Table 4 Treated and Untreated household samples

Treatment	Frequency	Percent
Treated	83	66.40
Untreated	42	33.60
Total	125	100.00

Source: Field survey 2017/2018

A follow-up survey was then conducted in August/September 2018, approximately 6 months after the intervention was provided. All the 125 non-user were surveyed during the follow-up survey. In both baseline and follow up surveys, the same questionnaire was used to capture data on the adaptive capacity resources across all the 125 surveyed households. Both baseline survey and follow up survey data are used to evaluate the impact of the provision of mobile phone based services on resources accessibility and household adaptive capacity.

3.4.3   Key expert interviews and focus group discussions

To better understand the challenges faced by the households in Makueni County, the resource ranking and availability, choosing of the resource sub-indicators at household in Makueni County, a total of 25 key experts were selected. The selected Key experts were from Makueni county government, Non-governmental Organizations (NGOs), Private sector and mobile phone network providers. Table 5 shows the interviewed key experts in Makueni County. A total of 10 focus group discussions were organized during the January-March 2018 field survey conducted in Makueni County. In each of the 5 sub-counties in Makueni County, two focus group discussions were conducted. Each focus group comprised approximately 7 to 14 members and gender balance was put into consideration in each respective group by ensuring that both females and males participated. In the focus group discussions, challenges experienced by households, accessibility to resources, use and benefit of mobile phone based services and how the social networks facilitate access to resources were discussed.

Table 5 Key experts interviewed in Makueni County

Name of Key experts department	Number of Key experts interviewed
Kenya Meteorological Department (KMD)	1
Kenya Agriculture Research Institute (KARI)	1
Extension officer	5
Peer farmers	10
Farmers organization leaders	4
Department of Agriculture, livestock, and fisheries	1
Kenya Agriculture Commodity Exchange (KACE)	1
Safaricom	1
Airtel	1
Total	25

Source: Field survey 2017/2018

3.5   Estimation methods

The analysis utilized data obtained in both baseline surveys before the intervention and the follow-up survey conducted 6 months after the intervention. In both baseline survey and follow up surveys, fundamental questions on households socio-demographic characteristics, resources (financial, information, human, physical and diversity of livelihood), mobile phone statistics and use of mobile phone based services to access the resources and data on household networks to access or exchange the resources which facilitate adaptive capacity development. Table 6 indicates the type of data used to facilitate data estimation in each objective of this study.

Table 6 A summary of data sources and estimation methods for study objectives

Objective/ Chapter	Data source/Sample size	Purpose	Estimation methods
1.Analyze household adaptive capacity and identify resources that need to be developed (Chapter 5: Household adaptive capacity assessment)	- Household surveys (n-250) - Key expert questionnaire (n=25)	- Get quantitative data on adaptive capacity resources - Facilitated on choosing and ranking of resources	- Analytical Hierarchy Process (AHP)
2. Assess households mobile phone usage and access to adaptive capacity resources to be developed (Chapter 6: Mobile phone use and household access to adaptive capacity resources)	- Household surveys (n=250) - Key expert interviews (n=25) - Focus group discussions (n=10)	- Get quantitative and qualitative data on mobile phone based services and how they are used to access resources	- Descriptive statistics - Multivariate multiple probit regression
3. Evaluate the impact of mobile phone based services on household adaptive capacity (Chapter 7: Impact of mobile phone based services on household adaptive capacity)	- Household Surveys (n=250) - Key expert interviews (n=25) - Intervention(Treated=83, untreated=42)	- Get quantitative data on the adaptive capacity for user/non-user and mobile phone based services - Information for mobile phone based services was provided	- Descriptive statistics - Combination of Propensity Score Matching and Difference-in-Difference methods (PSM-DID)
4. Examine the influence of mobile phone based services on household networks to access and exchange resources that facilitate adaptive capacity development (Chapter 8: Role of social networks on household adaptive capacity development)	- Household Surveys (n=250) - Key expert interviews (n=25) - Focus group discussions (n=10)	- Get qualitative and quantitative data on people households connect with to access/exchange resources	- Social Network Analysis (SNA) - Ordinary Least Square analysis

Source: Field survey 2017/2018

CHAPTER 4

A DESCRIPTIVE ANALYSIS OF HOUSEHOLDS CHARACTERISTICS AND SHOCKS
EXPERIENCED

4.1   Introduction

This chapter provides a detailed overview of the 250 surveyed households' demographic characteristics, the land-use and the shocks experienced by the households in Makueni county. The chapter is organized as follows; section 4.2 outlines the socio-economic characteristics of the 250 surveyed households, section 4.3 provides information on the land-use dynamics of the 250 surveyed households in this study, section 4.4 outlines the different shocks experienced by the households and the adaptive strategies applied by the households.

4.2   Households socio-economic characteristics

The socio-economic characteristics of the households captured during the survey include; the age of household head, average household income, the gender of the household head, education level of the household head, marital status, occupation, and household size. The social-economic characteristics for all households, users and non-users are indicated in Table 7.

The respondents comprised 55 female-headed households (48%) and 195 male-headed households (52%) as shown in Table 7. The women take over 80% of Kenya's rural farmers which is evident in this whereby the female respondents being more than male respondents (World Bank, 2013). Mostly, men engage in other activities to diversify the income of the household while females manage agricultural activities. Since this research focused on interviewing the household head the age group of the respondent range was 18 years to above 65 years. As indicated in Table 7, the average age of the respondent is 45 years for 250 households. Approximately 181 out of 250 respondents (72.4%) are above 35 years for all households while 93 out of 125 respondents (74.4%) and 88 out of 125 (70.4%) respondents are above 35 years for the user and non-user group respectively.

Table 7 Socio-economic profile of all households, users, and non-users

Criteria		Full sample (n=250)		Users (n=125)		Non-users (n=125)	
	Detail	Frequency	%	Frequency	%	Frequency	%
Age (Years)	18-24yrs	19	7.6	10	8.0	9	7.2
	25-29yrs	21	8.4	6	4.8	15	12.0
	30-34yrs	29	11.6	16	12.8	13	10.4
	35-39yrs	30	12.0	14	11.2	16	12.8
	40-44yrs	21	8.4	17	13.6	4	3.2
	45-49yrs	26	10.4	15	12.0	11	8.8
	50-54yrs	23	9.2	14	11.2	9	7.2
	55-59yrs	24	9.6	14	11.2	10	8.0
	60-64yrs	28	11.2	8	6.4	20	16.0
	Above 65yrs	27	10.8	12	9.6	15	12.0
	Total	250	100.0	125	100.0	125	100.0
	Average age	45		45		45	
HH Monthly Income (Ksh)	Below 1000	66	26.4	13	10.4	53	42.4
	1001-5000	129	51.6	75	60.0	54	43.2
	5001- 10000	29	11.6	22	17.6	7	5.6
	10001-15000	13	5.2	7	5.6	6	4.8
	15001-20000	0	0.0	0	0.0	0	0.0
	20001-25000	1	0.4	1	0.8	0	0.0
	25001-30000	0	0.0	0	0.0	0	0.0
	30001-35000	12	4.8	7	5.6	5	4.0
	Total	250	100.0	125	100.0	125	100.0
	Average Monthly income	Ksh.5174 (5.174dollars)		Ksh. 7829 (7.829dollars)		Ksh. 3732 (3.732dollars)	
Gender of household	Female	55	22.0	18	14.4	37	29.6
	Male	195	78.0	107	85.6	88	70.4
	Total	250	100.0	125	100.0	125	100.0
Education level of household head	Completed university	6	2.4	1	0.8	5	4.0
	A bit of university/ college	7	2.8	2	1.6	5	4.0
	Technical school	48	19.2	15	12.0	33	26.4
	Completed Secondary	34	13.6	24	19.2	10	8.0
	A bit of Secondary	36	14.4	16	12.8	20	16.0
	Completed Primary School	64	25.6	44	35.2	20	16.0
	A bit of Primary School	16	6.4	5	4.0	11	8.8

	None	15	6.0	7	5.6	8	6.4
	Informal School	24	9.6	11	8.8	13	10.4
	Total	250	100.0	125	100.0	125	100.0
	% Above primary school	78.0%		81.6%		74.4%	
	Married	181	72.4	103	82.4	78	62.4
	Widowed	18	7.2	7	5.6	11	8.8
Marital Status	Divorced	3	1.2	0	2.4	3	2.4
	Single	48	19.2	15	12.0	33	26.4
	Total	250	100.0	125	100.0	125	100.0
	Farming	158	63.2	84	67.2	74	59.2
	Business	27	10.8	14	11.2	13	10.4
Occupation of household head	Casual Labour	52	20.8	17	13.6	35	28.0
	Civil servant	13	5.2	10	8.0	8	2.4
	Total	250	100.0	125	100.0	125	100.0
	1-3 Members	56	22.4	28	22.4	28	22.4
	4-6 Members	110	44.0	68	54.4	42	33.6
HH size	7-9 Members	63	25.2	24	19.2	39	31.2
	10 Members and above	21	8.4	5	4.0	16	12.8
	Total	250	100.0	125	100.0	125	100.0
	Average HH size	6		5		5	

Source: Field survey 2017/2018

The average monthly household income is Ksh. 5174 (50.17 dollars[6]), Ksh (70.829 dollars[6]) for the users and Ksh. 3732 (30.732 dollars[6]) for non-users. As indicated in Table 7, 129 out of 250 households (51.6%) earn a monthly income range of 1001-5000 and 66 households (26.4%) earn a monthly income below 1000. Estimated 75 users (60%) and 54 non-users (43.2%) earn an income range of 1001 to 5000 respectively. This implies that 195 households (78.0%) earn an income below 50 dollars per month which is approximately 1.5 dollars per day indicating that these households live below the poverty line of below 1 dollar in a day as per the World Bank report (2015).

Table 7 shows that 195 households (78%) are male-headed with only 55 households (22%) female-headed. The users and non-users comprised of 107 users (85.6%) and 18 non-users (88%) male-headed households and only 88 households (14.4%) and 37 households (29.6%) female-headed households respectively. The same case is reflected in a study by Makueni CIPD (2013) whereby the households across Makueni County are male-headed. Approximately 61 households (78%) have education level above primary school with 64 households (25.6%) have completed primary school level and technical school 48 households (19.2%) compared to other education levels. Also, 102 users (81.6%) and 93 non-users (74.4%) and respectively have education levels above primary school as indicated in Table 7. The literacy rate in Makueni County is 22.4% which is considered low according to Kenya Vision 2030 (2013) but comprising a population that is able to read and write. In addition, the introduction of free primary education level introduced in 2007 by the government is expected to improve the literacy level (Makueni County CIDP 2013-2017, 2013).

Estimated 181 households (72.4%) are married while 103 users (82.4%) and 78 non-users (62.4%) of respondents are married in the respectively. Approximately 158 households (63.2%) of household heads practice farming as their main livelihood occupation. Also, this situation was reflected for the user and non-user household head with 84 users (67.2%) and 74 non-users (59.2%) main occupation being farming respectively. Other household head occupations as depicted in Table 7 are; 27 households (10.8%) in business, 52 households (20.8%) are casual labor and 13 households (5.2%) being civil servants out of 250 households. These points out that farming is the main livelihood activity in Makueni households which echoes past studies that over 80% of the rural population rely on farming for livelihood (Maina et al.,2018). The average household size is 6 members with 44% of households containing 4 to 6 members. The same case is reflected across the user and non-user with

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[6] The exchange rate for converting Kenya shillings (Ksh) to US dollars ($) in 2018 when this study was conducted was; 1USD = 100 Ksh (Central Bank of Kenya, 2018)

average household members approximately 5 members each with 54.4% and 33.6 % with 4 to 6 members respectively Table 7.

4.3   Land use in Makueni County

Estimated 193 households (77.2%) have a piece of land less than 2 hectares while only 57 households (22.8%) have a piece of land more than 2 hectares from field survey 2017/2018. The households indicated that the land is utilized for different activities with crop cultivation and livestock keeping being the main activities. Also, the result from field survey shows that 63 households (25.2%) own land size below 0.5hectares, 130 households (52%) own land size between 0.6 to 2 hectares, 26 households (10.4%) own a land size between 2.1 to 3.5 hectares, 20 households (8%) own a land size between 3.6 to 5 hectares and only 11 households (4.4%) own a land size of above 5.1 hectares.

The land ownership across the households vary with 143 households (57%) have inherited the land from the family. Other land ownerships included; 88 of households (35%) owned land through purchasing, 15 households (6%) through renting and 5 households (2%) through borrowing. This implies that households own the right to utilize the land to the activities that are beneficial. Households practice a single farming system and mixed farming system in Makueni county as depicted during the field survey. The single farming system comprises of food crop farming, cash crop farming, and livestock farming while mixed farming comprises of food crop/cash crop/livestock farming, food crop/cash crop and food crop/livestock farming. Estimated 46 households (18.4%) practice food crop farming, 5 households (0.8%) practice livestock farming, 5 households (0.8%) practice cash crop farming, 110 households (44%) practice food crop/livestock/cash crop farming, 64 households (25.6%) practice food crop/livestock farming, 14 households (5.6%) practice food/cash crop farming and 12 households (4.8%) practice cash crop/livestock farming. Generally, 50 households (20%) practice a single farming system while 200 households (80%) practice mixed crop farming.

The main food crops planted by the households in Makueni County include; maize, beans, cowpeas, cassava, arrow roots, sweet potato, French beans and green grains as indicated in Figure9. The result shows that maize and beans are the commonly planted food crops in Makueni county whereby 245 households (98%) and 232 households (92.8%) plant maize and beans respectively. These crops are solely grown for household subsistence purposes across all the surveyed households. The Makueni CIPD (2013) proves that maize and beans comprise the biggest contributor to the household food source and completely rain fed. The cash crop planted by the households in Makueni county include; mangoes, oranges, avocadoes, coffee, sugarcane, and sisal. The result

in Figure 9 shows that 184 households (73.6%) plant mangoes, 79 households (31.6%) plant oranges, 71 households (28.4%) plant avocadoes, 69 households (27.6%) plant sisal, and 13 households (5.2%) plant sugarcane. Mangoes and oranges are the common cash crops in Makueni County and are the main value chain cash crops (Makueni County CIPD, 2013).
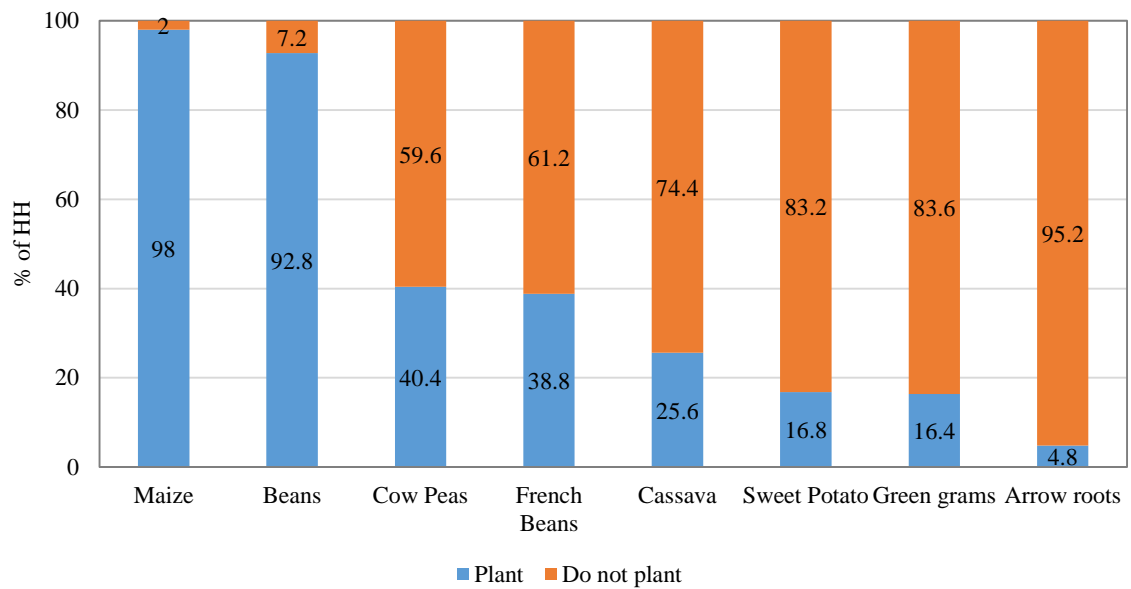
Figure 9 Types of food crops planted

Source: Field survey 2017/2018
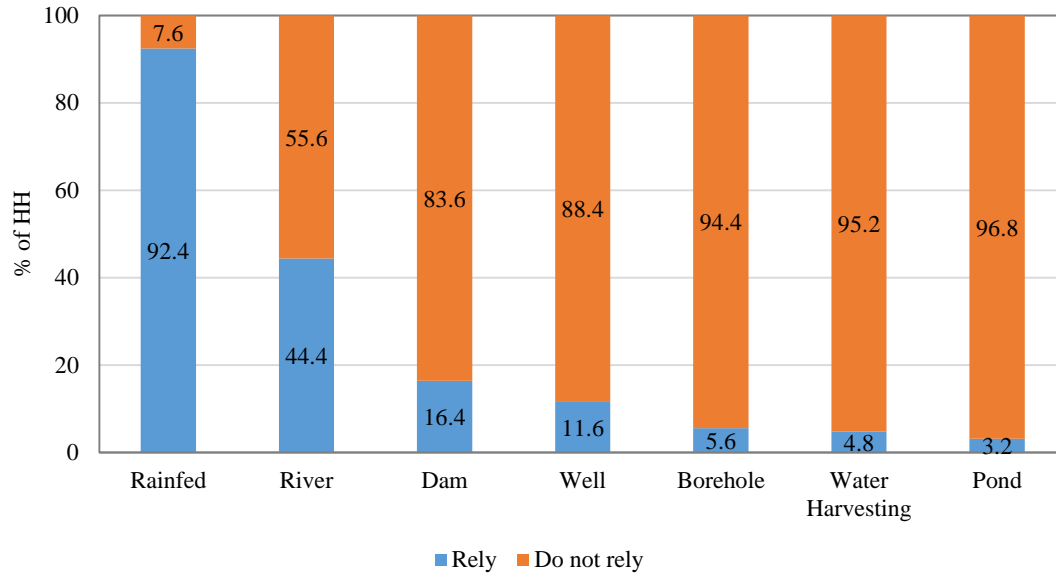
Figure 10 Sources of water for irrigation

Source: Field survey 2017/2018

The main source of water for irrigation is rainfall as 230 households (92%) rely on rainfall for their food and cash crop farming. As shown in Figure 10 Other sources of water for irrigation include; 110 households (44.4%) get water from the river, 41 households (16.4%) from the dam,29 households (11.6%) from well, 14 households (5.6%) from the borehole and 12 households (4.8%) through water harvesting as indicated in Figure 10. The results depict that most of the households in Makueni County rely on rainfall for their agricultural activities.

4.4 Shocks experienced by households in Makueni

To understand the challenges in rural Makueni, the surveyed households identified shocks frequently experienced that affect their livelihood, see Table 8. A total of 171 households (68.4%) indicated that they have experienced the shocks. Across all the identified shocks that households experience, 151 households (88.3%) have experienced increased droughts, 150 households (87.7%) have experienced changed rainfall timings, 129 households (75.4%) have experienced increased crop diseases and 127 households (74.3%) have experienced a water shortage. Other shocks experienced by households include; 124 households (72.5%) have experienced increased drought intensity, 110 households (64.3%) have experienced increased livestock diseases, 91 households (53.2%) have experienced a change in crop growing season and 34 households (19.9%) have experienced the death of livestock.

Due to the nature of the household's livelihood which is rain fed farming, the shocks experienced by households were linked to climate change and variability. This was echoed by the all the interviewed key experts, for instance, one of the extension officers from Makueni County stated that 'most of the households in Makueni county are farmers and are highly affected by the changing weather, the rainfall has been declining and dry seasons increasing which mostly lead to total crop failure in most areas'(.January-March field survey, 2018) Also, the same situation was echoed by an expert from Department of Agriculture, Livestock, and Fisheries, he stated that 'crop failure, increase in crop and animal diseases and water shortages have been increasing in Makueni County in the recent years, the farming households are highly affected and as a result, the rate of food crisis and also in some cases the impacts are severe leading to death of livestock' (January-March field survey, 2018). The situation is reflected in Table 8 whereby 129 households (75.4%) and 110 households (64.3%) affected by crop and livestock diseases respectively and that of the death of livestock affecting 43 households (19.9%).

According to the interviewed expert from the Kenya Meteorological Department (Makueni weather station), pointed out that, 'the county has been registering a decline in rainfall and a significant increase in temperatures since the 1990s, due to this the number and length of droughts have been increasing' (January-March field survey, 2018). The same situation was reflected by households as indicated in Table 8 whereby 151 households (88.3%) of households are severely affected by the drought and the increase in the drought intensity affecting 113 households (72.5%). Also, water shortage is one of the extensive challenges experienced by households with 127 households (74.3%) of the households affected.

Table 8 Shocks experienced by households and the rate of severity

Shock	No. of HH affected	No. of HH not affected	Total	% of HH affected	% of HH not affected	Total %	Rate of shock severity (%)					Total %
							Significant	Severe	Moderately severe	Very severe	Extremely severe	
Changed rainfall timings	150	21	171	87.7	12.3	100	15.2	9.9	12.1	18.4	44.4	100
Change in growing seasons	91	80	171	53.2	46.8	100	5.8	12.9	20.0	10.5	46.3	100
Shorter growing seasons	114	57	171	66.7	33.3	100	10.1	19.1	10.1	20.2	40.5	100
Increased droughts	151	20	171	88.3	11.7	100	12.3	8.2	16.4	9.8	53.3	100
Increased drought intensity	124	47	171	72.5	27.5	100	7.0	5.8	28.8	19.2	39.2	100
Water shortage	127	44	171	74.3	25.7	100	1.7	0.5	6.4	31.3	60.1	100
Increased crop diseases	129	42	171	75.4	24.6	100	5.3	5.3	28.6	18.7	42.1	100
Increased livestock diseases	110	61	171	64.3	35.7	100	4.1	3.5	38.0	15.2	39.2	100
Death of livestock	34	137	171	19.9	80.1	100	3.6	4.7	55.1	18.1	18.5	100

Source: Field survey 2017/2018

During focus group discussions conducted in January-March in 2018, the members presented a chart illustrating observable changes in rainfall and change of environment from 1977 to 2017 and it was pointed out that the rainfall has been declining. As a result, some permanent rivers in Makueni County have changed to seasonal rivers, for instance, River Kaiti. In addition, it was pointed out that a lot of deforestation has occurred as evidenced by reduced tree cover. Due to these, most of the members indicated that water shortage is a big challenge forcing many people in Makueni County to trek for more than 2 hours searching for clean drinking water and for livestock. Furthermore, the focus group members emphasized that the situation worsens during the dry season which occurs between May and November.

Estimated 171 households (68.4%) observed changes in rainfall and temperature in the last 10 years (from 1997 to 2017) has affected their agricultural production and other important areas of the household activities. Figure 11 shows the changes in rainfall and temperature observed by the households in the last 10 years. Estimated 155 households (90.6%) indicated that have observed a decrease in rainfall intensity, 151 households (88.3%) indicated a decrease in rainfall events and 147 households (86%) indicated a decrease in rainfall duration. On the other hand, the temperatures have increased as indicated by 141 households (82.5%), see Figure 11.
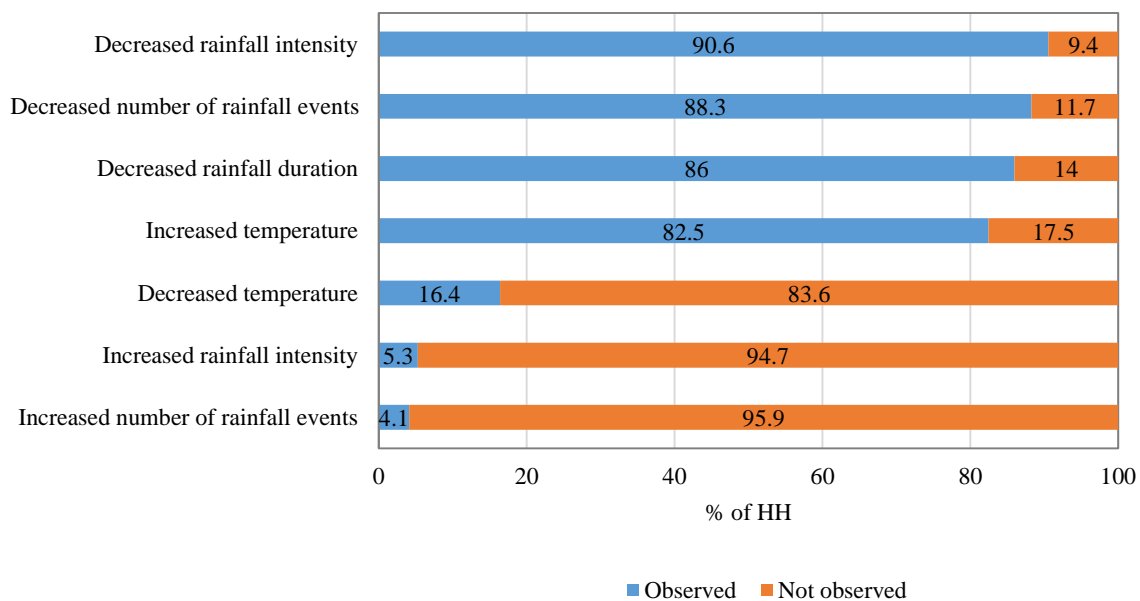
Figure 11 The percentage of observed changes in rainfall and temperature in Makueni County
Source: Field survey 2017/2018

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Table 9 Areas of households impacted by shocks

Areas affected	No. of HH Affected	No. of HH not affected	Total	% of HH affected	% of HH not affected	Total %	Rate of impact					
							Extremely low	Low	Moderately low	High	Extremely high	Total %
Vegetation cover	61	110	171	35.7	64.3	100	3.2	12.8	20.8	24.5	38.7	100
Source of water	127	44	171	74.3	25.7	100	2.3	0.0	12.3	25.8	59.6	100
Income generation	130	41	171	76.0	24.0	100	0.0	5.2	16.8	21.3	56.7	100
Livestock production	125	46	171	73.1	26.9	100	1.8	4.2	16.9	21.6	55.5	100
Crop production	160	11	171	93.6	6.4	100	1.2	1.2	7.0	25.7	64.9	100

Source: Field survey 2017/2018

The households pointed out that the identified and experienced shocks highly affect the operation of important areas of the household thus influencing their ability to sustain their livelihood. As indicated in Table 9, the most affected areas at households by shocks include; crop production, income generation and source of water whereby 160 households (93.6%), 130 households (76.0%) and 127 households (74.3%) are affected respectively. Other areas affected are livestock production and vegetation cover with 125 households (73.3%) and 61 households (35.7%) affected households respectively.

This implies that the household's livelihood is vulnerable to the shocks since 158 households (63.2%) depend on farming for livelihood which is entirely rain fed. These shocks are climate related as the households depicted that have observed changes in rainfall and temperature. Crop production and income generation are highly affected areas of households as indicated in Table 9. Due to the arid and semi-arid characteristics of Makueni County the impacts are expected to increase in the future (KMD, 2015). As a result, households in Makueni County will be at risk of severe food insecurity and to other extreme risks such as increased poverty. Currently, the county has been experiencing food insecurity due to crop failure associated with climate change and variability plugging households to highly rely on government and NGOs for food assistance during the crisis (Kenya Vision 2030, 2013).

Since 171 households (68.4%) indicated to have experienced shocks, the households were further asked whether they use any strategies to respond to the impacts caused by the shocks. Approximately 91 households (53%) indicated that they respond to the impacts in order to sustain their livelihood. The other 80 households (47%) do not apply any strategy to manage the changes caused by the shocks because 48 households (60%) indicated that they are not aware which strategies to apply and 60 households (75%) indicated that some strategies are expensive since they lack enough resources to support the strategies.

Figure 12 shows the adaptive strategies applied by households. Estimated 84 households (92.3%) change crop variety, 75 households (82.4%) change planting dates and 66 households (72.5%) diversify from farming to non-farming activities to manage the shocks and sustain their livelihood. Since most of the shocks are climate related and influence their ability to plan their farming activities accordingly, the households highly opt to change planting dates.
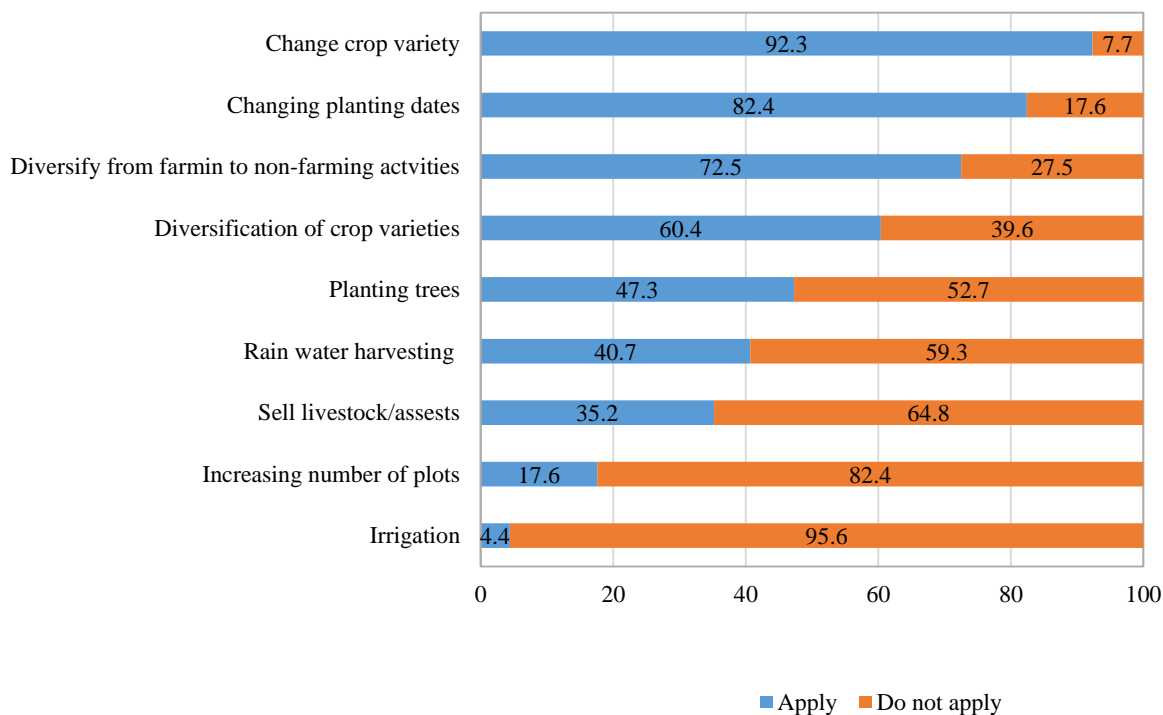
Figure 12 Adaptive strategies applied to manage the shocks

Source: Field survey 2017/2018

Maize and beans are the highly planted crops as depicted in this study and are entirely rain fed, production of these crops has been declining due to a decline in rainfall in the County (Field survey 2017/2018, Makueni CIPD, 2013). Other strategies applied by the households include; 55 households (60.4%) diversify crop varieties, 43 households (47.3%) plant trees, 37 households (40.7%) practice rainwater harvesting and 32 households (35.3%) dispose of their livestock and assets. The households depicted that the situation can exacerbate sometime forcing the households to sell their livestock and other assets in order to purchase food and other household necessities.

4.5   Summary

This chapter depicts three issues in regard to the surveyed households and an overview of the shocks experienced by the households in Makueni county. First, the socio-demographic characteristics of the 250 surveyed households are assessed. The results show that the average age of the household head is 45 years with a monthly income of approximately 5.17 dollars. Most of the households are male-headed households and above 78% have education above the primary school. Farming is the main occupation for the majority of the household head and the average number of members per household is 6 members. This result clearly indicated that agriculture is the main livelihood activity and source of food for the majority of the households in Makueni county. Also, agriculture is highly rain fed across the surveyed households.

Secondly, the land dynamics of the surveyed households were assessed. The finding of this study revealed that more than 77.2% of households have land less than 2 hectares. Maize and beans are the commonly planted food crops which are fully rain fed.

Thirdly, the shocks that are experienced by the households in Makueni county were assessed. The results show that the most experienced shocks by the households include; increased droughts, changed rainfall timings, increased crop diseases and water shortages affecting the households with an extreme rate of severity. The households depicted that the shocks highly affect crop production, livestock production, income generation and sources of water with an extremely high impact. Furthermore, the households depicted that they utilize their own resources to manage the shocks experienced by the households. The households further pointed out the rate of the shocks outweighs their already limited resources affecting their source of livelihood. Therefore, the adaptive capacity of the households should be assessed and developed to help them manage the shocks experienced.

For the purpose of the household's adaptive capacity development, this chapter suggests that the adaptive capacity of the households should be assessed. The next chapter (Chapter 5) outlines household adaptive capacity assessment to identify resources of the households that need to be developed.

CHAPTER 5

HOUSEHOLD ADAPTIVE CAPACITY ASSESSMENT

5.1   Introduction

In this study, these scenario is well evidenced in chapter 4 whereby the surveyed households in rural Makueni County severely experience several shocks such as increased droughts, change in rainfall timings, increased crop diseases and water shortages. Chapter 5 builds the first step of adaptive capacity development whereby the households' adaptive capacity is assessed and resources that need to be developed are identified. This chapter corresponds to objective 1 of this study and seeks to address the current gap in the literature that there are limited studies assessing adaptive capacity at the household level in rural Africa and Kenya. The qualitative and quantitative data obtained from 250 surveyed households and the 25 key expert's opinions were utilized to assess the households' adaptive capacities by using the AHP method.

This chapter is organized as follows; section 5.2 outlines the household adaptive capacity assessment, section 5.3 outlines the results for the estimated household's adaptive capacity and resource ownership, section 5.4 shows categorization of surveyed households HACIs into 3 levels (low, moderate and high) and also the household HACIs are further categorized based on the gender of household head and farming system. In section 5.5 the results on resources that need to be developed are discussed.

5.2   Household adaptive capacity assessment method

In this study, the household adaptive capacity is evaluated based on five resources adopted from the Sustainable Livelihood Framework (SL) by Chambers and Conways (1991) and DFID (1999). These resources include; financial, information, human, physical and diversity of livelihood. The detailed description of each resource and its subsequent sub-indicators is indicated in Table 10 based on the literature review as well as the help of the key experts and households who facilitated in choosing the sub-indictors that were used to estimate each resource in Makueni County. Analytical Hierarchy Process (AHP) a multi-criteria decision-making tool by Saaty (1990) was then applied in this study to assign a weight to each resource and sub-indicator.

AHP employs the Eigenvalue approach based on pairwise comparisons opinions suggested by Vaidya and Kumar (2006). A multi-level hierarchical structure with two levels indicators and sub-indicators was constructed based on AHP procedures to facilitate pairwise comparison using the key expert judgments as indicated in Figure 13.

Table 10 Adaptive capacity resources and resource sub-indicators

Resources	Resource sub-indicators	Source of resource	Meaning and relevance of the resource
Financial resource	Remittances received	Defiesta et al., 2014; Majeed and Kruse, 2017	- The total monetary assistance received by the household. - Remittances received by household play an important role in enhancing adaptive capacity to adapt to the climate change impact
	Value of animal units	Defiesta et al., 2014	- The total value of animals owned in monetary value - The value of animal value owned by household determine the adaptive capacity to climate change impacts
	Financial assistance from the government	Majeed and Kruse, 2017; Defiesta et al., 2014; Adger 2009	- The amount of money received by the household from government - Receiving financial assistance from the government to support determines the household adaptive capacity to climate change
	Access to credit	Frank and Buckley, 2012; Defiesta et al. , 2014	- If the household has any source of credit either formal or informal - Households that access credit are able better to adapt to climate change impacts
Human resource	Farm experience	Defiesta et al., 2014; Eakin et al., 2011, Lemos et al., 2013	- The total number of years that a respondent has been farming - Households that have more farming experience are able to adapt better to climate change impact
	Education of household head	Deressa et al., 2008	- The number of years the household head has spent in school - The level of education is detrimental in determining household adaptive capacity
	% of adults with primary education	Defiesta et al., 2014, Lemos et al., 2013	- The number of adults in the household with primary education over the total adults in the household in percentage - The level of education determines the household adaptive capacity. More adults with education above primary education enhance household adaptive capacity
	% of adults in the household	Defiesta et al., 2014	- The number of adults over the total members in that household - The number of adults in the household enhances household adaptive capacity
Diversity of Livelihood	Number of livelihoods	Defiesta et al., 2014	- Indicates all the number of income sources of the household - The number of livelihoods in a household is important in its adaptive capacity to climate change impacts
	% of land not in crops	Defiesta et al., 2014, Ellis, 2011	- Of the total size of the land owned by the household the percentage that is under other uses rather than crops - The percentage of land not under crop cultivation is important in determining the household adaptive capacity.
	Number of crops planted	Defiesta et al., 2014; Armah et al. (2011)	- It indicates the total number of crops planted by the households - The number of crops planted by the household is imperative in determining the household adaptive capacity. The more crops planted it enhances adaptive capacity
Information	Training attained on	Defiesta et al., 2014	- Determined by the kind of farming the farmers have attained in the last 5 years

resource	farming		- Training means being impacted with more knowledge regarding farming. The households that receive training enhance their adaptive capacity
	Receives technical assistance	Defiesta et al., 2014	- If the farming household has consulted for any expert or technical on farming - Households that receive assistance for their farming activities enhance adaptive capacity, for instance from extension officers
	Participation in farmers' organization	Defiesta et al., 2014	- If the respondent or any member of the household participates on farmers' organization - Participation in farmers' organization is imperative on household adaptive capacity, it provides builds social capital through social networking.
	Number of climate change information sources	Defiesta et al., 2014	- Indicated by how many channels the households can access climate change information - Access to climate change information enhances adaptive capacity. Households that have more sources of climate change information increase their adaptive capacity
Physical resource	Farm size	Defiesta et al., 2014; Chambers and Conway, 1991	- The total land size of the household in hectares - The size of land owned by the household is important in determining household adaptive capacity. The households with large farm size have a higher probability of diversifying farming practices to adapt better to climate changes
	Farm ownership	Defiesta et al., 2014; Eakin et al., 2015	- If the land is owned or leased - The households who own land stand a chance to utilize the land and apply better strategies to adapt compared to household that lease or borrow land
	Irrigation	Defiesta et al., 2014; DFID, 1999	- The main sources of irrigation to the farming household, either canal, well, dam and river - Source of water is imperative in determining the household's ability to adapt to climate change. The households that have more than one source of water for farming are expected to adapt better compared to those that rely on rainfall only.
	Number of farm machines	Defiesta et al., 2014; DFID, 1999	- The number of farming tools used by the farming household - A household with more farming tools stand a chance to increase their productivity and increase their ability to cope with climate change impacts

Source: Modified by Authors from Chambers and Conway, 1991; DFID, 1999; Defiesta et al. 2014
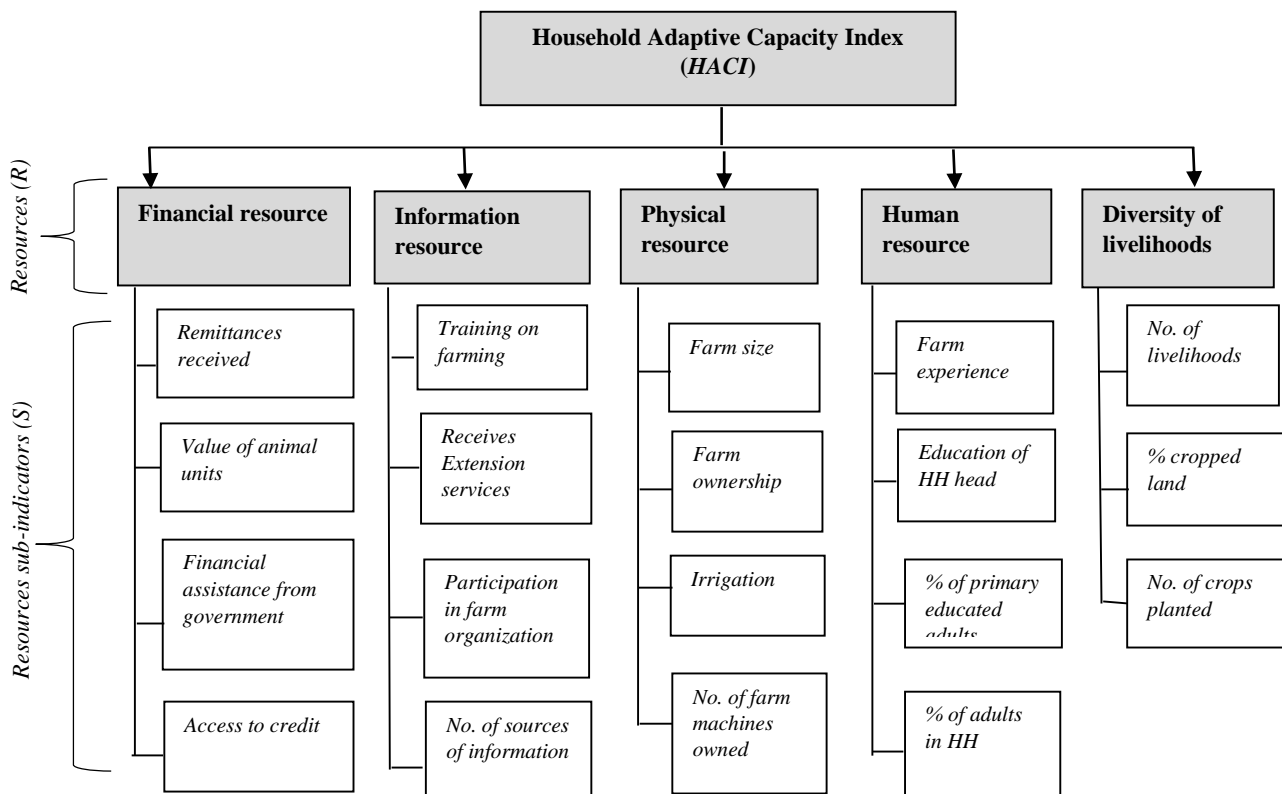
Figure 13 Three level hierarchy tree of adaptive capacity

Source: Field survey 2017/2018

The first level includes adaptive capacity resources including; financial resource, information resource, human resources, diversity of livelihood and physical resources. The second level comprises of the subsequent sub-indicators used to estimate each resource. The key experts' questionnaire utilized the AHP 9 - point scale format to elicit the importance of each resource and resource sub-indicators by ranking them based on the pairwise comparison method, see Table 11 and also the AHP questionnaire used in this study in appendix C.

Table 11 The Saaty AHP scale for pairwise comparisons

Values	Stated scale	Description
1	The equal importance of both elements	Two elements contribute to equality
3	Moderate importance of one element over the other	Experience and judgments favor one element over another
5	Strong importance of one element over the other	An element is strongly favored
7	Very strong importance of one element over the other	An element is strongly dominant
9	The extreme importance of one element over the other	An element is favored by at least an order of magnitude
2, 4, 6, 8	Intermediate values	It compromises between two judgments

Source: Berrittella et al., 2007; Saaty, 1991

The responses from key experts were then converted into a judgmental matrix and then priorities were calculated based on a procedure by Berittella et al. 2007. The judgmental matrix is as indicated below:

$$A = \begin{bmatrix} a_{11} & a_{12} & ... & a_{1n} \\ a_{21} & a_{22} & ... & a_{2n} \\ ... & ... & ... & ... \\ a_{n1} & a_{n2} & ... & a_{nn} \end{bmatrix} \quad .... (1)$$

Given that the number of elements to be compared by the key expert in a given level with respect to the upper level of the hierarchy are 1, 2...n[th] as indicated in equation 1, then the elements are first arranged in a row and a column to facilitate pairwise comparison rating using the scale of 1 to 9. The a in the matrix indicates the key expert actual judgement value after comparison rating between two elements using a scale of 1 to 9. If a_{ij} is a key expert's judgement value of row i and column j in the matrix after comparison rating between two elements of 1,2… n[th] of a given level with respect to the upper level of the hierarchy then;

$$a_{ij} > 0; \; a_{ij} = \frac{1}{a_{ji}}; \; a_{ii} = 1 \; for \; all \; i$$

Since the data obtained from the household's survey for the five resource sub-indicators were captured in different units, normalization is then conducted using the minimum-maximum approach by Nardo et al (2005) to standardize the values and ease computation and comparison of all the variables, see equation 2.

$$Normalized \; value = \frac{X_i - X_{min}}{X_{max} - X_{min}} .... (2)$$

whereby:

- X_i : represents the original value of a particular indicator X

- X_{min} : represents the minimum value of a particular indicator X

- X_{max} : represents the maximum value of a particular indicator X

HACI was obtained by aggregating the normalized household data and the weighting from the key experts of all the resources to develop the composite index. A composite index was constructed to come up with each household's HACI. It is constructed based on geometric aggregation by Nardo et al (2009), which is appropriate for non-comparable indicators and sub-indicators that are strictly expressed in different ratio-scales. The HACI is obtained by combining all the respective resources to come up with one single value of adaptive capacity ranging between 0 and 1. The equation to obtain the HACI is indicated in equation 3;

$$HACI_i = \sum_{r=1}^{t} R_w \, N_v \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

whereby:

- $HACI_i$: Household Adaptive Capacity Index of household indexed by i

- r: represents the rth resource of the household adaptive capacity (financial, physical, human, information and diversity of livelihood)

- t: represents the total number of resources (t=5)

- R_w: represents the weight of resource obtained from the Analytical Hierarchy Process (AHP)

- N_v: represents the normalized value from the household data

The next step was the categorization of all the obtained HACIs into three levels, which are low, moderate and high level. Generally, there is no specific rule to classify adaptive capacity levels, the classification in this study is based on previous studies by Eakin et al. (2008) and Gbetibouo (2010) in which three equal intervals are set based on the dispersion of data. This categorization of HACI into low, moderate and high levels facilitates the identification of the adaptive capacity resource that needs to be developed based on the disparity in HACI levels.

Furthermore, the categorization was conducted based on the gender of household head and the type of farming systems. The categorization HACIs based on the type of household farming system provides insights on the level of adaptive capacity and resources of the respective households. Through this, the vulnerable type of farming system based on the level of adaptive capacity is identified in order to facilitate the provision of appropriate decisions, services, and programs to develop the household adaptive capacity.

According to Pelling and Christ (2005), the decisive factor in the household is important in determining its adaptive capacity and resource distribution. These comprise of household decision-making mechanisms and execution of its adaptive strategies, which depend heavily on the household head. The resource distributions vary by the gender of the household head in rural Africa with the female-headed being more resource-constrained (Arora et al., 2014). In this study, the categorization of the adaptive capacity based on the gender of the household head of the surveyed households was conducted to provide insights on how the levels of HACI and resource accessibility vary in both male-headed and female-headed households. This facilitates the identification of the vulnerable households in order to help the provision of appropriate decisions, services, and programs to develop the household adaptive capacity. The societies comprising of populations depending on agriculture more so rural population in Africa where food security is a critical issue, it is essential to have gender-specific information on

how the population access and control resources (Ahearn et al., 2010; Arora et al., 2014). In addition, the importance of understanding the role of gender difference in rural Africa has been reflected in many past studies since it is highly considered for rural development more so in reforming property rights to facilitate equitable control over resources between men and women as well as encouraging adoption of agricultural technologies that develop productivity (Haddad et al., 1997; Smith, 2007; Ahearn, 2010; Kevane, 2012)

5.3   Result of estimated Household Adaptive Capacity Index (HACI) and resource ownership

The availability of resources reduces the vulnerability of a given shock and facilitates the achievement of development outcomes (Ellis, 2000). Holding all the other factors constant, the resources available are essential in determining the adaptive capacity of the households (Defiesta et al., 2014; Ospina et al., 2011). This means that households with a higher level of resources are expected to have a higher adaptive capacity.

With all the obtained aggregated weights of the five resources including; financial, information, physical, human and diversity of livelihood, one value of HACI ranging between 0 and 1 is obtained by summing the aggregated resource weights, see equation 3. Figure 14 shows the average aggregated weights for the financial resource as 0.0944, information resource as 0.0784, physical resource as 0.0546, diversity of livelihood as 0.0642 and human resource as 0.0613 and the HACI as 0. 3529. Generally, out of the five resources, financial resources scored the highest as indicated in Figure 14 with the human resource scoring lowest. These imply that, based on the key experts and household's opinions, the financial resource is considered as the most important resource for adaptive capacity and the physical resource the least important in Makueni County. The Information resource was ranked the second important resource to adaptive capacity, diversity of livelihood was ranked third, the human resource ranked fourth and physical resource ranked fifth. The detail explanation for each resource and subsequent sub-indicators is discussed in the next sub-sections.
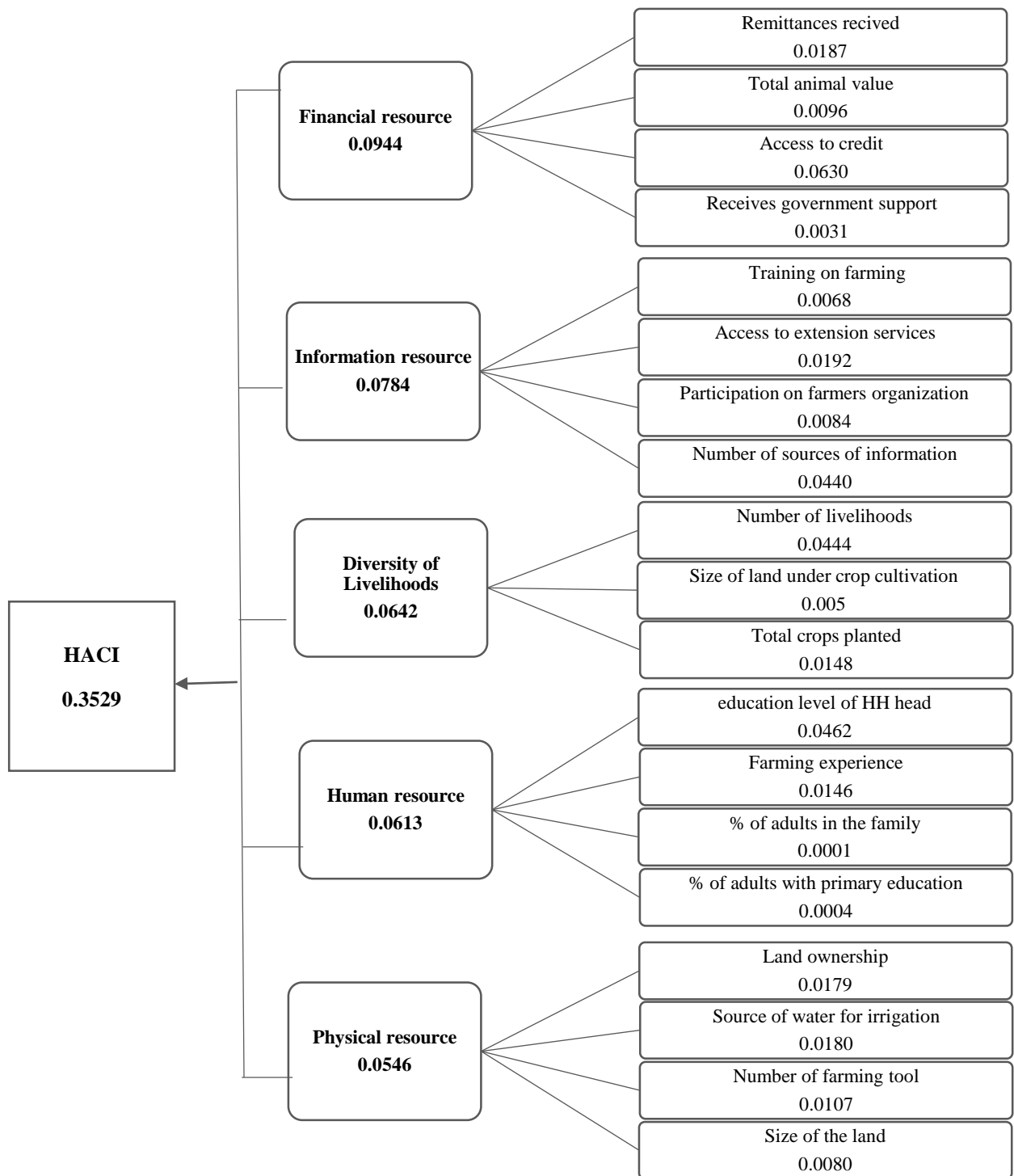
Figure 14 Hierarchy tree indicating average HACI, resources and resource sub-indicators

Source: Field survey

5.3.1 Financial resource

In this research, the financial resource of the household is estimated by aggregating remittances received, the value of the animal, access to credit and government support scores obtained, see Figure 14. Table 12 shows the average scores of the sub-indicators and the total financial resources of households.

Table 12 Scores Financial resource sub-indicators

Sub-indicators	Score
Remittances	0.0187
Value of animal	0.0096
Access to credit	0.0630
Government support	0.0031
Total Financial resource	0.0944

Source: Field survey 2017/2018

As indicated in Table 12, the estimated average scores of financial resource sub-indicators include; Access to credit is 0.0630, Government support is 0.0031, Remittance is 0.0187 and that of animal value is 0.0096. The average financial resource weight is estimated as 0.0944 as indicated in Table 12. Household access to credit scored highest and government supports the lowest as depicted by the scores in Table 12. These imply that the households consider access to credit as the most important sub-indicators for the household's financial resource. These depict that there is a need to increase households' credit accessibility. Although there are few financial institutions in Makueni County, the surveyed households depicted that its due to many formalities involved that limit accessibility to credit, for instance, giving out collateral as security and a limitation of knowledge regarding the whole credit accessibility process (Njunguna et al., 2012). A study by Njuguna et al (2012) also depicts that credit highly contributes to household financial resources in Kenya and it is essential in supporting agricultural production. Njuguna et al. (2012), further elaborated that the limited financial institutions in rural areas and many formalities to access credit such as collateral limit the households from accessing the credit through the bank.

Remittances received by the households was the second-ranked important financial resource sub-indicator based on Key experts and household's opinions as indicated by the score of 0.0187 in Table 12. In this study, the households depicted that they receive remittances of approximately Ksh. 10,000 (100 dollars) per annum from family members and friends living in cities. A study by Tsefaye et al. (2011) also proves that remittances received in households are extremely important for rural households since its one of the strategies that help the households to overcome risks such as economic crisis. The third-ranked financial resource sub-indicator is the value of the animal as indicated in Table 12. In this study, only 70 households (28%) keep livestock with an average of five animals (cows and goats) per household. The households depicted that its due to the high cost

of keeping livestock and decline in a pasture due to a decline in rainfall seasons and prolonged droughts in Makueni county that limit households from keeping livestock which contributed to the value of animal ranked as the third important sub-indicator of financial resource. Although the financial resource scored highest out of the five resources and ranked as the most important adaptive capacity resource by both household and key experts, the reflection of the household's financial resource is limited across the households. A study by Defiesta et al. (2014) also depicts financial resource as the most important resource of rural households but also the most limited resource.

5.3.2 Information resource

The No. of information sources, the participation of households in farmers' organizations, Access to extension services and Training on farming are the resource sub-indicators used to capture data on information resources across the household level in Makueni County as indicated in Table 13. From Table, the average scores of the information sub-indicators include; Access on extension services as 0.0192, Training on farming as 0.0068, Participation in farmer's organization as 0.0084 and No. of information sources as 0.0440. The total information resource of households is 0.0784 as indicated in Table 13. The number of sources of information owned by the household scored highest and the training on farming scored lowest as indicated in Table 13. This implies that the number of information sources is considered the most important sub-indicator of information resource with the training on farming considered least based on households and key experts' rankings. During the field survey, only 100 households (40%) indicated that they are able to receive agriculture and climate information with the average number of information sources being 2 across the households. These imply that although the number of information sources was ranked the most important information sub-indicator, the information sources across the households are limited. In addition, 163 households (65%) indicated that use their own experience for farming, 87 households (35 %) obtain the farming knowledge from family members.

Table 13 Scores of Information resource sub-indicators

Sub-indicators	Score
No of information sources	0.0440
Participation in farming organizations	0.0084
Access to extension services	0.0192
Training on farming	0.0068
Total Information resource	0.0784

Source: Field survey 2017/2018

Access to extension services is the secondly ranked important information resource sub-indicator for the as depicted in Table 13. From the household survey, only 13 households (5%) indicated that access extension services implying that most households do not access extension services. Estimated 238 households (95%) indicated that they do not access extension services. The households indicated that they are aware of the extension services, the problem to link the knowledge and action contributes to low participation in extension programs and training activities.

Participation in farmer's organization is the third-ranked important information resource sub-indicator as indicated in Table 13 based on key experts' and households' opinions. Estimated 81 households (32.5%) participate in farmers' organization and 169 (67.5%) do not. Training on farming was the least ranked by the key experts and households as indicated in Table 13. Only 63 (2.5%) had attained a training program on farming, the households depicted that training programs are expensive and only target the large scale farmers thus limiting most of the farmers from accessing them. Generally, due to low access to agriculture and climate change-related information, there is a high dependency on self and traditional knowledge. Although the information resource was secondly ranked the important resource of adaptive capacity out of the five resources by both household and key experts, the reflection of the household's information resource is limited across the households and therefore developing the information resource is a need across the rural households.

5.3.3   Physical resource

The No. of farming tools owned by the household, Source of water for irrigation, the Size of the land and Land ownership are the resource sub-indicators used to estimate the physical resource of households in this study as indicated in Figure 14. As indicated in Table 14, the estimated average scores of physical resource sub-indicators include; the No. of farming tools as 0.0107, Source of water for irrigation as 0.0180, the Size of the land as 0.0080 and Land ownership as 0.0179. The average physical resource weight for all the 250 surveyed households is estimated as 0.0546 as indicated in Table 14.

Table 14 Scores Physical resource sub-indicators

Sub-indicators	Score
Land ownership	0.0179
Size of the land	0.0080
Source of water for irrigation	0.0180
No. of farming tools	0.0107
Total Physical resource	0.0546

Source: Field survey 2017/2018

The Source of water for irrigation scored highest and the Size of the land scored the lowest. Since most of the households rely on agriculture for livelihood and food, then the sources of water for irrigation is essential to facilitate their agricultural activities. The water sources are prone to environment-related shocks such as a decline in rainfall, droughts, and floods (IPCC, 2014; World Bank, 2017). Out of 250 households, 181 households (72.4%) rely on rain fed agriculture for their agricultural activities indicating that households are prone to climate related changes like decline is rainfall and other shocks are shown in chapter 4 in Figure 11. Only 12 households (4.8%) use water harvesting as shown in chapter 4 in Figure 11, therefore, a decline in rainfall or occurrence of any other related climate related shock could plug households to water shortages. This is evidenced by water shortage which is one of the shocks affecting 187 households (74.3%) in Makueni County in Table 14.

The size of the land scored lowest across all the physical sub-indicators as depicted in Table 14. Estimated 156 households (62.5%) own a land size less than 2 hectares thus making the size of the land ranked the least important sub-indicator of physical resource. The land conflicts are minimal in Makueni county with an estimated 155 households (62%) bearing land ownership rights which grant them the freedom to manage land use activities. Approximately two simple farming tools such as fork and cutlass for farming activities.

5.3.4 Human resource

The human resource of the household is estimated by using; education of household head, the % of adults living in the HH, % of adults with primary education above primary school and the Farming experience of the household head shown in Figure 14. As indicated in Table 15, the estimated average scores of human resource sub-indicators include; the % of adults with primary education is 0.0004, the % of adults in the HH is 0.0001, the Farming experience is 0.0146, and that of the HH head education is 0.0462. The total human resource weight of households is estimated as 0.0613 as indicated in Table 15.

Table 15 Scores of Human resource sub-indicators

Sub-indicator	Score
% of adults with primary education	0.0004
% of adults in the HH	0.0001
Farming experience	0.0146
HH head education level	0.0462
Total Human resource	0.0613

Source: Field survey 2017/2018

The education level of the household head scored the highest and the percentage of adults in the household scored lowest as indicated in Table 15. This implies that the education of the household head is considered the most important human resources sub-indicator with the percentage of the adults in the household scoring least based on the households and key experts rankings. Although the farming experience of households was the second most considered sub-indicator in human resource, the household survey shows that 65% of the households have a farming experience of over 20 years which is a self-gained experience and also gained from friends and family members. In addition, only 20 households (8%) and 21 households (9%) rely on extrinsic knowledge from extension officers respectively The literacy rate has improved over the last 10 years to 96.6% across all age groups due to the Kenya free primary education system, but the climate change knowledge remains absent in the school curriculum (Kenya Vision 2030, 2013). As a result, the human resource was ranked the least important resource of adaptive capacity as depicted in Table 15.

5.3.5   Diversity of livelihood

The diversity of livelihood of the household is estimated by; the No. of sources of livelihood, the % of the piece of land in crops and the No. of crops planted in a given piece of land. As indicated in Table 16, the estimated average scores of the diversity of livelihood sub-indicators include; the No. of sources of livelihoods is 0.0444, the % of the piece of land in crops is 0.0050 and the No. of crops planted is 0.0148. The average diversity of livelihood weight for households is estimated as 0.0642 as indicated in Table 16.

The number of livelihoods owned by the households scored highest and the percentage of land under crop cultivation scored the least as indicated in Table 16. This implies that households consider the number of livelihoods of the household has as the most important sub-indicator of the diversity of livelihoods and the percentage of land under crop cultivation least important based on key expert and household rankings.

Table 16 Scores of Diversity of livelihood sub-indicators

Sub-indicator	Score
No. of crops planted	0.0148
% of the piece of land in crops	0.0050
No. of sources of livelihoods	0.0444
Total Diversity of livelihoods	0.0642

Source: Field survey 2017/2018

5.4   Results of categorization of HACI

Estimated 63% solely rely on crop farming and only 6 households 2.5% diversify to crop farming and business and 1.7% diversify crop farming and wages (Muasa et al., 2019). Furthermore, the results of this study prove that 158 households (63%) have one livelihood activity indicating that only a few households diversify livelihoods. The number of livelihoods supports households by increasing the amount of income through different activities thus the households considered it the third most important indicator of adaptive capacity. Although the diversity of livelihood was ranked the third most important resource for adaptive capacity in Makueni county by the key experts and household's rankings as indicated in Figure 14, the reflection of the diversity of livelihood across the households is still limited and need to be developed based on the obtained average adaptive capacity and the distribution of data. The HACIs of households were classified into three levels; low, moderate and high adaptive capacities to facilitate visualization and comparison. Table 17, 120 households (48%) and 125 households (50%) are categorized at low HACI level and moderate HACI level and only 5 households (2%) are categorized in high HACI level.

The resources scores vary across the three HACI levels as indicated in Table 17 with the low and moderate levels registering lower weights in all resources compared to the high HACI level. As a result, differences in the low, moderate and high levels were depicted whereby the average HACIs are 0.1906, 0.4930 and 0.7003 for low, moderate and high levels respectively. The result implies that there is a need to develop the adaptive capacity of households since most of the households are categorized in both low and moderate adaptive capacity levels and the average HACI is low in these two levels compared to the high HACI level.

Table 17 Categorization of average HACI of households and average resource weights

Levels of HACI	No of HH	% of HH	Physical resource	Human resource	Financial resource	Information resource	Diversity of Livelihoods	Average HACI
Low	120	48.0	0.0482	0.0595	0.0310	0.0268	0.0251	0.1906
Moderate	125	50.0	0.0602	0.0627	0.1504	0.1247	0.0897	0.4930
High	5	2.0	0.0784	0.0665	0.1896	0.1548	0.1547	0.7003
Total/average	250	100	0.0546	0.0613	0.0944	0.0784	0.0642	0.3952

Source: Field survey 2017/2018

5.4.1   Identification of resources to be developed across HACI levels

To identify the areas of adaptive capacity that need to be developed across the households, the resources causing a disparity in adaptive capacity were identified. In all the three levels of adaptive capacity, financial resources, information resources, and diversity of livelihood registered a disparity across the low, moderate and high HACI levels, Figure 16. This implies that financial resource, information resource, and diversity of livelihood are resources that need to be developed in order to enhance the household adaptive capacity in Makueni County.

Across the low, moderate and high levels of HACI, the disparity of human and physical resources is not so different as indicated in Figure 15. For the human and physical resources, the estimated household resource sub-indicator scores were at the same level across all the households, see sub-section 4.3.3 on human resource and section 4.3.4 on the physical resource. In addition, the key experts ranked these two resources as the least resources in developing the adaptive capacity of the households in rural Makueni.

Out of the five adaptive capacity resources; financial resource, information resource, and diversity of livelihood are the three most important resources that need to be developed at the household level in Makueni County that create a disparity in the 3 HACI levels. Also, the key experts ranked the financial resource, information and diversity of livelihood as the most important resources that need to be developed across the rural households in Makueni County. Generally, this result depicts that to develop the adaptive capacity of the households in the surveyed rural area in Kenya, the financial resource, information resource, and diversity of livelihood need to be increased.
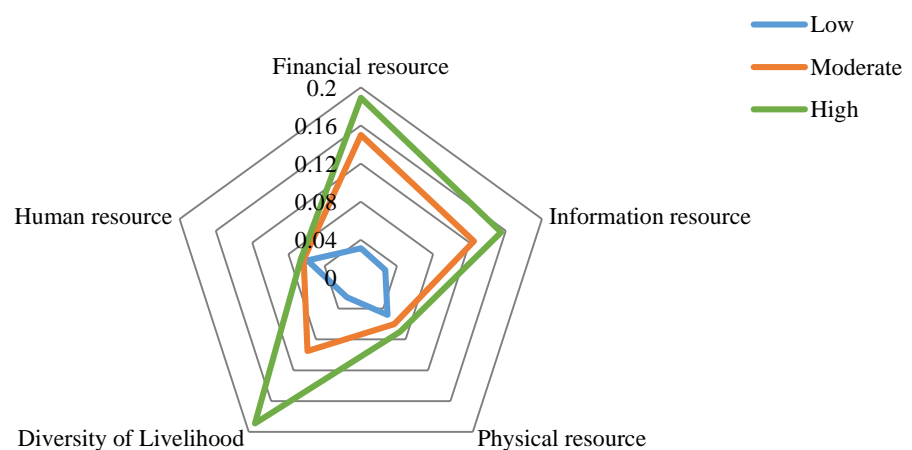
Figure 15 Resources disparity across low, moderate and high HACI levels

Source: Field survey 2017/2018

Table 18 Result of resources and sub-indicators of financial, information and diversity of livelihood

Resource	Sub-indicator	Low	Moderate	High	Average sub-indicator score
Financial resource	Receive remittances	0.0108	0.0249	0.0475	0.0277
	Total animal value	0.0065	0.0077	0.0071	0.0071
	Access to credit	0.0114	0.0109	0.0510	0.0241
	Receives government support	0.0024	0.0035	0.0080	0.0046
	Total	0.0310	0.0470	0.1136	0.0639
Information resource	Training on Farming	0.0008	0.0121	0.0185	0.0105
	Access to extension services	0.0028	0.0341	0.0400	0.0256
	Participate on farmers organization	0.0009	0.0149	0.0225	0.0128
	Number of sources of information	0.0223	0.0450	0.0500	0.0391
	Total	0.0268	0.1060	0.1310	0.0879
Diversity of Livelihood	Number of livelihoods	0.0082	0.0529	0.0780	0.0463
	Size of the land under cultivation	0.0041	0.0057	0.0094	0.0064
	Total crops planted	0.0128	0.0164	0.0217	0.0170
	Total	0.0251	0.0749	0.1090	0.0697

Source: Field survey 2017/2018

Table 18 shows the resources sub-indicator scores for the Financial, Information, and Diversity of livelihood. The result shows that the resource sub-indicator scores vary across the households and in the low, moderate and high levels. In the financial resource, remittances scored highest followed by access to credit with a score of 0.0277 and 0.0241. The total value of animal score 0.0071 and Receives government support lowest with a score of 0.0046. Across the low moderate and high levels, the remittances and access to credit registered the highest disparity compared to Total animal value and Receives government as shown in Table 18. This implies that Receive remittances and Access to credit cause differences in low, moderate and high HACI levels and therefore these two sub-indicators should be improved to enhance financial resource.

The average score of No. of information sources and access to extension services score highest with 0.0391 and 0.0256 respectively. Participation in farmers' organization scored 0.0128 and that of Training on farming was 0.0105. The No. of information sources and access to extension services registered a disparity across the low moderate and high HACI levels. This implies that the No. of sources and Access to extension services are the information resource sub-indicators that need to be improved in order to ensure the development of the Information resource.

For the diversity of livelihood, the Number of livelihood activities scored 0.0436 and total crops planted score 0.0170 and that of the size of land under cultivation was 0.0064. In the low moderate and high HACI levels, the Number of livelihood activities scored highest and the disparity in the scores in the low, moderate and high

HACI was more compared to Total crops planted and Size of the land under cultivation. This implies that the Number of livelihood activities causes differences in the diversity of livelihood scores of households in low moderate and high HACI and the sub-indicator to be improved for the purpose of enhancing the diversity of livelihood and adaptive capacity development.

5.5   Effect of the gender of household head and type of household farming system on HACI

5.5.1   Comparison of HACI based on the gender of the household head

The HACIs were categorized based on male-headed and female-headed households as shown in Table 19. The result depicts that, 36 female-headed households (65.5%) are categorized in the low HACI level compared to 85 male-headed households (43.6%) categorized in the low HACI level. From Table 19, 54.4% of the male-headed households are categorized at a moderate level and 4 households (2%) are categorized in the high HACI level. No female-headed households are categorized in a high HACI level. On the other hand, average HACI of male-headed households registered a slightly higher HACI in low and moderate levels which scored 0.1945 and 0.4991 respectively compared to that of female-headed households which scored 0.1813 in low and 0.4691 in moderate HACI levels as shown in Table 19.   Generally, the result depicts that the female-headed households are categorized with low adaptive capacity compared to the male-headed households which are also reflected in a study by Arora et al., (2014), that the female-headed households are more resource-constrained. Therefore, the is a need to consider developing the adaptive capacity of female-headed households.

Table 19 Categorization of HACI in male and female-headed households

Level of HACI	Male-headed households			Female-headed households		
	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI
Low	85	43.6	0.1945	36	65.5	0.1813
Moderate	106	54.4	0.4991	19	34.5	0.4691
High	4	2.0	0.7101	0	0.0	0.0000
Total/Average	195	100	0.4879	55	100	0.2168

Source: Field survey 2017/2018

5.5.2   Comparison of HACI based on the farming system of household

The household HACIs were further categorized based on the farming system practiced by the households. This research reveals that single farming and mixed farming are the two types of farming systems that the households engage in. The GOK report (2010) proves that rural households practice different types of farming including; mixed farming and single farming. Estimated 164 households (65.5%) engage in mixed farming while 86 households (34.5%).

In this research, the HACIs of households were categorized based on two types of farming systems practiced by the households including; single farming system which is food crop farming, livestock farming, and cash crop farming, and mixed farming system which is food crops/livestock/cash crop farming, food crop farming/livestock farming, food crop farming/cash crop farming and cash crop farming/livestock farming. Estimated 62 households (51.3%) engage in a single type of farming system are categorized with low HACI compared to 58 households (48.3%) in the mixed type of farming as indicated in Table 20. In addition, the average HACI of mixed farming systems is higher compared to that of singe farming systems.

As indicated in Table 20, around 52 households (66.7%) of households engage in food crop farming, 2 households (66.7%) in livestock farming and 4 households (80.0%) in cash crop farming systems are categorized with low HACI. On the other hand, most of the households that engage in mixed crop farming are categorized with moderate HACI level and only a few in low HACI as depicted by 19 households (25.7%), 32 households (47.8%) and 11 households (64.7%) of food crop/cash crop/livestock farming, food crop/livestock farming and food crop/ cash crop farming in low level as indicated in Table 20. The average HACI of the single type of farming is lower compared to that of mixed type of farming as depicted in Table 20.

Table 20 Categorization of HACI based on the farming system of the households

Level of HACI	Food crop farming			Livestock farming			Cash crop farming			Food crops/livestock/cash crop farming			Food crop/livestock farming			Food /Cash crop farming			Cash crop/livestock farming		
	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No of HH	% of HH	Averg. HACI
Low	52	66.7	0.1549	2	66.7	0.1554	4	80.0	0.1494	19	25.7	0.2245	32	47.8	0.2066	11	64.7	0.2401	0	0.0	0.0000
Moderate	25	32.0	0.3179	1	33.3	0.4217	1	20.0	0.4149	51	68.9	0.4388	35	52.2	0.4453	6	35.3	0.4108	6	100.0	0.4191
High	1	1.3	0.5731	0	0.0	0.0000	0	0.0	0.0000	4	5.4	0.7194	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000
Total/ Average	78	100	0.3465	3	100	0.1924	5	100	0.1881	74	100	0.4609	67	100	0.3379	17	100	0.3970	6	100	0.4191

Source: Field survey 2017/2018

5.6   Summary

In this chapter, the study highlights three important issues. First, the household adaptive capacity was assessed whereby a HACI value was developed based on five resources including; financial resource, information resource, human resource, physical resource and diversity of livelihood. The Analytical Hierarchy method was utilized to estimate the HACI whereby the household and key expert's rankings of the five resources are used to estimate the HACI. Also, the obtained HACIs of the surveyed households were categorized into 3 equal levels; low, moderate and high levels in order to understand the distribution of adaptive capacity across the households. The result depicts that the average HACI of the 250 surveyed households is 0.3529. Furthermore, the result reveals that most of the surveyed households in Makueni County are categorized with low and moderate HACI levels depicting a need to develop the household's adaptive capacity.

Secondly, the distribution of HACIs was further assessed based on the gender of the household head and the farming systems. To achieve this, the female-headed and male-headed households HACIs were compared in low, moderate and high HACI levels to understand the adaptive capacity distribution for the gender of the household head while the single type of farming system and mixed type of farming are compared in the case of farming systems. The results indicate that most of the female-headed households were categorized with low HACI compared to male-headed households. Furthermore, the categorization based on the farming system shows that most of the households engaging in a single type of farming system have low HACI compared to households practicing a mixed type of farming system. Therefore, there is a need to consider developing the adaptive capacity of female-headed households and households engaging in a single type of farming system.

Thirdly, the resources of adaptive capacity that need to be developed in Makueni County were identified based on households and key expert opinions. The study reveals that out of the five adaptive capacity resources, financial resource, information resource, and diversity of livelihood are considered the most important resources of adaptive capacity that need to be developed to ensure household adaptive capacity development in Makueni County. In addition, the results reveal that financial resources, information resources, and diversity of livelihood contribute to the disparity of the rural households' adaptive capacities.

This chapter generally suggests that, for the purpose of household adaptive capacity development, the level of financial resource, information resource, and diversity of livelihood needs to be improved. Increasing accessibility to the information resource, financial resource, and diversity of livelihood will facilitate household adaptive capacity development at the household level in Makueni County. Also, this chapter suggests a consideration of the female-headed households and households practicing a single type of farming in the adaptive capacity development interventions in Makueni County.

CHAPTER 6

MOBILE PHONE USE AND HOUSEHOLD ACCESS TO ADAPTIVE CAPACITY RESOURCES

6.1   Introduction

Chapter 6 forms the basis of the second part of this study, which is adaptive capacity development. This chapter corresponds to objective 2 of this study which is to assess households' mobile phone use and households access to the financial resources, information resource, and diversity of livelihood to facilitate adaptive capacity development. Household survey data for the 125 users and 125 non-users is employed to achieve this objective. The users are defined as households that own mobile phone and use mobile phone based services to access information, financial and diversify livelihood while non-users comprise two types of households; households that do not own a mobile phone and households that have a mobile phone but do not use mobile phone based services to access information, financial and diversify livelihood.

The descriptive analysis is employed to facilitate in comparing the users and non-users' accessibility to financial, information and diversity of livelihood. The hypothesis on whether the use of mobile phone based services contributes to higher access to financial, information and diversity of livelihood is tested. Furthermore, Multivariate Multiple regression analysis is used to test the hypothesis of whether mobile phone ownership contributes to access to financial, information and diversity of livelihood. This chapter is organized as follows; Section 6.2 outlines the social demographics for the users and non-users, the mobile phone usage, users' and non-users' accessibility to financial, information and diversity of livelihood, categorization of users and non-users based on gender and farming system practiced by the household. The results findings and discussions are discussed in the following sub-sections.

6.2   Social-economic characteristics of users and non-users

The social-economic characteristics of the users and non-users are illustrated in Table 21. The average age of both users and non-users is 45 years. The monthly income for the users is 7.8$ while that of the non-users is 3.7$. A study by Kenya Integrated Household Survey 2015/16 (KIHS, 2017) and the Makueni County Integrated Plan Development 2018/22 (Makueni CIPD, 2018) estimate the average monthly income of the households to be approximately 8$ and 7$ respectively which is mostly generated from the farming activities and from other sources. Furthermore, the studies depict that the households earning an average income of 7$ a month usually have the capacity to cover the household's important expenses while the households earning an average monthly income below 3$ a month usually have a limited capacity to cover the households' important expenses. In addition,

during the field survey, the households rated their household income level based on household expense by indicating whether; the household income usually not enough to cover household expenses, the income is just enough to cover important household expenses and the income can cover the household expense and have a surplus. Estimated 71 households (56.6%) indicated that their income is enough to cover the household expenses, 40 households (31.8%) indicated that the household income is not enough to cover household expenses and only 11.6% of households indicated that the household income usually covers the household expenses and have a surplus. Generally, this implies that the households can at least take care of primary needs such as food, shelter, education and health care.

Most users and non-users have the education level above primary school and are married. The average household size is 5 members for both users and non-users. All the 125 users own a mobile phone while 77 non-users (61.6%) own a mobile phone. In both users and non-users, most of the households are male-headed with 29.6% of the female-headed households categorized as non-users. Overall, 100 users (80%) engage in mixed farming which comprises; 55 users (44%) in food crop/livestock/cash crop farming, 32 users (25.6%) in food crop/livestock farming, 5 users (5.6%) in food crop/cash crop farming and 6 users (4.8%) in cash crop/ livestock farming as shown in Table 21. Only 25 users (20%) practice a single farming system with 23 users (18.4%),1 user (0.8%) and 1 user (0.8%) engaging in food crops, cash crops, and livestock farming respectively.

On the other hand, 61 non-users (48.8%) of the non-users practice the single type of farming whereby; 55 non-users (44.0%), 2 non-users (1.6%) and 4 non-users (3.2%) farm food crops, livestock, and cash crop respectively. Also, 64 non-users (51.2%) practice mixed farming systems whereby 19 non-users (15.2%), 36 non-users (28.8%) and 10 non-users (8%) engage in food crop/livestock/cash crop farming, food crop/livestock farming, food crop/cash crop farming and cash crop/ livestock farming respectively from Table 21. Generally, this result depicts that most of the non-users practice the single type of farming system with 55 non-users (44.0%) in food crop farming compared to 23 users (18.4%). Farming is the main household head occupation for 84 users (67.2%) and 74 non-users (59.2%) non-users. Although 41 users (32.8%) and 51 non-users (40.8%) household heads occupation is not farming, agriculture is practiced in the households since it is the source of food for all the households in rural Makueni County.

Table 21 A summary of users and non-users socio-economic characteristics

Characteristics		Users (n=125)		Non-users (n=125)	
		No. of HH	%	No. of HH	%
Education level (above primary school)	Above primary school	102	81.6	93	74.4
	Below primary school	23	18.4	32	25.6
Total		125	100	125	100
Marital status	Married	103	82.4	78	62.4
	Single	22	17.6	47	37.6
Total		125	100	125	100
Mobile phone ownership	Own	125	100.0	77	61.6
	Don not own	0	0.0	48	38.4
Total		125	100	125	100
Gender	Male-headed	107	85.6	88	70.4
	Female-headed	95	14.4	37	29.6
Total		125	100	125	100
Farming system	Food crop farming	23	18.4	55	44.0
	Livestock farming	1	0.8	2	1.6
	Cash crop farming	1	0.8	4	3.2
	Food crops/livestock/cash crop farming	55	44.0	19	15.2
	Food crop/livestock farming	32	25.6	35	28.0
	Food /Cash crop farming	7	5.6	10	8.0
	Cash crop/livestock farming	6	4.8	0	0.0
Total		125	100	125	100
Occupation	Farmer	84	67.2	74	59.2
	Non-farmer	41	32.8	51	40.8
Total		125	100	125	100
Average age		45 years		45 years	
Monthly Income		7829 Ksh. (7.829 dollars)		3732Ksh. (3.732 dollars)	
Average Household members		5		5	

Source Field survey 2017/2018

6.3 Mobile phone usage in Makueni County

6.3.1 The mobile phone penetration rate

The mobile phone penetration rate refers to the total mobile phone subscriptions over the total population of a certain country or region (ITU, 2017; World Bank, 2017). It measures the rate of active mobile phone users in a given region. Due to the multiple mobile phone ownership per individual, the mobile phone rate can exceed 100% (GSMA, 2018). In this study, the mobile phone penetration rate is estimated as defined by ITU (2017) and World Bank (2017). Therefore, the mobile phone penetration rate in this study is computed by dividing the 203 mobile phone subscribers over 250 households. The estimated mobile phone penetration rate in Makueni County is 81%. Only 19% of the surveyed households don't own a mobile phone who pointed out that its due to affordability and lack of ability to operate it.

6.3.2 Mobile phone types and usage patterns

There are two types of mobile phones that are currently used and owned by households which are feature phones and smartphones. Feature phone is a mobile phone that provides basic functionality like calling, camera and music player and sometimes it can be installed with internet features while a smartphone is more advanced than the feature phone. It has a good quality camera, music player, can access the internet and is installed with more applications (GSMA, 2018). In this study, 122 households (60%) own a feature phone and only 81 households (40%) own a smartphone. The feature phone and smartphone in this study were differentiated by checking the features which included; access to the internet and more advanced features of the mobile phone. The type of mobile phone owned by the household does not limit the households from access the mobile phone based services provided through voice calling and text messaging since the available mobile phone based services have been designed to be used by both feature and smartphones users as pointed out by the interviewed key experts from Safaricom (Field survey 2017/2018)

As indicated in Table 22, 98 households (39.2%) have an experience of above 10 years. As a result of wide ownership and experience on how to use the mobile phone, it creates a great platform to facilitate the empowerment of the rural population through mobile phone based services. A study by CGIAR (2014) has also proven that wide affordability and ownership of mobile phone makes it a convenient service delivery method in most of developing countries.

Table 22 Household mobile phone usage in years

No of years	No. of HH	% of HH
1-3 years	29	14.4
4-6 years	68	33.6
7-9 years	26	12.8
Above 10 years	80	39.2
Total	203	100

Source: Field survey 2017/2018

In Kenya, there are four main licensed mobile service providers which are; Safaricom, Airtel, Orange and Yu (CAK, 2016). Among the four mobile service providers, Safaricom is in the top position and has many mobile phone subscribers (CAK, 2016). Although mobile phone users have the advantage to choose which mobile phone provider they would like to use for communication, Safaricom has many subscribers due to the many services which are provided and beneficial to its users (CAK, 2016). This situation is evident in this study whereby 198 households (97.6%) indicated that use Safaricom and only 23 households (11.2%), 5 households (2.4%), and 2 households (0.8%) use Airtel, Orange, and YU respectively.

Table 23 ICTs owned by the households

ICTs owned	User (n=125)						Non-user (n=125)					
	No. of HH Own	No. of HH Do not own	Total	% of HH Own	% of HH Do not own	Total	No. of HH Own	No. of HH Do not own	Total	% of HH Own	% of HH Do not own	Total
Radio	123	2	125	98.4	1.6	100	120	5	125	96.0	4.0	100
Television	45	80	125	36.0	64.0	100	20	105	125	16.0	84.0	100
Mobile phone	125	0	125	100.0	0.0	100	78	47	125	61.6	38.4	100
Laptop	30	95	125	24.0	76.0	100	20	105	125	16.0	84.0	100

Source: Field survey 2017/2018

The commonly owned ICT devices across households in Makueni county include; radio, television, mobile phone and laptop as indicated in Table 23. The results depict that radio and mobile phones are the most owned ICT assets in both users and non-users. As indicated in Table 23, 123 users (98.4%) and 120 non-users (96.0%) non-users' own radio while all the 125 users own a mobile phone and 77 non-users (61.6%) of the non-users own a mobile phone.

6.4 User and non-user accessibility to financial resource, information resources and diversity of livelihood

The users and non-users resource accessibility vary with the user registering higher scores in financial resource, information resource, and diversity of livelihood. Table 24 shows the resource and sub-indicator scores of users and non-users. The financial resource score of the users is higher than that of non-users as shown by 0.1481 and 0.0405 in Table 24 respectively. Access to credit scored highest in both users and non-users with a score of 0.1074 and 0.0186 respectively. The access to credit and Remittances registered the highest disparity between the non-users and user implying more access to credit and remittances across the user compared to the non-user.

Table 24 Financial resource, Information resource, and Diversity of livelihood sub-indicator scores for users and non-users

Resource	Resource sub-indicator	Users	Non-users
Financial resource	Access to credit	0.1074	0.0186
	Remittances	0.0243	0.0130
	Animal value	0.0126	0.0065
	Receive government support	0.0038	0.0023
	Total	0.1481	0.0405
Information resource	Training	0.0133	0.0003
	Extension services	0.0346	0.0038
	Participate on farmers organization	0.0162	0.0005
	No. of information source	0.0680	0.0201
	Total	0.1321	0.0881
Diversity of livelihood	No. of livelihood activities	0.0762	0.0125
	Size of the land under crop cultivation	0.0057	0.0043
	No. of crops planted	0.0162	0.0134
	Total	0.0981	0.0302

Source: Field survey 2017/2018

The Information accessibility is more for the users than in non-users as indicated by 0.1321 and 0.0881 scores respectively as shown in Table 24. For the information resource sub-indicators, the No. of information and source scored highest for the user and for the non-user with 0.0680 and 0.0201 respectively. No. of information sources and access to extension services registered the highest disparity across the users and non-users by comparing the scores compared to Training, and participation in farmer's organization. This implies that the user has many numbers of information sources to receive information compared to the non-users and as well as access to credit. Also, the No. of information sources and Access to credit are the two sub-indicators that contribute to more differences in information resource since the user scored highest compared to the non-user.

The diversity of livelihood score 0.0981 for the users was also more compared to 0.0302 of the non-users as indicated in Table 24. The no. of livelihood activities sub-indicator score of 0.0762 for users and 0.0125 for the non-users scored highest compared to Size of the land under crop cultivation and No. of crops planted. More disparity was registered in the No. of livelihood sub-indictor compared to the other sub-indicators between users and non-users. This implies No. of livelihood activities cause the highest differences in the users and non-users.

Since more than 195 households (78%) households are farmers, the user indicated that the mobile phone based services facilitate access to agricultural information, climate information and market information which help them to plan and execute their farming activities accordingly especially with the current unpredictable climate conditions. The results depict that 60 users (48%), 41 users (33%), 16 users (13%), and 6 users (5%) receive the

information in their mobile phones through voice calls, text messaging, mobile phone radio and internet respectively (Muasa et al., 2019). On the other hand, approximately 122 households (48.7%) can manage and monitor different livelihood activities engaged in through mobile phone based services which facilitate monitoring and management of the livelihood activities. Through the mobile phone, 64 users (51%), 58 users (46%) and 4 users (3%) can manage and monitor their livelihood activities by a voice call, mobile money transfers and text messaging respectively. The following sections discuss how the mobile phone plays a role in increasing accessibility to resources.

6.4.1 Financial resource accessibility for the users and non-users

As indicated in Table 25, 111 users (88.8%) receive remittance, 82 users (65.6%) access credit and 117 users (93.7%) are able to save using the mobile phone based service. On the other hand, only 26 non-users (20.8%) receive remittances, 43 non-users (34.3%) access credit and 30 non-users (24%) are able to save. This result clearly indicates that the users are able to receive remittances, access credit and save more compared to the non-users.

Table 25 Financial resource accessibility for the users and non-users

Accessibility to finances	Users (n=125)						Non-users (n=125)					
	Remittances (n=111)		Credit (n=82)		Save (n=117)		Remittances (n=26)		Credit (n=43)		Save (n=30)	
	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%
Access	111	88.8	82	65.6	117	93.7	26	20.8	43	34.4	30	24.0
No access	14	11.2	43	34.4	8	6.3	99	79.2	82	65.6	95	76.0
Total	125	100	125	100	125	100	125	100	125	100	125	100

Source: Field survey 2017/2018

Approximately 92 users (83.2%) receive remittances from family members and 19 users (16.8%) receive from friends while 22 non-users (86.4%) receive remittances from family and 4 non-users (13.6%) from the friends living in cities or abroad (Field survey 2017/2018). Estimated 106 users (95.6%) receive remittances through mobile phone based services and only 4 users (3.5%) and 1 user (0.8%) receive the remittances through face to face and visit the mobile money agent shop respectively as indicated in Table 26.

On the other hand, 20 non-users (76.9%) receive the remittances through face to face with 2 non-users (7.7%) and 4 non-users (15%) receiving through friend's mobile phone and mobile money agent shop respectively. Through the mobile phone, 106 users (95.6%) use M-Pesa service a mobile phone money banking service developed by Safaricom to receive remittances from family and friends. From the field survey 2017/2018, users portrayed that the mobile money banking service conveniently helps them to frequently receive remittances from family members living in cities and abroad. As depicted in Table 26 the users' access to credit is more compared to the non-users.

The users and non-users are able to access credit through; the bank, social organization, table banking system, farmer's organization, loan leaders and mobile phone as depicted in Table 26. Generally, the use of mobile phone based services has facilitated an increase in access to credit compared to the non-users. From table 26, the 57 users (70%) accessing credit through mobile phone use "M-shwari" a mobile phone based service developed by Safaricom that helps users to access short loans through the mobile-phone. Generally, this result implies that mobile phone based services facilitate access to credit as indicated in Table 26, as evident by 50 users (70%) access to credit through the mobile phone compared to the other sources. Although banking institutions are limited in rural area of Makueni County most of the households do not qualify for the borrowing criteria of the financial institution due to many formalities thus limiting access to credit compared to the mobile phone based services which are convenient and easily accessible since the registration procedures and formalities are minimal and no collateral is required as it was pointed out by the interviewed key expert from Safaricom and Airtel (field survey 2017/2018).

Table 26 Sources of finances for the users and non-users

Sources used to access finances		Remittances						Credit												Savings					
		Mobile money agent shop		Face to face		Mobile phone		Bank		Social organization		Table banking system		Farmers organization		Loan lenders		Mobile phone		Bank		Home		Mobile phone	
		No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%
Users	Use	1	0.9	4	3.5	106	95.6	22	26.8	13	16.0	22	26.5	71	8.6	40	4.9	57	70.0	78	26.8	35	15.0	82	70.0
	Do not use	110	99.1	107	96.5	5	4.4	60	73.2	69	84.0	60	73.5	11	91.4	42	95.1	25	30.0	39	93.3	82	70.0	35	30.0
	Total	111	100	111	100	111	100	82	100	82	100	82	100	82	100	82	100	82	100	117	100	117	100	117	100
Non-users	Use	4	15.4	20	76.9	2	7.7	5	11.7	6	15	5	11.7	0	0.0	5	11.7	0	0.0	8	6.7	5	30.0	0	0.0
	Do not use	22	84.6	6	23.1	24	92.3	38	88.3	37	85	38	88.3	0	0.0	38	88.3	0	0.0	22	73.2	25	85.0	0	0.0
	Total	26	100	26	100	26	100	43	100	43	100	43	100	0	0.0	43	100	0	0.0	30	100	30	100	0	0.0

Source: Field survey 2017/2018

The users save more compared to the non-users, there are different methods in which the households save their money including; bank, home and mobile phone. Through the mobile phone, 70% of the users are able to access mobile phone based services such as; M-Pesa and M-shwari developed by Safaricom. As indicated in Table 26, 8 non-users (30%) save their money at home and only 5 non-users (6.7%) save in the bank. During the field survey conducted in 2017/2018, the interviewed key experts from Safaricom and Airtel highlighted that Makueni County has only 4 functional financial institutions (Banks) which are located in the main towns of the County, Wote and Mbooni. Estimated 94 households (37.7%) have a bank account and approximately 156 (62.3%) are unbanked as portrayed by the interviewed households in the 2017/2018 field survey.

The 122 households (78%) without bank accounts indicated that the proximity of the banks limits them from accessing the bank services and also many formalities limit them from accessing credit services. This result is reflected in a study by Njuguna et al. (2010, 2012) that over 70% of the rural population in Kenya are unbanked due to limited financial institutions in rural areas as well as many formalities required for account registration and obtaining credit. Therefore, the use of mobile phone based services has facilitated the saving and access to credit due to limited financial institutions in rural areas and the services are easily accessible to the users.

6.4.2 Information resource accessibility for the users and non-users

Table 27 shows information resource accessibility for users and non-users. For agricultural information, 95 users (76%) access agricultural information and only 23 non-users (18.4%) access agricultural information. The climate information received by household comprises; weather, seasonal and long-term projections. The users access the climate information more compared to the non-users as pointed out in Table 27.

Estimated 82 users (65.6%) receive weather information, 88 users (70.4%) access seasonal information and 59 users (47.2%) receive long-term projections on climate information. On the other hand, only 17 non-users (13.6%), 16 non-users (12.8%), and 8 non-users (6.4%) receive weather, seasonal and long-term projections respectively as shown in Table 27. The market information is essential to both users and non-user to facilitate marketing farm produce and also purchasing farm inputs. Estimated 85 users (68%) access market information and only 8 non-users (29.6%) access market information.

Table 27 Information resource accessibility for users and non-users

Accessibility to information	Users (n=125)										Non-users (n=125)									
	Agricultural information		Climate information						Market information		Agricultural information		Climate information						Market information	
			Weather		Seasonal		Long term projections						weather		Seasonal		Long term projections			
	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No of HH	%	No. of HH	%	No. of HH	%
Access	95	76.0	82	65.6	88	70.4	59	47.2	85	68.0	23	18.4	17	13.6	16	12.8	8	6.4	37	29.6
No access	30	24.0	43	34.4	37	29.6	66	52.8	40	32.0	102	81.6	108	86.4	109	87.2	117	93.6	88	70.4
Total	125	100	125	100	125	100	125	100	125	100	125	100	125	100	125	100	125	100	125	100

Source: Field survey 2017/2018

The households receive different types of agricultural information crop and livestock farming and the information sources vary across the users and non-users. Table 28 shows the type of agricultural information received by the users and non-users. The users are able to access most of the agricultural information compared to non-users, for instance, both users and non-users are able to receive information on an introduction to new pesticides and herbicides but 59 users (62.4%) receive the agricultural information and only 3 non-users (11.2%) receive. Also, the other agricultural information indicates that users access more agricultural information than non-users.

As indicated in Table 28, 59 users (62.4%) receive introduction of new pesticides/herbicides, 48 users (50.4%) receive crop diseases/treatment /control and 41 users (43.2%) receive new crop varieties are most type of agricultural information while non-users receive more of new crop varieties, receive crop diseases/treatment/control and introduction of new crop varieties as evident by 9 non-users (39.1%), 4 non-users (17.3%), and 3 non-users (11.2%) respectively. Since the mobile phone is the main source of agricultural information compared to the other sources, it indicates that mobile phone based services contribute to accessing agricultural information.

Table 28 Type of agricultural information accessed by users and non-users

Agricultural information	Users (n=95)						Non-users (n=23)					
	No. of HH access	No. of HH No access	Total HH	% HH access	% HH No access	Total %	No. of HH access	No. of HH No access	Total HH	% HH access	% HH No access	Total %
Introduction of new pesticides	59	36	95	62.4	37.6	100	3	20	23	11.2	88.8	100
Crop diseases/ treatment/ control	48	47	95	50.4	49.6	100	4	19	23	17.3	82.7	100
New crop varieties	41	54	95	43.2	56.8	100	9	14	23	39.1	60.9	100
Livestock diseases/ treatment/ control	41	54	95	43.2	56.8	100	3	20	23	11.2	88.8	100
Introduction of improved seedlings	40	55	95	42.4	57.6	100	2	21	23	8.6	91.4	100
Better crop rotation practices/fertilizer application	32	63	95	33.6	66.4	100	5	18	23	21.7	78.3	100
New methods of crop preservation	32	63	95	33.6	66.4	100	2	21	23	8.6	91.4	100
Type of soils and best soil types for planting	22	73	95	23.2	76.8	100	3	20	23	11.2	88.8	100
Introduction of new animal vaccines/ drugs	22	73	95	23.2	76.8	100	2	21	23	8.6	91.4	100
Use of Artificial Insemination (AI)	11	84	95	11.2	88.8	100	1	22	23	4.3	95.7	100

Source: Field survey 2017/2018

Table 29 summarizes the different sources used by users and non-users to access agricultural information A mobile phone, radio, and other farmers are the main sources of agricultural information for the users whereby 76 users (80%) receive the information through mobile phone, 43 users (45%) though the radio and 43 users (45%) through other farmers. On the other hand, the radio and other farmers are the main sources of agricultural information for the non-users whereby 9 non-users (40%) receive through the radio and 7 non-users (30%) from other farmers as pointed out in Table 29. Overall, this result implies that although the users have different sources of agricultural information, most of the information is received through the mobile phone. Both users and non-users do not receive agricultural information through the television and newspaper as shown in Table 29.

Table 29 Sources of agricultural information for the users and non-users

Source	Agricultural information											
	Users (n=95)						Non-users (n=23)					
	No. of HH access	No. of HH No access	Total HH	% of HH Access	% of HH No access	Total %	No. of HH access	No of HH No Access	Total HH	% of HH Access	% of HH No access	Total %
Radio	43	52	95	45.0	55.0	100	9	14	23	40.0	60.0	100
Other farmers	43	52	95	45.0	55.0	100	7	16	23	30.0	70.0	100
Extension services	27	68	95	28.8	71.2	100	2	21	23	4.8	95.2	100
Chief meetings	29	66	95	30.4	69.6	100	3	20	23	9.0	91.0	100
Farmers organization	15	80	95	16.0	84.0	100	1	22	23	1.6	98.4	100
NGO	5	90	95	4.8	95.2	100	1	22	23	1.6	98.4	100
Mobile phone	76	19	95	80.0	20.0	100	-	-	-	-	-	-
Research agents	5	90	95	5.6	94.4	100	-	-	-	-	-	-
Television	-	-	-	-	-	-	-	-	-	-	-	-
Newspaper	-	-	-	-	-	-	-	-	-	-	-	-

Note: the dash (-) denotes that information is not received by the user or non-user household from that source

Source: Field survey 2017/2018

Table 30 shows the type of climate information received by the users and non-users ranging from daily weather forecasts, seasonal changes in rainfall and temperature including; rainy season start dates/end times, change in rainfall intensity, change in temperature, early warning on drought and flood. In addition, long term historical and future projections are depicted comprising; projections of future rainfall and temperature, historical trends in rainfall and temperature as well as historical changes in extreme events.

As indicated in Table 30, the users are able to receive more climate information than non-users. The result shows that 56 users (64%) receive information on rainy season starts dates/end dates compared to 6 non-users (38.1%). Also, access to information on early warning droughts is more for users compared to the non-users whereby 43 users (48.7%) and 6 non-users (28.6%) access as portrayed in Table 30. The climate information on future and historical changes in rainfall and extreme evens is only accessible to the users with 26 users (29.4%), 26 users (29.4%) and 26 users (29.4%) can access projections on future rainfall/temperature, historical trends in rainfall/temperature and historical changes in extreme events respectively as indicated in Table 30. These imply that the users are more get most of the climate information and awareness of the climate events, rainfall and temperature details more than the non-users thus enabling them to prepare the farming activities well by determining the suitable adaptive measures to manage the extreme events.

Table 30 Type of climate information received by user and non-user

Climate information	Users (n=88)						Non-users (n=17)					
	No. of HH access	No. of HH No access	Total HH	% of Access	% of No access	Total %	No. of HH access	No. of HH No access	Total HH	% of access	% of No access	Total %
Rainy season start dates/End dates	56	32	88	64.0	36.0	100	6	11	17	38.1	61.9	100
Early warning on droughts	43	45	88	48.7	51.3	100	5	12	17	28.6	71.4	100
Projection of future rainfall/temperature	26	62	88	29.4	70.6	100	2	15	17	14.3	85.7	100
Historical trends in rainfall/temperature	26	62	88	29.4	70.6	100	0	0	0	0.0	0.0	100
Historical changes in extreme events	26	62	88	29.4	70.6	100	0	0	0	0.0	0.0	100
Change in rainfall intensity	23	65	88	25.6	74.4	100	0	0	0	0.0	0.0	100
Daily weather forecast	20	68	88	23.1	76.9	100	2	15	17	14.3	85.7	100
Change in Temperature	18	70	88	20.5	79.5	100	1	16	17	9.5	90.5	100
Early warning on floods	17	71	88	19.2	80.8	100	2	15	17	14.3	85.7	100

Source: Field survey 2017/2018

The climate information received by the users and non-users is obtained from different sources including; radio, other farmers, extension officers, chief meetings, mobile phone and research agents and television as indicated in Table 31. Estimated 55 users (62.4%) obtain the information from a mobile phone, 35 users (40%) from radio and 17 users (19.2%) from chief meetings are the main sources of climate information compared to the other sources. The main sources of climate information are radio and other farmers as indicated by 6 non-users (35%) and 2 non-users (10.6%) respectively in Table 31. Both users and non-users do not receive climate information through the Farmers organization and NGO. Overall, the number of climate information sources is more for users compared to non-users. Also, Mobile phone is the main source of climate information to the users compared to the other sources of climate information implying that mobile phone based services play a role in accessing climate information.

Table 31 Sources of climate information for the users and non-users

Source	Climate information											
	Users (n=88)						Non-Users (n=17)					
	No. of HH access	No. of HH No access	Total HH	% of HH Access	% of HH No access	Total %	No. of HH access	No of HH No access	Total HH	% of HH access	% of HH No access	Total %
Radio	35	53	88	40.0	60.0	100	6	11	17	35	65.0	100
Other farmers	11	77	88	12.0	88.0	100	2	15	17	10.6	89.4	100
Extension services	11	77	88	12.0	88.0	100	1	16	17	2.4	97.6	100
Chief meetings	17	71	88	19.2	80.8	100	1	16	17	3.2	96.8	100
Farmers organization	-	-	-	-	-	-	-	-	-	-	-	-
NGO	-	-	-	-	-	-	-	-	-	-	-	-
Mobile phone	55	33	88	62.4	37.6	100	-	-	-	-	-	-
Research agents	3	85	88	3.2	96.8	100	-	-	-	-	-	-
Television	16	72	88	18.4	81.6	100	1	16	17	5.9	94.1	100
Newspaper	-	-	-	-	-	-	-	-	-	-	-	-

Note: the dash (-) denotes that information is not received by the user or non-user household from that source

Source: Field survey 2017/2018

The users and non-users receive market information on the quality and prices of products as indicated in Table 32. Table 32 shows that 58 users (68%) access market information on price while only 9 non-users (24%) access the prices of the products as the market information. On the other hand, Table 32 shows that 34 users (40%) and 6 non-users (16%) access market information on the quality[7] of products. Overall, the users access market information more than non-users.

Table 32 Type of market information accessed by users and non-users

Market information	Users (n=85)						Non-users (n=37)					
	No. of HH access	No. of HH No access	Total HH	% of Access	% of No access	Total %	No. of HH access	No. of HH No access	Total HH	% of access	% of No access	Total %
Price	58	27	85	68.0	32.0	100	9	28	37	24.0	76.0	100
Quality	34	51	85	40.0	60.0	100	6	31	37	16.0	84.0	100

Source: Field survey 2017/2018

The users and non-users obtain the market information from radio, other farmers, mobile phones, television and newspaper as indicated in Table 33. For the users, although they have different sources of market information, 70 users (82.5%) receive the information through the mobile phone. Other sources of information accessed are; 37 users (43.5%) access from radio, 65 users (76.5%) access from other farmers and 62 users (72.8%) access from television. On the other hand, 14 non-users (37.6%) receive the market information from radio, 8 non-users (21.6%) from other farmers and 2 non-users (5.6%) from television as illustrated in Table 33. Overall, these results imply that the number of market information sources is more for users compared to non-users. Also, the mobile phone based service plays a role in accessing the market information as depicted by the result whereby the mobile phone is the main source of market information to the users.

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[7] Quality is defined as the incorporated features of a product that help the households to meet their wants and satisfaction through improving the product and free from any deficiencies or defects. The households seek information on farm produce and therefore they were asked whether they receive information regarding the condition of the farm produce in the market in order to make decision on buying and selling the products for instance; the size, the volume or defects in mangoes, oranges etc.

Table 33 Sources of market information for the users and non-users

| Source | Market information | | | | | | | | | | | |
| | User (n=85) | | | | | | Non-user (n=37) | | | | | |
	No of HH access	No of HH No access	Total HH	% of HH Access	% of HH No access	Total %	No. of HH access	No. of HH No access	Total HH	% of HH access	% of HH No access	Total %
Radio	37	48	85	43.5	56.5	100	14	23	37	37.6	62.4	100
Other farmers	65	20	85	76.5	23.5	100	8	29	37	21.6	78.4	100
Extension services	-	-	-	-	-	-	-	-	-	-	-	-
Chief meetings	-	-	-	-	-	-	-	-	-	-	-	-
Farmers organization	-	-	-	-	-	-	-	-	-	-	-	-
NGO	-	-	-	-	-	-	-	-	-	-	-	-
Mobile phone	70	15	85	82.5	17.5	100	-	-	-	-	-	-
Research agents	-	-	-	-	-	-	-	-	-	-	-	-
Television	62	23	85	72.8	27.2	100	2	35	37	5.6	94.4	100
Newspaper	10	75	85	12.0	88.0	100	1	36	37	2.4	97.6	100

Note: the dash (-) denotes that information is not received by the user or non-user household from that source

Source: Field survey 2017/2018

6.4.2.1   An analysis to determine the gaps in the information provided

During the field survey, the households were asked to indicate the kind of information agricultural, climate and market information provided and the service providers who provide the information as discussed in the previous parts of this chapter. A matrix table was developed with all the kind of information provided to the households indicated in the top row and the service providers listed in the first column as illustrated in Table 34. The households then ranked the information provided by each service provider into 3 levels using a score of 2, 1 and 0 denoting if the information is sufficiently provided, if the information provided is sufficient and if the information is not provided respectively. The assumptions made for this analysis was that all the service providers provide related information on crop and livestock farming since the surveyed households rely on agriculture for livelihood. Also, the agricultural, climate and market information is essential for farming activities of the households.

The total score for each information was computed to facilitate identify the kind of information gaps based on the household's perceptions. The kind of information provided by the information providers is regarded as the demand and the service providers are regarded as the supply. The purpose of this estimation was to capture the household's perception of the kind of information provided to them from providers in order to provide insights that help policymakers to design the appropriate programs and services that will facilitate increased access to information resources to the rural households in Makueni County. The supply is considered to be the source of information. The information providers in Makueni county included; Extension services, Radio, Research agent, NGO, Farmer's organization, input providers, chief meetings, mobile phone, KMD, television, other farmers, peer farmers, KARI and Veterinary officer. The total score in the last column is computed to indicate the total supply of the kind of information provided across agricultural, climate and market information while the bottom row shows the total score of each kind of information in agricultural, climate and market information. The total score was computed to facilitate identifying the kind of information in each area of agricultural, climate and market information that is sufficiently supplied.

In Table 35, agricultural information provided included; new crop varieties, new methods of preservation, food crop/disease control, introduction to improved seedlings, livestock/ pest disease control, better rotation methods, and fertilizer applications. Based on the household ranking, only new crop variety information is sufficiently provided through the mobile phone and extension services since it scores highest compared to the other agricultural information with a score of 11. Approximately 68 users (54%) receive the new crop variety of information indicated that the information is sufficiently provided and beneficial to their farming activities as

portrayed in Table 34. Some information sources such as the Kenya Meteorological Department (KMD) and television do not provide agricultural information.

Across the information provided by the households and information supply to the household's new crop varieties scored highest (11), livestock pests/disease control (9) and better crop rotation practices and fertilizer application (8). Households indicated that the information on some of the important crops grown in Makueni County is missing and which ranked information on crops/diseases control least provided information with a score of 6. Furthermore, as depicted the information on better preservation methods was least provided with a score of 3 compared to the other information needed by the households. The households indicated the post-harvest information is adequately not provided and only a few households received it. Generally, this implies that for the agricultural information, there is a great need to increase the information on food crops/disease control and on new methods of the crop preservation method.

For the climate information as indicated in Table 34, the households receive much information through extension services, through mobile phones and KMD (Kenya Meteorological Department). Although the households receive more information from these 3 sources most of the climate information is sufficiently provided through the mobile phone compared to the other sources. There are fewer sources of information sources for climate information compared to agricultural information. Across the climate received by the households, information on rainfall seasons start and end dates, early warning on droughts/floods, change in rainfall temperate and daily weather is sufficiently provided through the mobile phone, this means that over 62.4% of users are able to prepare adequately and plan their farming activities compared to the non-user that do not receive the information.

The market information provided includes the price and quality of the products in the market. As indicated in Table 34, the quantity of products in the market is not provided from any sources available. The information on the quality of products is least provided with a score of 2 and generally, there are few sources of market information. Mobile phone and input providers are the most providers of the price and quality of product information but it is not sufficiently provided. This implies that there is a great need to increase market information in general. Generally, as indicated in Table 34 the total score for the highest information supply to the households was a mobile phone which scored 21, extension services which scored 14 and peer farmers scored 10. This implies that the users are able to access information through mobile phone based services access compared to the other sources. These result has been depicted in the previous sections whereby the mobile phone based services facilitate access to agricultural, climate and market information.

Table 34 Analysis of gaps in the information provided to users and non-users in Makueni County

Demand / Supply	AGRICULTURAL INFORMATION						CLIMATE INFORMATION							MARKET INFORMATION			TOTAL SCORE
	New crop varieties	New crop preservation methods	Food crop/disease/control	Introduction of improved seedlings	Livestock/pest/disease control	Better crop rotation practices/fertilizer application	Long-term change in precipitation/temperature	Historical changes in extreme events	Better adaptive strategies	Daily weather forecast	Change in rainfall and temperature	Early warning on droughts/floods	Rainfall season start/end dates	Price	Quality	Quantity	
Extension Services	●	○	○	○	○	○	○	○	○	○	○	○	○	✗	✗	✗	14
Radio	✗	✗	○	○	○	○	✗	✗	✗	○	○	○	○	○	✗	✗	9
Research agents	○	✗	✗	✗	✗	○	✗	✗	○	✗	✗	✗	✗	✗	✗	✗	3
NGO	○	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Farmers organization	○	○	○	○	○	○	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	5
Input providers	○	✗	○	○	○	○	✗	○	✗	✗	✗	✗	✗	○	○	✗	8
Chief meetings	✗	○	✗	✗	○	✗	✗	○	✗	✗	✗	○	✗	✗	✗	✗	3
Mobile phone	●	✗	○	○	○	○	○	○	○	●	●	●	●	○	○	✗	20
KMD	✗	✗	✗	✗	✗	✗	○	✗	○	●	○	○	○	✗	✗	✗	8
Television	✗	✗	✗	✗	✗	✗	○	✗	✗	○	○	○	○	○	✗	✗	6
Other Farmer	○	✗	✗	○	○	✗	○	✗	○	✗	○	○	○	○	✗	✗	9
Peer farmers	○	✗	○	○	○	○	✗	✗	●	✗	○	○	○	✗	✗	✗	10
KARI	○	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Veterinary officer	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
TOTAL SCORE	11	3	6	7	9	8	5	3	7	7	8	9	8	5	2	0	98

Source: Field Survey 2017/2018

● Sufficiently provided=2   ○ Provided but Insufficient = 1   ✗ Not provided=0

6.4.3 Diversification of livelihood

The main livelihood activities practiced by both users and non-users include; farming, business, casual Labour and civil service as illustrated in Table 35. Generally farming is the main livelihood activity for both users and non-users compared to the other livelihood activities. Farming is the main livelihood activity for 77 users (61.6%) and 68 non-users (54.4%) as shown in Table 35. For the other livelihood activities; business is the main livelihood activity for 19 users (15.4%) and 20 non-users (15.8%), casual labor is main livelihood activity for 13 users (10.2%) and 22 non-users (17.6%) while civil service is the main livelihood activity for 16 users (12.8%) and 15 non-users (12.4%).

Table 35 The main livelihood activity for the users and non-users

Main livelihood activity	Users (n=125)		Non-users (n=125)	
	No. of HH	% of HH	No. of HH	% of HH
Farming	77	61.6	68	54.4
Business	19	15.4	20	15.8
Casual Labour	13	10.2	22	17.6
Civil servant	16	12.8	15	12.4
Total	125	100	125	100

Source: Field survey 2017/2018

The users and non-users were evaluated whether they participate in different activities other than the main livelihoods activity. Most of the users diversify more compared to non-users as indicated in Table 36. As indicated in Figure 18, the users have more livelihood activities other than the main activity which they engage in. For the users whose main livelihood activity is civil servants, 14 users (86%) engage in farming and 2 users (14%) engage in business as other livelihood activities. The users whose main livelihood is farming, 6 users (8%) are civil servants, 42 users (54%) engage in casual labor and 28 users (38%) engage in business as other livelihood activities.

On the other hand, the non-users whose main livelihood activity is farming diversify more compared to the other main livelihood activities. This is evident by 5 non-users (8%) engage in civil service, 57 non-users (84%) engage in casual labor and 5 non-users (8%) engage in casual labor as shown in Table 36. In general, the households with casual labor as the main livelihood activity they diversify on farming, business, and civil servant while the households with farming as the main livelihood activity they diversify on business, casual labor, and civil servant. The business activity as the main livelihood activity they only diversify on farming. The non-user whose main livelihood activity is civil servant, engage only in farming as the other livelihood activity. The non-users whose main livelihood activity is farming engage in other livelihood activities including; business, casual labor, and civil servant.

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Table 36 Diversity of livelihood for users and non-users

Other livelihood activities HH engage in	Main livelihood activity															
	User (n=125)								Non-user(n=125)							
	Civil servant (n=16)		Casual labor (n=13)		Farming (n=77)		Business (n=19)		Civil servant (n=15)		Casual labor (n=22)		Farming (n=68)		Business (n=0)	
	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%
Civil servant	0	0.0	0	0.0	6	8.0	0	0.0	0	0.0	0	0.0	5	8.0	0	0.0
Casual labor	0	0.0	0	0.0	42	54.0	0	0.0	0	0.0	0	0.0	57	84.0	0	0.0
Farming	14	86.0	9	71.0	0	0.0	19	100.0	15	100.0	22	100.0	0	0.0	0	0.0
Business	2	14.0	5	29.0	29	38.0	0	0.0	0	0.0	0	0.0	5	8.0	0	0.0
Total	16	100	13	100	77	100	19	100	15	100	22	100	68	100	0	0

Source: Field survey 2017/2018

6.4.4 **Financial, information, and diversity of livelihood accessibility based on gender and farming system for the users and non-users**

To understand the resource accessibility across the users and non-users the financial resource, information resource and diversity of livelihood were categorized based on the gender of the household head and farming system of the household. The result shows that the financial, information and diversity of livelihood accessibility is higher for male-headed households than in female-headed households in users as indicated by 0.1818, 0,1242 and 0.1018 for the male-headed households and 0.1458, 0.1192 and 0.0765 for female-headed households in Table 37 respectively. On the other hand, the non-users the accessibility is higher for the male-headed household than female-headed households as shown by 0.0.0471, 0.0228 and 0.0302 for the female-headed households and 0.0385, 0.0295 and 0.0201 for the female-headed households in Table 37. Overall, the result implies that the male-headed households in both users and non-users access financial, information and diversity of livelihood more compared to the female-headed households.

Table 37 Financial, Information and diversity of livelihood accessibility by gender of the household head

Resources	Users (n=125)		Non-users (n=125)	
	Female-headed	Male-headed	Female-headed	Male-headed
Financial	0.1458	0.1818	0.0385	0.0471
Information	0.1192	0.1242	0.0295	0.0228
Diversity of livelihood	0.0765	0.1018	0.0201	0.0302

Source: Field survey 2017/2018

The financial resource, information resource, and diversity of livelihood accessibility for the users and non-users were further categorized based on the farming systems. The farming systems are categorized into single farming systems (cash crop, food crop, and livestock farming) and the mixed farming system (food crop/livestock/cash crop farming). Table 38 shows the categorization of the resources based on the farming system for the users and non-users

Table 38 Financial, information and diversity of livelihood accessibility based on the farming system for the users and non-users

Type of farming system	Users (n=125)			Non-users(n=125)		
	Financial resource	Information resource	Diversity of livelihood	Financial resource	Information resource	Diversity of livelihood
Food crop farming	0.1192	0.1245	0.0742	0.0294	0.0248	0.0220
Livestock farming	0.1367	0.1236	0.0387	0.0221	0.0210	0.0126
Cash crop farming	0.1418	0.1365	0.1074	0.0177	0.0158	0.0084
Food crops/livestock/cash crop farming	0.1985	0.1681	0.1937	0.0468	0.0384	0.0397
food crop/livestock farming	0.1631	0.1264	0.0971	0.0326	0.0283	0.0231
Food /Cash crop farming	0.1658	0.1158	0.0669	0.0175	0.0206	0.0263
Cash crop/livestock farming	0.1449	0.1326	0.0836	0.0000	0.0000	0.0000

Source: Field survey 2017/2018

Table 38 shows the average resource score for the users and non-users based on the type of farming system. The result depicts that the score for the single farming system in both users and non-users is lower than that of users although the average score for financial, information and diversity of livelihood is higher for the single farming system in the users compared to the non-users. Since 140 non-users (60.8%) practice a single farming system while 100 users (80%) practice a mixed farming system these results imply that there is a need to focus on improving the financial, information and diversity of livelihood for the single farming systems for the non-users. The resource accessibility for the non-users is lower compared to the users as shown in Table 38. Generally, the results from this analysis depict that there is a need to increase financial, information and diversity of livelihood accessibility to the female-headed households and the single type of farming. This implies that consideration of the gender of household head and the type of farming system should be included in resource distribution and the rural adaptive capacity development interventions.

6.4.4.1 Effects of mobile phone ownership on accessing the financial resource, information resource, and diversity of livelihood

A statistical analysis to assess whether mobile phone ownership contributes to the access of financial resource, information resource and diversity of livelihood was conducted in which a multivariate multiple probit regression was applied. This analysis was to hypothesize whether mobile phone ownership contributes to access to finances, information, and diversity of livelihood. Multivariate multiple probit regression analysis appropriate for this analysis since 3 equations with dependent variables including; access to finances, access to information and access to the diversity of livelihood variables are used. According to Johnson et al., (2007), the multivariate

multiple probit regression is suitable for modeling multiple dependent variables with a set of a single set of independent variables.

The dependent variables; access to financial resource, access to information resource and access to the diversity of livelihood are binary variables whereby, 1=access and 0=no access. The dependent variables were regressed to household ownership to a mobile phone (1= own and 0 otherwise) and a set of household head characteristics which includes; the age of household head in years, the gender of household head, years of schooling of household head and the main occupation of the household head (1=farmer and 0=otherwise). The purpose of this analysis is to hypothesize whether mobile phone ownership among households contributes to an increase in access to finances, access to information and diversity of livelihood of the households. Since access to finances, access to information and diversity of the livelihood influence the household adaptive capacity, the multivariate multiple linear regression was suitable to understand the effect of a mobile phone simultaneously. Equation 5 shows the model used to estimate the coefficients of the covariates.

$$Y_i = \beta_0 + \beta_1 ownmob. + \beta_2 X + \varepsilon \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots(5)$$

Whereby:

$Y_i = accessFinc.$ = access Financial resource (1= access, 0=no access)

$accessInfo.$ = access information resource (1= access, 0=no access)

$accessDivL.$ = diversify livelihoods (1= diversify, 0=do not diversify)

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ = Parameters

Ownmob. = Own Mobile phone (1= 0wn, 0=No mobile phone)

X= Household head characteristics (Age, Gender, Years of schooling, Occupation)

ε = Error term

Table 39 shows the results of the multivariate multiple probit regression analysis indicating the coefficients and standard errors of the covariates indicated in parentheses.

Table 39 Multivariate multiple probit regression analysis results

Parameters	Access Financial	Access Information	Diversity of Livelihood
Cons	-0.393*** (0.160)	-0.381*** (0.159)	-0.127** (0.157)
Age (years)	0.001 (0.002)	0.002 (0.002)	-0.002 (0.001)
Gender (1=female,0=Male))	-0.201*** (0.062)	-0.144** (0.060)	-0.250*** (0.007)
Years of schooling	0.017 (0.015)	0.003** (0.014)	-0.000 (0.016)
Occupation (1=farmer,0=non-farmer)	0.038 (0.055)	0.049 (0.051)	0.359 (0.054)
Ownmob (1=own, 0=no mobile phone)	0.521*** (0.072)	0.399*** (0.070)	0.114*** (0.070)
Total Observation Adjusted R-Squared F-Value	250 0.370 23.791***	250 0.277 15.508***	250 0.045 17.734***

Note: Standard error in Parentheses ***p<0.01, **p<0.05, *P<0.1 representing 1%, 5% and 10% level of significance
Source: Field survey 2017/2018

The hypothesis that mobile phone ownership contributes to access to financial, information and diversity of livelihood increase with mobile phone ownership, variable Ownmobilephone, is supported as portrayed in Table 39. The coefficients of Ownmobilephone indicate that mobile phone ownership increases access to financial resources by 0.521, access to information resources by 0.399 and diversity of livelihood by 0.1140.

Gender is statistically significantly different from zero in access to financial, information and diversity of livelihood with -0.201, -0.144 and 0.521 coefficients respectively as indicated in Table 39. This implies that access to financial and diversity of livelihood increases with male-headed households. A study by Defiesta et al. (2014) also shows that male-headed households have higher accessibility to resources compared to female-headed households. The years of schooling is statistically significantly different from zero on access to information resource with a coefficient of 0.049. This implies that the years of schooling increases with an increase in mobile phone usage to access information resource.

6.5 Barriers and challenges to accessing mobile phone services

Table 40 shows the users and non-users outlined challenges that limit them from using the available mobile phone based services. These challenges include; unawareness of the registration process of the services, preference to face to face learning, unawareness of the services, perceived high price to access the services, mobile phone network issues and the information provided in the services is limited.

Estimated 90 users (72%) perceived a high price is involved in accessing the mobile phone based services, 86 users (68.8%) stated that the information provided is not enough, 69 users (55%) experience mobile phone network issues and only 13 users (10%) were not aware of the registration procedure to access the services.

The user pointed out that although they need to access the services the cost of receiving the information is expensive compared to normal text messaging. During the focus group discussions conducted during the 2017/2018 field survey, the users highlighted that the information provided is not enough especially for some of the commonly planted crops in Makueni County. Also, the issue of poor mobile phone networks was indicated as a common problem identified by both users and non-users whereby they indicated that mobile network is not stable sometimes thus interrupting utilization of the mobile phone based services (Field survey 2017/2018).

On the other hand, 100 non-users (80%) are unaware of the available mobile phone based services and 96 non-users (76.8%) perceived high prices to access mobile phone based services. Also, 61 non-users (54%) and 41 non-users (33%) experience mobile phone network issues and are unaware of registration procedures thus limit them from using the available mobile phone based services. Furthermore, 25 non-users (20%) pointed out that prefer face to face learning to mobile phone based services as shown in Table 40. Therefore, this result implies that there is a need to address the challenges limiting both users and non-users from using the available mobile phone based services.

Table 40 Barriers and challenges experienced by the users and non-users to access mobile phone based services

Barrier and challenge	Users (n=125)						Non-users (n=125)					
	No of HH experienced	No. of HH not experienced	Total HH	% of HH experienced	% of HH not experienced	Total %	No of HH experienced	No. of HH not experienced	Total HH	% of HH experienced	% of HH not experienced	Total %
Information provided is not enough	86	39	125	68.8	31.2	100	25	100	125	20.0	80.0	100
Mobile phone network issue	69	56	125	55.0	45.0	100	68	57	125	54.0	46.0	100
Unaware of the services	0	0	0	0.0	0.0	0	100	29	125	80.0	20.0	100
Perceived high price	90	35	125	72.0	28.0	100	96	25	125	76.8	23.2	100
Preference to face to face learning	0	0	0	0.0	0.0	0	25	100	125	20.0	80.0	100
Unaware of registration procedures	13	112	125	10.0	90.0	100	41	84	125	33.0	67.0	100

Source: Field survey 2017/2018

6.6 Summary

This chapter highlights four key issues to achieve its objective which is assessing the household mobile phone usage and access to adaptive capacity resources to be developed (financial resource, information resource, and diversity of livelihood, from chapter 5). First and foremost, mobile phone types and usage was generally highlighted across the surveyed households. It is depicted that; mobile phone is a commonly owned ICT across the households. Although most of the households own a feature phone, they are able to access the services through it. This proves that a mobile phone is a promising ICT technology that can be utilized for rural development.

Secondly, access to the financial resources, information resources, and diversity of livelihood for the users and non-users was assessed. The study reveals that the financial resource, information resources and diversity of livelihood for the users are higher than the non-users. Also, it is evident that mobile phone based services facilitate access to the information resource, financial resource, and diversity of livelihood for users. It further outlines the information gaps currently existing in the information provided to the households and identifies challenges or barriers that limit users and non-users from accessing the mobile phone based services. The study further depicts that lack of awareness, high cost, and insufficient information are the major challenges limiting utilization of the available mobile phone based services and therefore there is a need to address the identified challenges to encourage usage of the available mobile phone based services.

Thirdly, the chapter assesses the financial resource, information resource and diversity of livelihood accessibility by the gender of the household head. A comparison of both users and non-users is done to understand the accessibility of the financial, information resource and diversity of livelihood. The study reveals that financial, information and diversity of livelihood accessibility is higher in male-headed households compared to the female-headed households in both users and non-users although the users have higher access compared to the non-users. Therefore, there is a need to increase the resource accessibility of female-headed households.

Fourthly, this chapter evaluates the financial, information and diversity of livelihood accessibility based on the type of farming system by comparing the single type of farming and mixed type of farming system. The chapter reveals that financial, information and diversity of livelihood is higher in the mixed type of farming system compared to the single type of farming in both users and non-users. This result depicts that there is a need to consider increasing the single farming system resource accessibility.

This chapter suggests that for the purpose of increasing access to the financial resource, information resource and diversity of livelihoods to the non-users, there is a need to encourage utilization of the available mobile phone based services since the mobile phone is a commonly owned asset across the surveyed households. This is proved

by the statistically conducted to assess the effects of mobile phone ownership on access to financial, information and diversity of livelihood using the multiple multivariate analysis in which the hypothesis that mobile phone ownership contributes to access to finances, access to information and diversity of livelihood was supported. In addition, information gaps and challenges limiting the utilization of mobile phone based services should be considered to ensure utilization of the available mobile phone based services. Furthermore, the chapter suggests that female-headed households and single farming systems should be considered in resource distribution and rural adaptive capacity development interventions.

In the next chapter (Chapter 7), the impacts of mobile phone based services on the adaptive capacity of users and non-users are discussed in whereby a social experiment is conducted to the non-users and impact evaluated.

CHAPTER 7

IMPACT OF MOBILE PHONE BASED SERVICES ON HOUSEHOLD ADAPTIVE CAPACITY

7.1   Introduction

This chapter is set to address objective 3 of this study which is to evaluate the impact of mobile phone based services on household adaptive capacity. Furthermore, an intervention is conducted targeting the non-users whereby information and training on mobile phone based services to access financial, information and diversity of livelihood is provided. A baseline and follow-up survey data are utilized to assess the impact of the intervention.

Descriptive analysis is employed to compare the users and non-users HACI as well as the impacts derived from a developed adaptive capacity to the household. A combination of Propensity Score Matching and Difference-in-Difference methods are applied to evaluate the impact of the intervention on household adaptive capacity. This chapter is organized as follows; section 7.2 outlines the categorization of users and non-users HACIs which comprises categorization of users and non-users by the gender of household head and type of farming system. Section 7.3 outlines the benefits of mobile phone based services to the users and section 7.4 outlines the findings on the impact of mobile phone based services on household resource accessibility and adaptive capacity.

7.2   Categorization of HACI for users and non-users

Table 41 indicates the disparity in resources across user and non-user, it shows that there is a significant difference in financial, information and diversity of livelihood across the user and non-user. The increase in the financial, information and diversity of livelihood influenced the HACI of the households. Also, the average HACIs for the users and non-users are depicted in Table 41. The estimation indicates that the average HACI for the user is 0.5012 and that of non-user is 0.2046. The average HACI of the user is also higher compared to that of all households, which is 0.3529.

Table 41 Average HACI for users, non-users and full sample

Details	Users (n=125)	Non-users (n=125)	Full sample (n=250)
Human resource	0.0627	0.0600	0.0613
Financial Resource	0.1481	0.0405	0.0943
Information Resource	0.1320	0.0248	0.0784
Physical Resource	0.0602	0.0491	0.0547
Diversity of Livelihood	0.0982	0.0302	0.0642
Average HACI	0.5012	0.2046	0.3529

Source: Field survey 2017/2018

Generally, these results indicate that the mobile phone based services utilized by the user facilitated an increase in financial, information and diversity of livelihoods which generally contributes to higher HACI. Therefore, mobile phone based services impact the HACI through increasing resource accessibility which contributes to higher HACI as depicted by the user and non-user.

In order to understand the distribution of users and non-users HACIs, the households were categorized into; low, moderate and high HACI levels. The result in Table 42 shows that 114 users (91.2%) are categorized in the moderate and 6 users (4.8%) in the high HACI level and only 5 users (4%) are categorized in low HACI level. On the other hand, 114 non-users (91.2%) categorized in low HACI level and 11 non-users (8.8%) at moderate HACI level. No households are categorized in high HACI across the non-users.

As indicated in Table 42, in both users and non-users the resources vary from low, moderate and high. The average HACIs for the users are 0.2731, 0.5040 and 0.7101 for the low, moderate and high levels respectively while that of the non-users is 0.1863 and 0.3930 for the low and moderate HACI levels. This result shows that the average HACI for the users is higher compared to that of the non-users at low and moderate levels.

Table 42 Average HACI and resources scores of users and non-users in HACI levels

	Level of HACI	No. of HH	% of HH	Human resource	Financial resource	Information resource	Physical resource	Diversity of livelihood	Average HACI
User	Low	5	4.0	0.0588	0.0204	0.1081	0.0564	0.0294	0.2731
	Moderate	114	91.2	0.0627	0.1523	0.1324	0.0599	0.0968	0.5040
	High	6	4.8	0.0663	0.2069	0.1521	0.0732	0.2000	0.7101
	Total/Average	125	100	0.0627	0.1481	0.1320	0.0602	0.0982	0.5012
Non-user	Low	114	91.2	0.0595	0.0316	0.0225	0.0477	0.0247	0.1863
	moderate	11	8.8	0.0632	0.1326	0.0486	0.0636	0.0850	0.3930
	High	0	0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Total/Average	125	100	0.0600	0.0405	0.0248	0.0491	0.03020	0.2046

Note: The total is for the number of households and the percentage of households. The average is for the human resource, financial resource, information resource, physical resources, diversity of livelihood and the average HACI

Source: Field survey 2017/2018

7.2.1   Comparison of users and non-users HACI by gender of household head and the type of farming system

The HACIs of the users and non-users were categorized based on the gender of the household head and the type of farming system to understand how the adaptive capacity vary and identify the vulnerable households based on these categorizations. The average HACI for the 18 female-headed households (14.4%) in users is 0.2279 while that of the 107 male-headed households (85.6%) in users is 0.5018 as shown in Table 43. On the other hand, the non-users comprised of 37 female-headed households (29.6%) and 88 male-headed households (70.4%). From Table 43, the average HACI for female-headed households is 0.1885 while that of male-headed households is 0.2003. Table 43 shows that 2 users (8.6%) and 16 users (91.4%) for the female-headed households are categorized in low and moderate HACI levels while in the non-users,35 non-users 94.6% and 2 non-users 5.4% are categorized in low and moderate HACIs levels for the female-headed households. Estimated 5 users (4.7%), 97 users (90.6%) and 5 users (4.7%) of the male-headed households are categorized in low, moderate and high HACI levels respectively while 70 non-users (79.5%) and 18 non-users (20.5%) are categorized in low and moderate HACI levels respectively as indicated in Table 43.

The HACIs for the female-headed households are 0.2031 and 0.4807 for the users in the low and moderate category while that of the male-headed households in the users is 0.2871, 0.5082 and 0.7101 for the low. Moderate and high HACI levels respectively. This result shows that the average HACI for the male-headed household is higher than the female-headed households. Also, in the non-users, the average HACI for the male-headed households in low moderate and high levels is higher than that of the female-headed households.

Generally, the average HACI of the male-headed households is higher compared to the female-headed households and the same is depicted in the low, moderate and high levels of HACI in both users and non-users. The results further depict that the adaptive capacity of both male-headed and female-headed households in the users is higher than in the non-users as indicated in Table 43.

Table 43 Comparison of users and non-users based on the gender of the household head

| Level of HACI | Users | | | | | | Non-users | | | | | |
| | Female-headed | | | Male-headed | | | Female-headed | | | Male-headed | | |
	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI
Low	2	8.6	0.2031	5	4.7	0.2871	35	94.6	0.1771	70	79.5	0.2070
Moderate	16	91.4	0.4807	97	90.6	0.5082	2	5.4	0.3885	18	20.5	0.3940
High	0	0.0	0.0000	5	4.7	0.7101	0	0.0	0.0000	0	0.0	0.0000
Total	18	100	0.2279	107	100	0.5018	37	100	0.1885	88	100	0.2003

Source: Field survey 2017/2018

The comparison of the HACI by the farming system of the households depict that the average HACI of the single farming system which includes food crop farming, cash crop farming, and livestock farming, is lower than the mixed farming system in both users and non-users across the low, moderate and high HACI level, see Table 44. Estimated 21 users (91.3%) engage in food crop farming, 1 user (100%) livestock farming and 1 user (100%) in cash crop farming from the moderate HACI while 51 non-users (92.7%) engage in food crop farming, 2 non-users (100%) in livestock farming and 4 non-users (100%) in cash crop farming from the low HACI level as shown in Table 44. This result implies that single farming users have higher HACI compared to non-users. For the mixed farming, 48 users (87.3%) practice food crop/cash crop/livestock farming, 31 users (96.7%) in food crop/livestock farming, 6 users (85.7%) in food /cash crop farming and 6 users (100%) in cash/livestock farming are categorized with moderate HACI while 16 non-users (84.2%), 31 non-users (88.6%) and 10 non-users (100%) categorized in the low HACI level engage in food /cash/livestock farming, food/livestock farming, food/cash crop farming respectively.

Furthermore, the users using a mixed farming system registered higher HACIs compared to non-users as well as in the single farming system. The average HACI for users practicing food crop farming, livestock farming, and cash crop farming is 0.4583, 0.4217 and 0.5949 while that of non-users includes 0.0947, 0.0777 and 0.0747 respectively as indicated in Table 44. Generally, this result implies that mobile phone based services have an impact on users' HACIs. Also, the adaptive capacity of the non-users' needs to be improved and consideration should be done on households practicing single farming as evidenced by the estimated HACI being lower than that of households practicing mixed farming.

Table 44 Categorization of HACI based on the type of farming systems for the users and non-users

Level of HACI		Type of farming system																				
		Food crop farming			Livestock farming			Cash crop farming			Food crops/livestock/cash crop farming			food crop/livestock farming			Food /Cash crop farming			Cash crop/livestock farming		
		No of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI	No. of HH	% of HH	Averg. HACI
Users	Low	1	4.3	0.2173	0	0.0	0.0000	0	0	0.0000	3	5.5	0.2704	1	3.1	0.2079	1	14.3	0.3028	0	0	0.0000
	Moderate	21	91.3	0.4844	1	100.0	0.4217	1	100	0.5949	48	87.3	0.5016	31	96.9	0.5033	6	85.7	0.4108	6	100	0.4791
	High	1	4.4	0.6731	0	0.0	0.0000	0	0	0.0000	4	7.2	0.7194	0	0.0	0.0000	0	0.0	0.0000	0	0	0.0000
	Total	24	100.	0.4583	1	100	0.4217	1	100	0.5949	55	100	0.4971	32	100.0	0.5949	7	100	0.3556	6	100	0.4791
Non-users	Low	51	92.7	0.1726	2	100.0	0.1554	4	100	0.1494	16	84.2	0.1786	31	88.6	0.2052	10	100	0.1773	0	0	0.0000
	Moderate	4	7.3	0.3115	0	0.0	0.0000	0	0	0.0000	3	15.8	0.3760	4	11.4	0.3872	0	0.0	0.0000	0	0	0.0000
	High	0	0.0	0.0000	0	0.0	0.0000	0	0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0.0	0.0000	0	0	0.0000
	Total	55	100	0.0947	2	100	0.0777	4	100	0.0747	16	100	0.1849	41	100	0.1975	10	100	0.1773	0	0	0.0000

Source: Field survey 2017/2018

7.3 Benefits of mobile phone based services on household

Table 45 shows the benefits derived by the users in using the mobile phone based services. The mobile phone based services have facilitated 110 users (88%) to receive timely information regarding the planting and harvesting seasons, 94 users (75.2%) to acquire market information, 68 users (54.4%) get advance warning of weather risk and 40 users (32%) get information on livestock stocking and feeding strategies. Furthermore, mobile phone based services have facilitated 84.8% of the users to diversify sources of income,94 users (75.2%) to reduce the cost of doing things and 90 users (72%) to access technical and financial services which basically contribute to the finances of the households. Other benefits accrued by users are that mobile phone based services have helped to reduce travel hours from one place to get the services for 90 users (72%) of the users as indicated in Table 45. Also, the mobile phone has facilitated the expansion of social networks that facilitate exchange and access to resources and a tool to empower the rural population based on the benefits that the users accrued from the services.

Table 45 Benefits of mobile phone based services on households

Benefit	No. of users HH with the benefit	No. of users HH with no benefit	Total user HH	% of users HH with the benefit	% of users HH with no benefit	Total %
Timing of planting and harvesting seasons	110	15	125	88.0	12.0	100
Diversifying sources of income	106	19	125	84.8	15.2	100
Timely acquisition on price, market and farming practice information	94	31	125	75.2	24.8	100
Reduced cost of doing things	94	31	125	75.2	24.8	100
Facilitates access to technical and financial services	90	35	125	72.0	28.0	100
Reduced travel hours	90	35	125	72.0	28.0	100
Protecting lives and property from extreme events	90	35	125	72.0	28.0	100
Increased social networks	83	42	125	66.4	33.6	100
Easy connect with other farmers for more effective collective action	80	45	125	64.0	36.0	100
Major capital investments (purchase farm inputs/equipment's)	70	55	125	56.0	44.0	100
Get advance warning of weather risks	68	57	125	54.4	45.6	100
Easier to link my products to distant markets and higher agricultural value chains	58	67	125	46.4	53.6	100
Livestock stocking and feeding strategies	40	85	125	32.0	68.0	100

Source: Muasa et al., 2019

7.4 **Impact of mobile phone based service intervention on household resource accessibility and adaptive capacity development**

To further understand the impact of mobile phone based services on resources accessibility and household adaptive capacity development, a social experiment is conducted in which information and training on how to use the available mobile phone based services are conducted. This experiment targets the surveyed 125 non-users in this study. The training and information provided focused on the 3 resources, which are financial, information and diversity of livelihood, that need to be developed. The intervention was a 2hour 30-minute session in which information and training on the importance of mobile phone based services, how to use the mobile phone based services and who is conducted for financial and information resources through the mobile phone based services. For financial resources, the participants were trained on how to use mobile money banking services to facilitate access to credit, remittances, and savings.

The mobile phone based services provided included; send and receive money by Mpesa and Airtel and for credit access and savings services by Mshwari. The session was conducted in collaboration with experts from the climate change technical team of Makueni County government, Safaricom and Airtel experts which are Mobile phone network providers and Kenya Meteorological Department in Makueni county (KMD Makueni County). The experts from Safaricom and Airtel trained the participants on financial services for mobile money banking and helped the participants register for the services. The climate change technical team of Makueni county and KMD provided the participants with information on the kind of information provided through the mobile phone and also the service provided to conduct for the services.

Out of the 125 non-users, 83 people participated who are called as "Treated group" and 42 people did not participate who are called the "Untreated group." A baseline survey is conducted before the experiment and then a follow-up survey for both treated and untreated groups was conducted 6 months after the intervention. During the baseline survey, the non-users were purposively briefed about the experiment and were encouraged to participate in the experiment. This experiment targeted the 125 non-users selected through stratified random sampling during the baseline survey but only 83 non-users participated and 42 did not participate. Therefore, all the 125 non-users were granted an equal chance to participate in the experiment. Due to other factors, this criterion can contribute to biasness on the participants in the social experiment and therefore statistically matching the treated and untreated groups facilitates understanding the differences prior to estimation of the impact of the intervention. The baseline and follow-up surveys are used to estimate the impact of the intervention. Table 46 shows the socio-characteristics of the Treated and Untreated group.

Table 46 Socio-characteristics of the Treated and Untreated groups

Characteristic		Treated group (n=83)		Untreated group (n=42)	
		No. of participants	%	No. of non-participants	%
Gender	Female headed	22	26.5	15	35.7
	Male headed	61	73.5	27	64.3
Total		83	100	42	100
Education level	Above primary school	62	74.1	30	72.2
	Below primary school	21	25.9	12	27.8
Total		83	100	42	100
Farming system	Food crop farming	42	50.6	13	31.0
	Livestock farming	4	5.3	0	0.0
	Cash crop farming	6	7.2	0	0.0
	Food crops/livestock/cash crop farming	7	8.0	10	23.8
	Food crop/livestock farming	16	19.3	19	45.2
	Food /Cash crop farming	8	9.6	0	0.0
	Cash crop/livestock farming	0	0.0	0	0.0
Total		83	100	42	100
Average Age		45 years		45 years	
Average Monthly Income		Kshs. 3262.65 (3.2$)		Kshs. 4201.35 (4.2$)	
Household size		6		6	

Source: Field survey 2017/2018

The treated group comprised of 22 participants (26.5%) from female-headed households and 61 participants (73.5%) from the male-headed households while in the untreated group were 15 non-participants (35.7%) and 27 non-participants (64.3%) in the female-headed household and male-headed household respectively as shown in Table 46. Estimated 62 participants (74.1%) in the treated group have education above primary school and 30 non-participants (72.2%) from the untreated group. For the type of farming system, 52 participants (41.6%) in the treated group engage in single farming in which 42 (50.6%), 4 (5.3%) and 6 (7.2%) participants practice food crop farming, livestock farming, and cash crop farming respectively.

Table 46 shows that the mixed farming system had 48 participants (58.4%) in the treated group. On the other hand, 13 non-participants (31%) have a single farming system on food crop farming and 29 non-participants (56%) engage in mixed farming. The average age and household size for both participants and non-participants are 45 years and 6 members respectively. The average monthly income of the participants is 3.2 dollars and that of non-participants 4.2 dollars. Therefore, this implies that there are similarities in the social characteristics of the Treated and Untreated group.

Table 47 shows the average HACI and resource scores for the Treated and Untreated group. Comparing the baseline and follow-up survey for the Treated group it is portrayed that the HACI increased from 0.1916 to 0.3494 after the intervention and that of the Untreated group at baseline and follow up survey is at 0.2298 and 0.2411 respectively. The financial, information and diversity of livelihood of the Treated group increased from 0.0347, 0.0249 and 0.0233 in baseline survey to 0.1334, 0.0590 and 0.0580 in follow up survey respectively. On the other hand, the financial, information and diversity of the livelihood of the Untreated group remained almost the same by comparing the baseline and follow up surveys as indicated in Table 47.

In the Treated group financial resource sub-indicators, Remittances and Access to credit improved from 0.0110 to 0.0248 and 0.0151 to 0.1006 respectively after intervention as proven by the baseline and follow up surveys in Table 47. The remittances of the Untreated group in baseline and follow-up surveys were 0.0170 and 0.0179 while in access to credit was 0.0163 and 0.0356 respectively as shown in Table 47. In the Information sub-indicators, the Access to extension services and Number of sources of information improved in the Treated group from 0.0029 to 0.0162 and 0.0207 to 0.0407 after the intervention as shown by the baseline and follow-up surveys in Table 47. From Table 47, the Number of livelihoods a Diversity of livelihood sub-indicator improved from 0.0123 to 0.0356 in the Treated group after intervention.

Generally, access to credit, remittances, access to extension services, number of sources of information and number of livelihoods improved in the Treated group after the intervention thus contributing to an increase in Financial, Information, and Diversity of livelihood scores and HACI. This result clearly proves that providing information and training on mobile phone based services to the non-users increases accessibility to financial resources, information resources and diversity of livelihood as well as the household adaptive capacity development as depicted by the changes of the baseline and follow up surveys. The financial, information and diversity of livelihood, registered an increase after the intervention on the treated group as indicated by comparing the baseline and follow up survey

Table 47 Result of Average HACI, resources, and sub-indicators in baseline and follow up survey of Treated and Untreated groups.

Resource	Sub-indicator	Treated (n=83)		Untreated group (n=42)	
		Baseline	Follow up	Baseline	Follow up
Financial resource	Remittances received	0.0110	0.0248	0.0170	0.0179
	Total animal value	0.0063	0.0063	0.0069	0.0119
	Access to credit	0.0151	0.1006	0.0163	0.0356
	Receives government support	0.0023	0.0023	0.0023	0.0023
	Total	0.0347	0.1334	0.0519	0.0728
Information resource	Training on farming	0.0002	0.0008	0.0004	0.0004
	Access to extension services	0.0029	0.0162	0.0057	0.0057
	Participation in farmers organization	0.0013	0.0013	0.0011	0.0011
	Number of sources of information	0.0207	0.0407	0.0171	0.0170
	Total	0.0251	0.0590	0.0243	0.0242
Diversity of livelihood	number of livelihoods	0.0123	0.0356	0.0196	0.0196
	Size of the land	0.0040	0.0044	0.0040	0.0040
	Total % of land under cultivation	0.0134	0.0160	0.0102	0.0135
	Total	0.0233	0.0560	0.0338	0.0371
HACI		0.1916	0.3494	0.2298	0.2411

Source: Field survey 2017/2018

Furthermore, out of the 83 treated group, 22 households (26.5%) are female-headed and 61 households (73.5%) are male-headed. Comparing the baseline and follow up surveys as in Table 48, the average HACI of the treated female-headed households increased from 0.1908 to 0.3670 and that of male-headed households also increased from 0.1939 to 0.3431. Also, the financial resource, information resource, and diversity of livelihood increased after the intervention for both female-headed households and male-headed households as depicted in Table 50. The financial, information and diversity of the livelihood increased from 0.0293 to 0.1510, 0.0233 to 0.0587 and 0.0241 to 0.0498 respectively for the treated female-headed households after the intervention. The financial, information and diversity of livelihood for the treated male-headed households also increased from 0.0331 to 0.1271, 0.0255 to 0.0468 and 0.0230 to 0.0583 respectively after the intervention indicated in Table 48.

In the financial resource, access to credit and remittance sub-indicators improved from 0.0062 to 0.1245 and 0.0145 to 0.0177 for female-headed respectively and 0.0096 to 0.0129 and 0.0160 to 0.1055 for male-headed households respectively. In the information resource as shown in Table 48, access to extension services and the number of sources of information improved after the intervention in female-headed households from 0.0064 to 0.0392 and 0.0163 to 0.0194 while that of male-headed households from 0.0040 to 0.0236 and 0.0210 to 0.0225 respectively. Number of livelihood activities and total crops under cultivation improved from 0.0077 to 0.0289 and 0.0129 to 0.0160 in the female-headed households while in male-headed households improved from 0.0097 to 0.0379 and 0.0106 to 0.0158 respectively in the Diversity of livelihood as shown in Table 48.

This result implies that providing information and training on mobile phone based services increases the financial resource, information resource, diversity of livelihood and the household adaptive capacity as depicted by the changes in the baseline and follow up survey after the intervention. In addition, the intervention contributed to an increase in access to credit and remittances for financial resource, access to extension services and the number of sources of information for information resource and the number of livelihood activities and total land under crop cultivation for the diversity of livelihood.

Table 48 Comparison of the treated group based on the gender of the household head

Resource	Sub-indicator	Treated group			
		Female-headed (n=22)		Male-headed(n=61)	
		Baseline	Follow up	Baseline	Follow up
Financial resource	Remittances received	0.0145	0.0177	0.0096	0.0129
	Total animal value	0.0044	0.0043	0.0070	0.0070
	Access to credit	0.0062	0.1245	0.0160	0.1055
	Receives government support	0.0044	0.0043	0.0015	0.0015
	Total	0.0293	0.1510	0.0331	0.1271
Information resource	Training on farming	0.0003	0.0003	0.0003	0.0003
	Access to extension services	0.0064	0.0392	0.0040	0.0236
	Participation in farmers organization	0.0003	0.0003	0.0002	0.0003
	Number of sources of information	0.0163	0.0194	0.0210	0.0225
	Total	0.0233	0.0587	0.0255	0.0468
Diversity of livelihood	Number of livelihoods activities	0.0077	0.0298	0.0097	0.0379
	Size of the land	0.0034	0.0034	0.0047	0.0047
	Total % of land under cultivation	0.0129	0.0166	0.0106	0.0158
	Total	0.0241	0.0498	0.0230	0.0583
HACI		0.1908	0.3670	0.2094	0.3431

Source: Field survey 2017/2018

Furthermore, the treated group was categorized based on the type of farming systems and through comparing the baseline survey and follow up survey the provision of the information and training on mobile phone based services on financial, information, diversity of livelihood and average HACI. As indicated in Table 49, the HACI, financial resource, information resource and diversity of livelihood for the food crop farming increased from 0.1888, 0.0320, 0.0246 and 0.0236 to 0.3487, 0.1331, 0.0602 and 0.0559 respectively. The HACI, financial resource, information resource and diversity of livelihood for the households practicing mixed crop farming also increased after the intervention as proven by comparing baseline and follow up survey as indicated in Table 49.

The HACI for the food crop/livestock/cash crop farming, food crop/livestock farming and food crop/cash crop farming increased from 0.1914, 0.2014 and 0.1691 to 0.3347, 0.3764 and 0.3372 respectively as depicted in Table 49. Also, the financial resource increased from 0.0341, 0.0400 and 0.0262 to 0.1217, 0.1508 and 0.1228 for the food crop/livestock/cash crop farming, food crop/livestock farming and food crop/cash crop farming respectively as depicted in Table 49. The information resource also increased from 0.0211, 0.0244 and 0.0203 to 0.0418, 0.0602 and 0.0498 for the food crop/livestock/cash crop farming, food crop/livestock farming and food crop/cash crop farming respectively as depicted in Table 48. Also, the diversity of livelihood increased from 0.0161, 0.0280 and 0.0161 to 0.0612, 0.0612 and 0.0616 for the food crop/livestock/cash crop farming, food crop/livestock farming and food crop/cash crop farming respectively as depicted in Table 49.

The Financial resource sub-indicators, Remittances received and Access to credit improved after the intervention all the types of single farming systems as follows; 0.0102 to 0.0176 and 0.0102 to 0.1039 in Food crop farming, 0.0088 to 0.0683 and 0.0170 to 0.0983 in livestock farming and 0.0018 to 0.0109 and 0.0260 to 0.1070 in cash crop farming respectively. Also, improvement in Access to credit and Remittances received was evident in mixed farming systems as follows; 0.0100 to 0.0141 and 0.0163 to 0.0999 in Food crops/livestock/cash crop farming, 0.0074 to 0.0538 and 0.0269 to 0.0913 in food crop/livestock farming and 0.0050 to 0.0160 and 0.0171 to 0.1027 in food/cash crop farming respectively as shown in Table 49.

In Information resource sub-indicators, Access to extension services and Number of sources of information improved after the intervention in single farming system in treated group as follows; 0.0056 to 0.0296 and 0.0179 to 0.0295 for food crop farming, 0.0086 to 0.0144 and 0.0158 to 0.0458 for livestock farming and 0.0074 to 0.0124 and 0.0158 to 0.0358 in cash crop farming respectively as indicated in Table 51. In the mixed farming system, the Access to extension services and Number of information of sources of information improved as follows; 0.0019 to 0.0126 and 0.0192 to 0.0292 in Food crops/livestock/cash crop farming, 0.0053 to 0.0240 and 0.0191 to 0.362 in food crop/livestock farming and 0.0045 to 0.0360 and 0.0158 to 0.0178 in Food /Cash crop farming respectively as portrayed in Table 49.

The number of livelihoods sub-indicator in the Diversity of livelihoods improved after the intervention as evidenced by the differences in the baseline and follow up survey scores from Table 49. In the single type of farming the number of livelihood activities scores improved as follows; 0.0138 to 0.0367 in food crop farming, 0.0113 to 0.0413 in livestock farming and 0.0050 to 0.0313 in cash crop farming. The Number of livelihood activities improved also in the mixed farming system participants as shown; 0.0133 to 0.0260 in Food crops/livestock/cash crop farming, 0.0124 to 0.0271 in food crop/livestock farming and 0.0109 to 0.0341 in food/cash crop farming. This is a result of the training and the information the participants received during the experiment on how to use the mobile phone based services to diversify livelihood as shown in Table 49.

This result implies that provision of the information and training on mobile phone based services on financial, information and diversity of livelihood increase accessibility to the financial resource, information resource, diversity of the livelihood and the average HACI in both single and mixed crop farming. Generally, the results from the intervention prove that providing information and training on mobile phone based services to non-users (intervention) increases access to financial, information and diversity of livelihood and average HACI. Also, an increase in financial, information, diversity of livelihood accessibility and average HACI of the treated female-headed households and single farming system households is depicted. In addition, the intervention contributed to the improvement of access to credit and remittances received in financial resource, Access to extension services and the number of sources of information in Information resource and the number of livelihood activities in Diversity of livelihood. As a result, the financial resource, information resource and diversity of livelihood enhanced contributing to development in household adaptive capacity.

Table 49 Comparisons of type of farming system in the Treated group

Resource	Sub-indicator	Type of farming system											
		Food crop farming		Livestock farming		Cash crop farming		Food crops/livestock/cash crop farming		food crop/livestock farming		Food /Cash crop farming	
		Baseline	Follow up	Baseline	Follow up	Baseline	Follow up	Baseline	Follow up	Baseline	Follow up	Baseline	Follow up
Financial resource	Remittances received	0.0102	0.0176	0.0088	0.0683	0.0018	0.0109	0.0100	0.0141	0.0074	0.0538	0.0050	0.0160
	Total animal value	0.0074	0.0074	0.0137	0.0137	0.0068	0.0068	0.0078	0.0077	0.0037	0.0037	0.0041	0.0041
	Access to credit	0.0102	0.1039	0.0170	0.0983	0.0260	0.1070	0.0163	0.0999	0.0269	0.0913	0.0171	0.1027
	Receives government support	0.0042	0.0042	0.0005	0.0005	0.0002	0.0000	0.0000	0.0000	0.0020	0.0020	0.0000	0.0000
	Total	0.0320	0.1331	0.0400	0.1508	0.0345	0.1247	0.0341	0.1217	0.0400	0.1508	0.0262	0.1228
Information resource	Training on farming	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Access to extension services	0.0056	0.0296	0.0086	0.0144	0.0074	0.0124	0.0019	0.0126	0.0053	0.0240	0.0045	0.0360
	Participation in farmers organization	0.0006	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Number of sources of information	0.0179	0.0295	0.0158	0.0458	0.0158	0.0358	0.0192	0.0292	0.0191	0.0362	0.0158	0.0178
	Total	0.0246	0.0602	0.0244	0.0602	0.0232	0.0482	0.0211	0.0418	0.0244	0.0602	0.0203	0.0498
Diversity of livelihood	Number of livelihoods	0.0138	0.0367	0.0113	0.0413	0.0050	0.0313	0.0133	0.0260	0.0124	0.0271	0.0109	0.0341
	Size of the land	0.0044	0.0044	0.0054	0.0054	0.0082	0.0082	0.0052	0.0052	0.0033	0.0033	0.0026	0.0026
	Total % of land under cultivation	0.0054	0.0148	0.0113	0.0144	0.0020	0.0248	0.0024	0.0300	0.0123	0.0308	0.0026	0.0249
	Total	0.0236	0.0559	0.0280	0.0611	0.0159	0.0643	0.0161	0.0612	0.0280	0.0612	0.0161	0.0616
HACI		0.1888	0.3487	0.2074	0.3764	0.1791	0.3412	0.1914	0.3347	0.2014	0.3764	0.1691	0.3372

Source: Field Survey 2017/2018

7.4.1   A combination of PSM and DID estimation to evaluate the impact of the intervention

Furthermore, an estimation to evaluate the impact of the intervention on both treated and untreated groups is conducted applying a combination of Difference-in-Difference and Propensity Score Matching methods (DID-PSM). Using both PSM and DID helps to reduce biases during the evaluation period (Ravallion et al., 2005). The existence of a baseline and follow-up survey made these methods suitable to evaluate the impact of the provision of information and training on mobile phone based services to access resources on household adaptive capacity in this research. First and foremost, the DD is conducted using the baseline and follow-up data for HACI and resources of treated and untreated groups. Then, the PSM is applied to match the treated and untreated households.

Equation 6 shows the model used to compute the DID estimator. From equation 6, $HACI_b$ is the score for the HACI of the treated group obtained from the baseline survey, $HACI_{Ft}$ the score of HACI obtained from the follow-up survey, $HACI_{bN}$ is the HACI score for the untreated group in the baseline survey and the $HACI_{fN}$ is the computed HACI score for the untreated group. The difference between the baseline and follow up survey to compare the treated and untreated groups are computed as follows; the difference in HACI between the baseline and follow-up survey for the treated group. ($HACI_{bT}$-$HACI_{fT}$), then the difference in HACI between the baseline and follow-up survey for the untreated group ($HACI_{bN}$ - $HACI_{fN}$) and then the difference between the difference in outcome for the treated and untreated group is conducted using the equation 6.

$$DID = (HACI_{bT}\text{-}HACI_{fT})\text{- }(HACI_{bN}\text{ - }HACI_{fN}) \dots\dots\dots\dots\dots \quad (6)$$

Whereby;

- DID = Difference in difference estimator
- $HACI_{bT}$ = Baseline HACI score for the treated group
- $HACI_{Ft}$ = Follow up HACI score for the treated group
- $HACI_{bN}$ = Baseline HACI score for the untreated group
- $HACI_{fN}$ = Follow up HACI score for the untreated group

Propensity Score Matching (PSM) is then conducted to estimate the effect of the intervention. Propensity Score Matching refers to the pairing of treated and untreated groups with similar values on propensity scores and other covariates (Rubin, 2001). In the PSM the propensity scores are estimated that signifies the probability of being assigned the treatment given a vector of observed covariates (Rosenbaum and Rubin, 1983). According to past studies, there is no consensus as to which covariates to include in the PSM model (Austin, 2007; Austin, 2011). Furthermore, the past studies depict that the possible set of covariates for inclusion in the PSM model includes the measured baseline covariates associated with the treatment assignment and that affect the outcome variable (Austin, 2007; Austin, 2011).

The first step of the Propensity Score Matching technique was to estimate the probability that a household will participate in the social experiment based on the selected covariates (explanatory variables). In this study, the following covariates are selected to predict the treatment; the age of household head, the gender of household head, household size, the occupation of the household head, marital status, and mobile phone ownership. According to Heckman (1997) and Thavaneswaran et al., (2008), the PSM model commonly employ logistic regression or probit regression to estimate the propensity scores. In this study, the PSM model used probit regression to estimate the propensity scores. In the PSM model, the dependent variable is binary, whereby 1 is the value for the treated group and the value for the untreated group is 0. The sample size for the treated group is 83 households while that of the untreated group is 42 households. Equation 7 shows the Probit model used the estimation of propensity score

$$Y^* = \alpha + \sum X\beta + \varepsilon, \ldots\ldots\ldots\ldots (7)$$

Whereby;

Y^* = binary variable describing treatment status where: the treated group is 1, the untreated group is 0

$\alpha, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Parameters

X = Household socio-demographic characteristics (age, gender, size of household, occupation and marital status, own mobile phone)

ε = Error term

From equation 7, y^* is a binary dependent variable whereby 1 is for the treated group while 0 is for the untreated group. X is the list of household characteristics (covariates) used to predict the treatment. These covariates include; the age of household head, the gender of household, the size of household, occupation of the household head, marital status of the household head and mobile phone ownership.

Table 50 shows the propensity score estimation for access to the provision of information and training on mobile phone based services with a log-likelihood of -54.7158 and a p-value of 0.0000. This indicates that the PSM model is statistically significant. The estimation results show that the age, gender, occupation of the household head and the ownership of mobile phone is statistically significant to participation in the social experiment and HACI of the household.

Table 50 Estimation of the propensity scores based on observed characteristics

Variables	Treatment (treated=1, untreated=0)
Constant	0.662 (0.822)
Age	0.027** (0.012)
Gender (1=female)	-1.268*** (0.508)
Size of household	0.016 (0.049)
Occupation (1=Farmer)	0.470* (0.310)
Marital Status	0.480 (0.204)
Ownmobilephone (1=own, 0=no mobile phone)	1.796** (0.329)
Total Observation Pseudo R2 Log-likelihood	125 0.291 -54.540

Note; 1) Probit regression; the dependent variable is 1 if the household participated in the social experiment (treated), and 0 otherwise. 2)Standard error in Parentheses, ***$P<0.01$, **$P<0.05$, *$P<0.1$ representing 1%, 5% and 10% level of significance. The treatment is the provision of information and training on mobile phone based services.

Source: Field survey 2017/2018

As shown in Table 50, the likelihood that a household participates in the social experiment on provision of information and training on mobile phone based services is more if the household head is older, the main occupation is farming and own a mobile phone as proven by the positive coefficients of 0.027, 0.470 and 1.796 respectively. By contrast, the likelihood that a female-headed household participates in the social experiment the participation on the social experiment is smaller as proven by the negative coefficient of 1.268.

A region of common support was then defined in order to understand where the distribution of the treated and untreated groups overlap as shown in Table 51. The area of common support is those propensity scores within the range of the lowest and highest estimated values for the households in the treatment group.

Table 51 Description of the estimated propensity score in the region of common support

	Percentiles	Smallest
1%	0.0723	0.0713
5%	0.1424	0.0722
10%	0.2026	0.0969
25%	0.5018	0.0996
50%	0.7342	
		Largest
75%	0.8911	0.9889
90%	0.9614	0.9892
95%	0.9870	0.9925
99%	0.9942	0.9947

Note: the total number of blocks=5, total observations= 125, mean=0.6674, Std. Dev. = 0.2372

Source: Field survey 2017/2018

In Table 51, the output indicates that the identified region of common support is (0.0713, 0.9947). This implies that the propensity scores that lie below the lowest value which is 0.0713 and above the highest value which is 0.9947 were discarded from the analysis. This minimum-maximum approach of choosing the common support is suitable when the method to estimate the effects is ATT. Once the propensity scores were estimated, the next step was to subclassify them into different strata called blocks and they should be balanced on propensity scores. According to Rosebaum & Rubin (1983), 5 blocks are a good start point to stratify the propensity scores. The number of blocks ensures that the mean propensity score is not different for the treated and controls in each block. In this research, the final number of balanced blocks were 5. This implies that the propensity scores on each stratum are balanced and all the covariates in each stratum achieved equivalence in distribution.

The test of balancing priority of the propensity scores is satisfied and the common support was selected as indicated in Table 52. The total sample of 125 comprising of 83 Treated and 42 Untreated was stratified into 5 balanced blocks after calculating the propensity scores. The first block comprised of propensity scores smaller than 0.2 but larger than 0.05 and 8 Untreated and 1 Treated were classified in this block as shown in Table 54. In the second block the propensity scores smaller than 0.40 and larger than 0.20 were classified, the result in Table 52 shows that 10 Untreated and 2 Treated were categorized in this block. Block 3 included 12 Untreated and 6 Treated, block 4 included 9 Untreated and 23 treated while block 5 included 3 Untreated and 49 Treated.

Table 52 Inferior Bound, the number of treated and the number of untreated for each block

Inferior of the block of P score	Access to information on mobile phone based services		Total
	0	1	
0.07	8	3	11
0.20	10	2	12
0.40	12	6	18
0.60	9	23	32
0.80	3	49	52
Total	42	83	125

Note: the common support option has been selected

Source: Field survey 2017/2018

Once the generation of propensity scores and the balancing propriety was satisfied, the treated and untreated households were matched on the estimated propensity scores. The Difference in Difference estimator which is the change of HACI obtained from before and after the intervention as shown in equation 6 was used as the outcome variable to evaluate the effect of the intervention. The effect of the provision of information and training on mobile phone based services on outcome variable was evaluated using the three commonly adopted matching techniques including; nearest neighbor matching method, radius matching method and Kernel matching method to match the each treated to one or more untreated households on the propensity score. Furthermore, once the treated and untreated are matched then the difference is computed between the matched treated and untreated households (Becker et al., 2002).

The estimated treated effect of the provision of information and training on mobile phone based services program is defined using the Average Treatment on Treated (ATT) as illustrated in Table 53. The hypothesis that the provision of information and training on mobile phone based services contributes to an increase in household adaptive capacity is supported as proven by the positive ATT estimations for the nearest neighbor matching being 0.155, radius matching as 0.158 and that of Kernel matching methods as 0.145 from Table 53. The HACI of the treated group increases when provided with the information and training on mobile phone based services on financial, information and diversity of livelihood. This implies that the non-user HACI increased after the intervention due to an increase in accessibility to financial resources, information and diversify livelihood using mobile phone based services.

Table 53 Average Treatment on Treated (ATT) estimation given the propensity score

Matching Method	No. of treated	No. of Control	ATT	Std. Err.	t-statistic
Nearest Neighbor Matching Method	83	29	0.155	0.022	6.516
Radius Matching Method	75	42	0.158	0.015	8.297
Kernel Matching Method	83	42	0.15	-	-

Note: the (-) indicate that the standard error and t are not computed implying that there is exactly one treated and one control in one or more blocks

Source: Field survey 2017/2018

7.5 Summary

The objective of this chapter was to evaluate the impact of mobile phone based services on household adaptive capacity and three key issues are highlighted. First, the categorization of the HACI for the users and non-users in the low, moderate and high HACI levels was conducted. The result depicts that most of the users are categorized in moderate and high HACI levels while most of the non-users are categorized in low HACI level. Furthermore, the chapter proves that the user's HACIs are higher in low, moderate and high HACI levels compared to the non-users. Therefore, a clear difference was noted between the users and non-users' adaptive capacity with the users registering a higher adaptive capacity compared to the non-users. Also, the categorization of the users and non-users HACIs were compared based on the gender of the household head and the type of farming system. The result depicts that the HACIs for the male-headed households is higher compared to that of female-headed households in both users and non-users. The HACIs of the households practicing single farming system were lower compared to households practicing the mixed type of farming in both users and non-users. This proves that there is a need to consider female-headed households and a single type of farming system in adaptive capacity development.

Secondly, the study evaluates the impact of the social experiment on HACI and resource accessibility conducted on the non-users whereby information and training on mobile phone based services on financial, information and diversity of livelihood were provided. Baseline and follow up survey is used to evaluate the impact by comparing the treated and untreated groups. The result proves that providing information and training on mobile phone based services to non-users increase accessibility to financial resource, information resource, and diversity of livelihood as well as the household adaptive capacity level.

Thirdly, the impact of the social experiment on HACI based on the treated gender of household head and the type of farming system was conducted. The result proves that the provision of information and training on mobile phone based services contributed to an increase in financial resources, information resources, and diversity of livelihood. As a result, an increase in the households' adaptive capacity of both males-headed and female-head households was also depicted. Furthermore, an increase in financial, information, and diversity of livelihood for the households practicing a single type farming system was also noted. Also, this result proves that this social experiment can be applied to the non-users to ensure their adaptive capacity development.

This chapter, therefore, suggests that for the purpose of household adaptive capacity development, providing information and training on mobile phone based services to the non-users contribute to an increase in the financial resource, information resource, and diversity of livelihood as well as increased household adaptive capacity. Furthermore, it will facilitate an increase in resource accessibility and adaptive capacity development for the female-headed household and households practicing a single farming system.

CHAPTER 8

ROLE OF SOCIAL NETWORKS ON HOUSEHOLD ADAPTIVE CAPACITY DEVELOPMENT

8.1   Introduction

According to Schramsk et al (2016), social networks play a role in ensuring the adaptive capacity of the household through increasing accessibility and exchange of resources. Although the household networks have been indicated to increase the accessibility to the resources that facilitate adaptive capacity development, there are limited studies on how the ICTs influence these networks (Ingold et al., 2010; Luthe et al. 2012, Rotberg 2013; Ingold 2015). Also, there are no studies that qualitatively or qualitatively visualize how the mobile phone one of the ICT and the focus of this study influences social networks facilitating resource accessibility and generally contributing to adaptive capacity development.

This chapter address objective 4 of this study which is to examine the influence of mobile phone based services on household networks to access and exchange resources that facilitate adaptive capacity development. To achieve these objectives a network visualization of the users and non-users is developed for the information and financial resources.

The developed network visualizations for the financial and information resources help to understand the individuals that the users and non-users connect with to access financial and information resources. The data obtained from household surveys for users and non-users is used in this chapter to create a visualization map for the access and exchange of financial and information resources between households and service providers.

8.2   Social Network Analysis (SNA) method

Social Network Analysis (SNA) method is applied to visualize the user and non-user household's networks. SNA encompasses theories, methods that are used to measure human relations (Kadushin, 2012). According to Scott (2012) network is formed by the ties between the actors in a given system. In this study, the household survey was conducted in Makueni county to collect data on Social networks across the households, around 25 key expert interviews from Makueni county were also interviewed in order to identify how the households and the service providers are able to exchange the financial and information resource of the household. The households were asked to identify up to 10 actors whom they connect with to access financial and information resources. The collected data from the household survey was then converted into a symmetric adjacency matrix. A visualization map is created to show access and exchanges of resources across the identified actors.
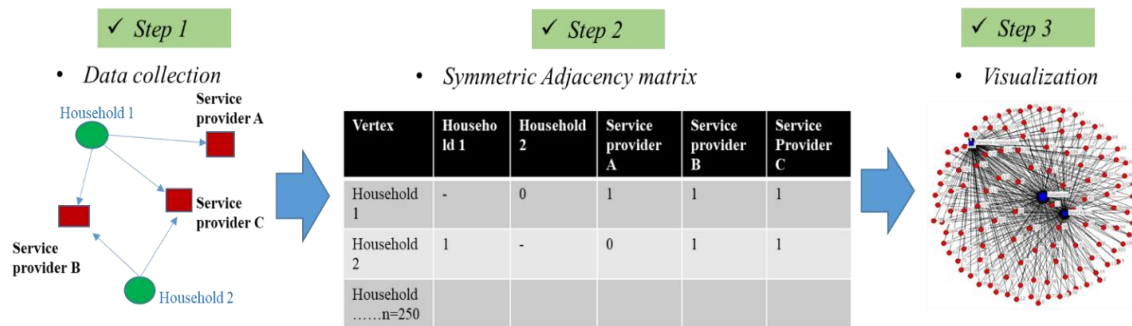
Figure 16 Steps to create a visualization map

Source: Field survey 2017/2018

Visualization diagrams for both user and non-users are created to facilitate comparison and depict the influence of mobile phone based services in increasing resource accessibility and thus facilitating adaptive capacity development. The steps to create the visualization diagram is indicated in Figure 16. SNA helps to understand the relationship between various types of actors by visualizing and investigating their interactions in a given network (Bodin et al. 2006, McCulloh and Carley 2011, Scott 2012, Rad et al. 2015). Furthermore, to hypothesize the impact of mobile phone based service facilitated networks on household adaptive capacity the Ordinary Least Square (OLS) was conducted to evaluate the significance of the number of links

8.3 Result of network visualization to access Financial resource and Information resource access for users and non-users

Through the household surveys, the households were asked to indicate at least ten individuals whom they contact to access the financial and information resource. The individuals contacted include service providers and other households who aid the household to access the financial and information services. The users indicated the service providers connected through the mobile phone and the non-users indicated the service providers conducted through face to face. Also, the users and non-users indicated the financial services received and the kind of information received. The responses obtained from the households are then converted to a symmetric adjacency matrix to facilitate network visualization of the user and non-user access to information and financial resources. The purpose of creating the networks was to visualize the service providers the users and non-users connect with to obtain Financial and information resources. Furthermore, the number of connections for the users and non-users was estimated for each service provider and compared to the HACIs of the users and non-users. The user network was developed through the connections to services providers to receive the financial and information resources through the mobile phone based services.

8.3.1   Network visualization of users to access information resource through mobile phone based services

Table 54 shows the list of the service providers contacted by users through mobile phone based services to access The services providers provide agricultural, climate and market information to the users. From Table 54, 120 users (96%) contact Safaricom, 79 users (63.2%) contact veterinary officer, and 73 users (58.4%) contact peer farmers. Also, 43 users (34.4%) contact input providers, 36 users (28.8%) contact farmer's organization,36 users (28.8%) contact extension officer, 28 users (22.4%) contact Airtel Kilimo, 25 users (20%) contact KMD, 18 users (14.4%) contact KARI, 17 users (13.6%) contact KACE and 7 users (5.6%) contact FAO as indicated in Table 57. The result clearly indicates that the frequently contacted service providers are; Safaricom, veterinary officers, and peer farmers through mobile phone based services by the users to get information. The least contacted by the user through the mobile phone based services are the research agent institutions (KARI, KACE, and FAO). During the Field survey conducted in 2017/2018 in the households, 101 users (80.8%) indicated that they receive the information from the service providers through voice calling and 86 users (68.8%) through text messaging.

Table 55 shows descriptive statistics of the users with respect to each service provider contacted to receive information through mobile phone based services. The statistics summarize the symmetric adjacency matrix generated from household surveys to create the user's information network visualization illustrated in Figure 17.   From Table 55 the minimum value of 0 represents the response from the users if the user does access information from the contacted service provider through mobile phone based services while the maximum value of 1 represents the users' response if the user access information from the contacted service provider through mobile phone based services as shown in Table 55. Table 55 shows more details on the mean, standard deviation, variance, SSQ, MCSSQ and Euclidean norm statistics of the users in respect to each service providers

Table 54   Number of users contacting the service providers

Service Provider	No. of HH Contact	No of HH Do not contact	Total HH	% HH Contact	% of HH Do not contact	Total %
Safaricom	120	5	125	96.0	4.0	100
Veterinary officer	79	46	125	63.2	36.8	100
Peer Farmers	73	52	125	58.4	41.6	100
Input Providers	43	82	125	34.4	65.6	100
Farmers organization	36	89	125	28.8	71.2	100
Extension officer	36	89	125	28.8	71.2	100
Airtel Kilimo	28	97	125	22.4	77.6	100
KMD (Kenya Meteorological Department)	25	100	125	20.0	80.0	100
KARI (Kenya Agriculture Research Institute)	18	107	125	14.4	85.6	100
KACE (Kenya Agriculture Commodity Exchange)	17	108	125	13.6	86.4	100
FAO (Food and Agriculture Organization)	7	118	125	5.6	94.4	100

Source: Field survey 2017/2018

Table 55 Descriptive statistics of users and service providers to access the Information resource

	Detail	Veterinary officer	Peer Farmers	Farmers organization	Input providers	KMD	Extension officer	KARI	FAO	Safaricom	Airtel Kilimo	KACE
1	Observations	125	125	125	125	125	125	125	125	125	125	125
2	Minimum	0	0	0	0	0	0	0	0	0	0	0
3	Maximum	1	1	1	1	1	1	1	1	1	1	1
4	Mean	0.632	0.584	0.288	0.344	0.200	0.288	0.144	0.056	1	0.224	0.136
5	Standard Deviation	0.482	0.493	0.453	0.475	0.400	0.453	0.351	0.230	0	0.417	0.343
6	Sum	79	73	36	43	25	36	18	7	120	28	17
7	Variance	0.233	0.243	0.205	0.226	0.160	0.205	0.123	0.053	0	0.174	0.118
8	SSQ	79	73	36	43	25	36	18	7	125	28	17
9	MCSSQ	29.072	30.368	25.632	28.208	20	25.632	15.408	6.608	0	21.728	14.688
10	Euclidean norm	8.888	8.544	6	6.557	5	6	4.243	2.646	11.180	5.292	4.123

Note: the statistics describe the users characteristic with respect to each service provider contacted

Source: Field survey 2017/2018

Note: The more central and bigger the size of the box the more the service provider is contacted by the household. The centralities of this network diagram are indicated in Appendix D1
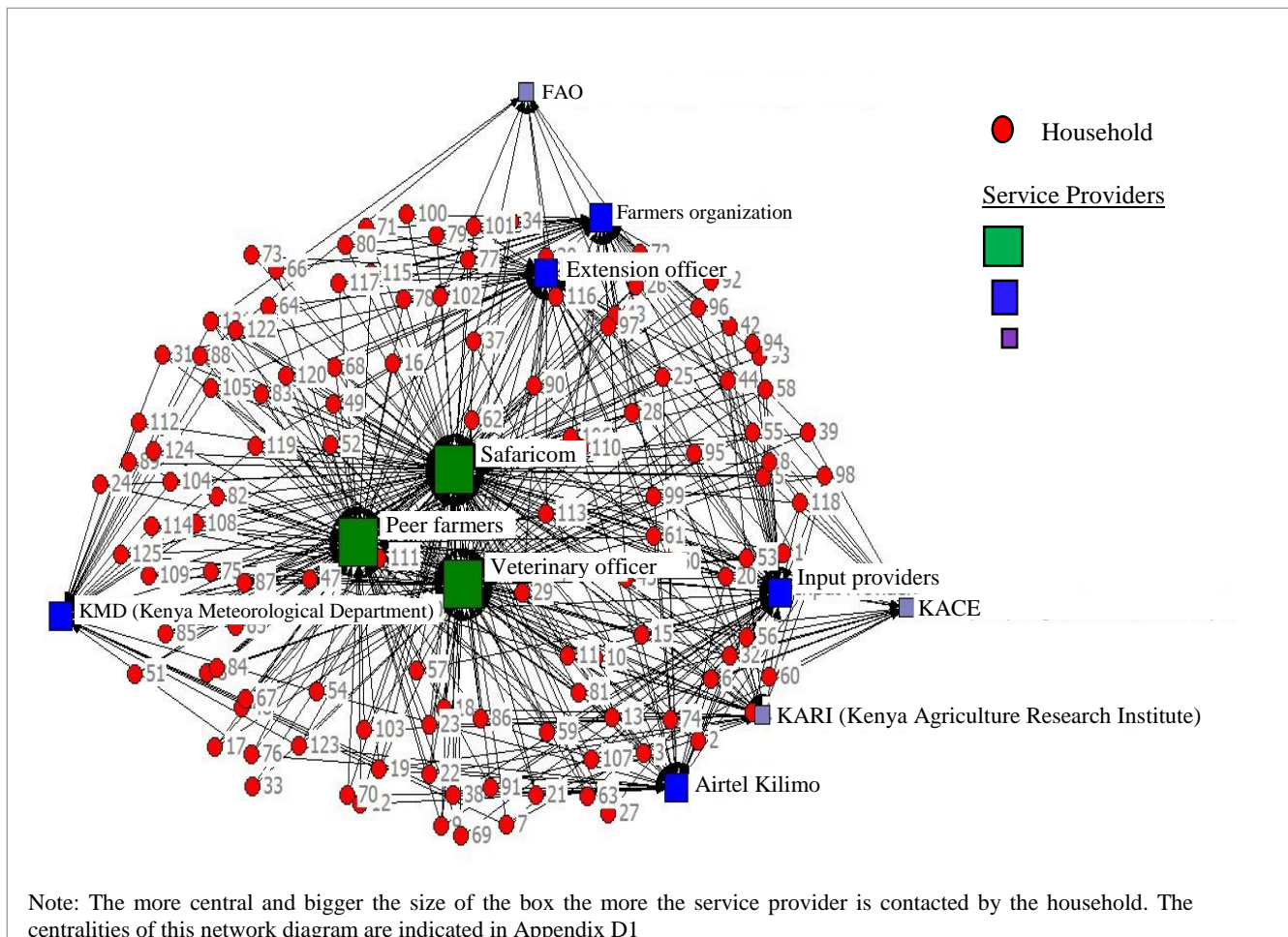
Figure 17 Network visualization for users to access information resource through mobile phone based services

Source: Field survey 2017/2018

The information access for the users through mobile phone based services is highly connected as shown in Figure 17. Safaricom, veterinary officers, and peer farmers [8] are the most connected service providers and most central in the network. This is also evident in Table 55 with 120 users contacting Safaricom, 79 users contacting veterinary officers and 73 contacting peer farmers. This implies that through the wide range of mobile phone based services that have the households can use mobile phone based services to access the agricultural, climate and market information. Other service providers by households include; extension officer, farmer's organization, input providers, Airtel kilimo and Kenya meteorological department as indicated in Figure 17. KARI, KACE and FAO are the least contacted.

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[8] Peer farmers are selected farmers who have been trained by the county government of Makueni County. They include; church leaders, social group leaders.

Table 56 Type of Information obtained from a veterinary officer by the users

Type of information	No. of HH	% of HH
Livestock diseases treatment and control + use of artificial Insemination	16	12.5
Livestock treatment and diseases control + Introduction of new drugs and vaccines	10	8.3
Use of artificial insemination) Introduction of new animal vaccines and drugs	9	7.3
Livestock disease treatment and control + use of artificial Insemination	17	13.5
Introduction of new animal vaccines and drugs	13	10.4
Use of Artificial Insemination	13	10.4
Livestock disease treatment and control	47	37.5
Total	125	100

Sources: Field survey 2017/2018

Table 56 shows that 47 users (37.5%) contact the veterinary officer to receive livestock diseases treatment and control, 16 users (12.5%) receive Livestock diseases treatment and control and use of artificial insemination, 10 users (8.3%) receive livestock treatment and diseases control and introduction of new drugs and vaccines, 17 users (13.5%) receive livestock disease treatment and control information and use of artificial insemination. This information is through mobile phone based services.

8.3.2   Network visualization of non-users to access Information resource

The non-users can only access the information through face to face. Table 57 shows the service providers that the non-users contact to access information. As indicated in Table 39, 25 non-users (20%), 33 non-users (26.4%), 14 non-users (11.2%), and 13 non-users (10.4%) contact the veterinary officers, peer farmers, input providers, and the extension officers to get the information respectively. Since the non-users do not have mobile phone based services, they can only contact few service providers to access information, therefore, they lack access to information from KMD, KARI, FAO, Safaricom, Airtel Kilimo and KACE which provides most information through mobile phone based services. Generally, this implies that non-users have limited access to information compared to the user as depicted by the network of the non-user being less interconnected to service providers compared to that of users

Table 57 Number of non-users contacting the service providers

Service provider	No. of HH Contact	No. of HH Do not contact	Total HH	% of HH Contact	% of HH Do not contact	Total %
Veterinary officer	25	100	125	20.0	80.0	100.0
Peer Farmers	33	92	125	26.4	73.6	100.0
Input Providers	14	111	125	11.2	88.8	100.0
Extension officer	13	112	125	10.4	89.6	100.0
Farmers organization	0	0	0	0.0	0.0	0.0
KMD (Kenya Meteorological Department)	0	0	0	0.0	0.0	0.0
KARI (Kenya Agriculture Research Institute)	0	0	0	0.0	0.0	0.0
FAO (Food and Agriculture Organization)	0	0	0	0.0	0.0	0.0
Safaricom	0	0	0	0.0	0.0	0.0
Airtel Kilimo	0	0	0	0.0	0.0	0.0
KACE (Kenya Agriculture Commodity Exchange)	0	0	0	0.0	0.0	0.0

Source: Field survey 2017/2018

Table 58 shows the descriptive statistics of non-users with respect to each service provider contacted to access information resources. The statistics in Table 58 summarizes the symmetric adjacency matrix used to visualize the non-users' information network illustrated in Figure 18. The non-users can only contact veterinary officers, peer farmers, input providers, and Extension officers. Estimated 33 non-users (26.4%) contact veterinary officer and the most contacted service provider through face to face to access information resource. Table 58 shows the mean, standard deviation, variance, SSQ, MCSSQ and Euclidean norm of the non-users in veterinary officers, peer farmers, input providers, and extension officers. Estimated 40 non-users are isolated, do not have contact with any service provider to access information. The network visualization of the non-users is indicated in Figure 18.

Table 58 Descriptive statistics of non-users and service providers to access the information resource

	Detail	Veterinary officer	Peer Farmers	Farmers organization	Input providers	KMD	Extension officer	KARI	FAO	Safaricom	Airtel Kilimo	KACE
1	Observations	125	125	125	125	135	125	125	125	125	125	125
2	Minimum	0	0	0	0	0	0	0	0	0	0	0
3	Maximum	1	1	0	1	0	1	0	0	0	0	0
4	Mean	0.200	0.264	0	0.112	0	0.104	0	0	0	0	0
5	Standard Deviation	0.400	0.441	0	0.315	0	0.305	0	0	0	0	0
6	Sum	25	33	0	14	0	13	0	0	0	0	0
7	Variance	0.160	0.194	0	0.099	0	0.093	0	0	0	0	0
8	SSQ	25	33	0	14	0	13	0	0	0	0	0
9	MCSSQ	20	24.288	0	12.432	0	11.648	0	0	0	0	0
10	Euclidean norm	5	5.745	0	3.742	0	3.606	0	0	0	0	0

Note: the statistics describe the users characteristic with respect to each service provider contacted

Source: Field survey 2017/2018

Note: The more central and bigger the size of the box the more the service provider is contacted by the household.
Appendix D2 shows the descriptive statistics of four-measure; degree, closeness, betweenness and eigenvector
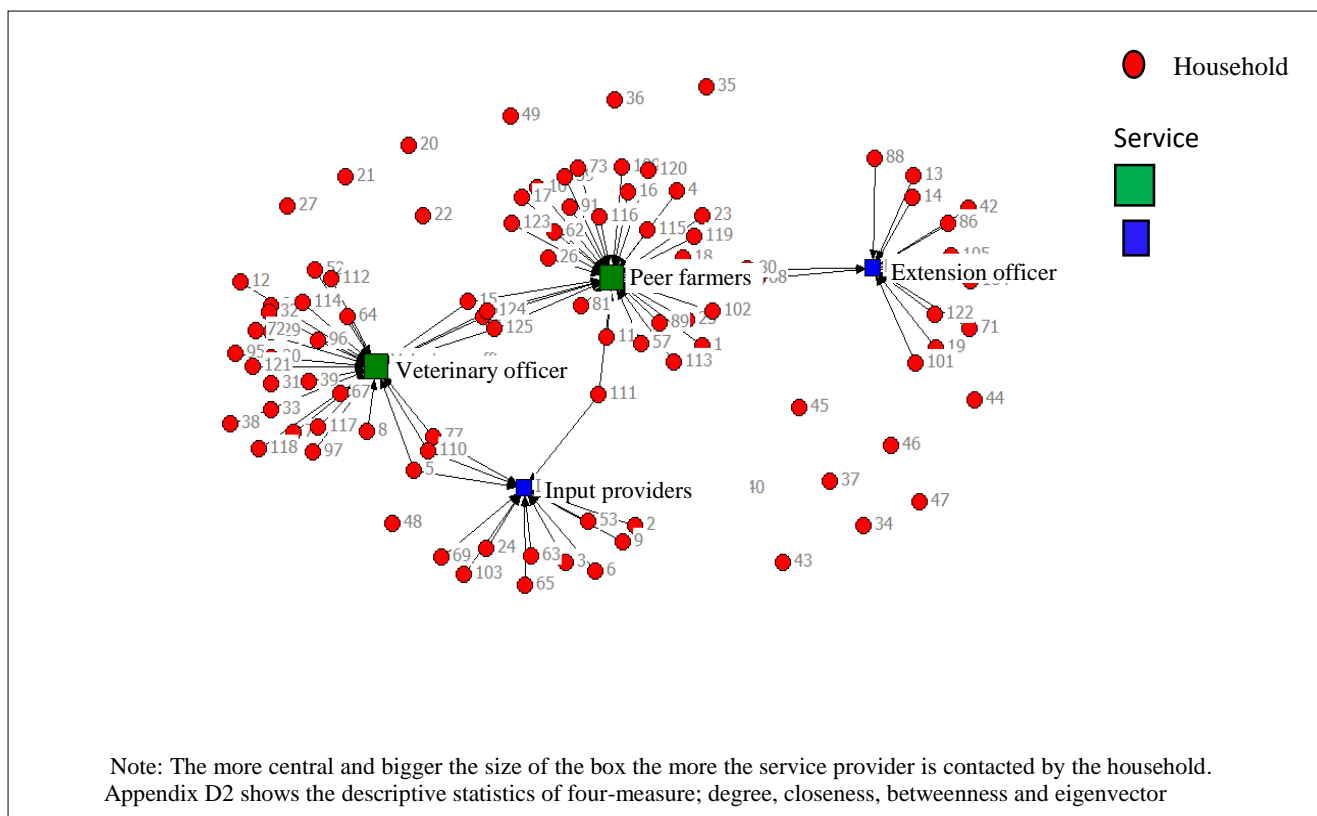
Figure 18 Network visualization for Non-users to access information resource through face to face

Source: Field survey 2017/2018

The network for the non-users is less connected to access information from the services providers as indicated in Figure 18. Also, 16 non-users (12.8%) are isolated, indicating that they are not connected to any service provider or other households to access the information. The non-users frequently connect to the veterinary officer and peer farmers as indicated in Figure 18. Also, the households contact the services providers based on their system of farming and the nature of the information they are interested in. For instance, the households that contact the veterinary officer practice livestock keeping and frequently contact the veterinary officer to receive information on livestock diseases and control, Artificial insemination and introduction to new drugs and vaccines.

8.3.3 Network visualization for users to access Financial resource through mobile phone based services

Estimated 86 users (70%) are able to access credit through mobile phone based services as portrayed during field survey 2017/2018. Table 59 shows the descriptive statistics of users with respect to each service provider contacted to access financial resource through the mobile phone. The statistics in Table 59 describe the adjacency matrix used to create the visualization of users illustrated in Figure 18. A sum of 125 users access the financial resource from Safaricom, 36 users access from farmers' organizations and 28 users from Airtel Kilimo through mobile phone based services.

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Table 59 Descriptive characteristics of users and service providers to access financial resource

	Characteristics	Veterinary officer	Peer Farmers	Farmers organization	Input providers	KMD	Extension officer	KARI	FAO	Safaricom	Airtel Kilimo	KACE
1	Observations	125	125	125	125	135	125	125	125	125	125	125
2	Minimum	0	0	0	0	0	0	0	0	0	0	0
3	Maximum	0	0	1	0	0	0	0	0	1	1	0
4	Mean	0	0	0.288	0	0	0	0	0	1	0.224	0
5	Standard Deviation	0	0	0.453	0	0	0	0	0	0	0.417	0
6	Sum	0	0	36	0	0	0	0	0	125	28	0
7	Variance	0	0	0.205	0	0	0	0	0	0	0.174	0
8	SSQ	0	0	36	0	0	0	0	0	125	28	0
9	MCSSQ	0	0	25.632	0	0	0	0	0	0	21.728	0
10	Euclidean norm	0	0	6	0	0	0	0	0	11.180	5.292	0

Source: Field survey 2017/2018
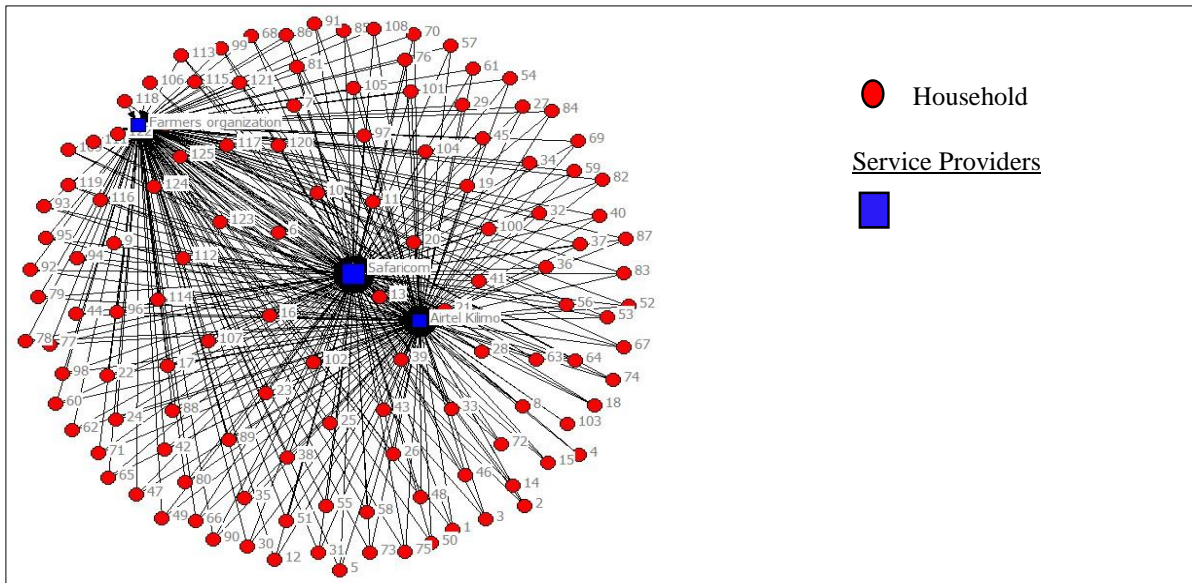
Note: The more central and bigger the size of the box the more the service provider is contacted by the household

Figure 19 Network visualization for users to access the financial resource through the mobile phone based services

Source: Field survey

Figure 19 shows the network visualization for users to access financial resource through mobile phone based services. The result shows that Safaricom, Airtel and Farmers organization can provide financial services to the users through mobile phone based services. Safaricom approximately 86 users (68.8%) utilize M-shwari application to access credit. Although the users have other sources of finances, for instance, 32 users (26.8%) access from the finances through the bank, 33 users (26.5%) access through the table banking system and 6 users (4.8%) through the money lenders as discussed in chapter 7 while over 86 users (70%) get the finances through the mobile phone. The financial network of the users indicates that the users are capable of accessing financial serves through mobile phone based services. These imply that mobile phone based services facilities access finances since they are able to obtain short loans from the service providers they contact as portrayed by the interviewed key expert from Safaricom and Airtel during the field survey 2017/2018. Access to credit is very essential for the rural population in Kenya since most of the households are farmers and they require finances to increase inputs such as fertilizers, seeds, labor and land that facilitate an increase in total output (Agricultural productivity). Since the financial institutions are limited in the rural areas and only 15% to 21% of the rural households are banked in Kenya (Gaganis et al, 2009; Njuguna et al, 2015), the use of the mobile phone based services increases the accessibility of finances to the users. Most of the households in the rural areas are not banked due to fewer financial institutions, preference of households to use home banking and many formalities to access credit (Dupas et al., 2012). Therefore, the use of mobile phone based services increases and expand the networks

to get financial services for the users compared to the non-users. The formalities to access the mobile phone based financial services to access finances are more efficient to accommodate rural households.

8.4 Impact of mobile phone based services on networks and HACI

To statistically understand the impact of networks on household adaptive capacity a descriptive and statistical analysis was conducted employing Ordinary Least Square (OLS). First and foremost, the descriptive analysis to evaluate whether the number of connections contributes to the household adaptive capacity index is conducted. Table 60 shows the descriptive statistics of users and non-users indicating the total number of connections to the service providers contacted to access information and financial resources.

As indicated in Table 60, 43 users (34.4%), 76 users (60.8%) and 6 users (4.8%) have 0 to 3, 4 to 7 and 8 to 11 number of connections to the service providers to access information and financial resources through the mobile phone based services respectively. Also, the users' average HACIs for 0.3568, 0.4940 and 0.6528 are 0 to 3 number of connections, 4 to 7 number of connections and 8 to 11 number of connections to service providers respectively. In the case of the non-users, 124 non-users (99.2%) have 0 to 3 number of connections and only 1 non-user (0.8%) have 4 to 7 number of connections.

The average HACIs for the non-users across 0 to 3 and 4 to 7 number of connections as depicted in Table 60. No non-users have 8 to 11 number of connections to the service providers to access information and financial resources. In all sample of households, 167 households (66.8%) have 0 to 3 number of connections and an average HACI of 0.2014, 77 households (30.8%) have 4 to 7 number of connections and a HACI of 0.2044, only 6 households (2.4%) have 8 to 11 number of connections and the average HACI being 0.6528. The results imply that the number of connections to the service providers increases with an increase in HACI level as depicted in both users, non-users and all households sampled.

Table 60 The number of connections and HACI for users, non-users and the all sample

No. of connections	Users			Non-users			All sample		
	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI	No. of HH	% of HH	Average HACI
0 to 3	43	34.4	0.3568	124	99.2	0.2052	167	66.8	0.2014
4 to 7	76	60.8	0.4940	1	0.8	0.2040	77	30.8	0.2044
8 to 11	6	4.8	0.6528	0	0.0	0.0000	6	2.4	0.6528
Total	125	100	0.5012	125	100	0.2046	250	100	0.3529

Source: Field survey 2017/2018

Furthermore, to understand how the gender of household influence networks that facilitate access to resources and household adaptive capacity (HACI), Table 61 shows the relationship between the number of connections and HACI based on the gender of the household head for both users and non-users. Estimated 37 non-users (100%) in female-headed households and 86 non-users male-headed (97.7%) households have fewer connections between 0 to 3 connections while 9 female-headed users (50%) households and the 67 male-headed (68.2%) having more than 4 connections. Also, the HACIs vary by the number of connections in both female-headed and male-headed households for users and non-users as shown in Table 61.

The HACI of female-headed households in users is 0.4228 and 0.4923 in male-headed households in users while in non-users HACI for female-headed households is 0.2181 and that of male-headed households is 0.2277 for the 0 to 3 number of connections. In the 4 to 7 number of connections to the service providers, HACI for the female-headed households and male-headed households in the users is 0.4915 and 0.5970 while that no non-users categorized with 4 to 7 connections. In the 8 to 11 connections category, the HACI of the male-headed household is more compared to the female-headed households in the users as portrayed by o.4915 and 0.5970 respectively. This result implies that the HACI of female-headed households is lower than that of male-headed households in both users and non-users.

The number of connections and the average HACIs for the users and non-users is compared based on the household farming system as indicated in Table 62. Estimated 7 users (30.4%), 1 user (100%) and 1 user (100%) are categorized with 0 to 3 number of connections to the service providers in food crop farming, livestock farming, and cash crop farming respectively. The average HACI of users engaging in single farming system is as follows; 0.5251 in food crop farming, 0.5097 in livestock farming and 0.5300 in cash crop farming while for the mixed farming system is as follows; 0.4791 in food crop/livestock/cash crop farming, 0.5010 in food crop/livestock, 0.5545 in food crop/cash crop farming and 0.5173 in food crop/livestock in 0 to 3 number of connections category as shown in Table 62.

From Table 62, users are categorized with 4 to 7 number of connections to service providers but only 14 users (60.9%) practice food crop farming in single farming system while in the mixed farming system, 33 users (60%) in food crop/livestock/cash crop farming, 24 users (64.9%) in food/livestock farming 5 users (71.4%) in food crop/cash crop farming and 7 users (63.6%) in cash crop/livestock farming. Also, the HACI of the single farming system is as follows; 0.5455 in food crop farming which is lower than in mixed farming system indicated as follows; 0.4831 in food crop/livestock/cash crop farming, 0.4831 in food crop/livestock farming, 0.4307 in food crop/cash crop farming and 0.4935 in cash crop/livestock farming in the 4 to 7 number of connections to the

service provided. In the 8 to 11 number of connections to service providers, 2 users (8.7%) in food crop farming with 0.6167 for the single farming system while in mixed farming system is as follows; 1 user (1.8%) with HACI of 0.6731, 2 users (5.4%) with HACI of 0.7162 and 1 users (9.1%) with HACI of 0.5778.

In the non-users, 55 non-users (100%) with HACI of 0.1679, 2 non-users (100%) with HACI of 0.1180, 4 non-users (100%) with 0.1433 as single farming system have 0 to 3 number of connections to the service providers while for the mixed farming with 0 to 3 number of connections is as indicated; 19 non-users (100%) with 0.2637 and 10 non-users (100%) with 0.1817. This result implies that the number of connections to the service providers increases with an increase in average HACI as shown by the values of HACI from Table 62, also the HACI for the single farming system is lower than that of the mixed farming system. Therefore, the number of connections to the services providers to access information and diversity of livelihood, the higher the HACI of the household.

Table 61 The number of connections and HACI based on the gender of the household head

Number of connections	User						Non-users					
	Female-headed			Male-headed			Female-headed			Male-headed		
	No of HH	% of HH	Average HACI	No of HH	% of HH	Average HACI	No of HH	% of HH	Average HACI	No of HH	% of HH	Average HACI
0 to 3	9	50.0	0.4228	34	31.8	0.4923	37	100	0.2181	86	97.7	0.2277
4 to 7	9	50.0	0.4915	67	62.6	0.5970	0	0	0.0000	2	2.3	0.2998
8 to 11	0	0.0	0.0000	6	5.6	0.6428	0	0	0.0000	0	0.0	0.0000
Total	18	100	0.4572	107	100	0.5774	37	100	0.2181	88	100	0.5275

Source: Field survey 2017/2018

Table 62 The number of connections and HACI by household farming system

No of connections		Food crop farming			Livestock farming			Cash crop farming			Food crop/livestock/cash crop farming			food crop/livestock			Food crop/cash crop farming			cash crop/ livestock farming		
		No of HH	%	HACI	No of HH	%	HACI	No of HH	%	HACI	No of HH	%	HACI	No of HH	%	HACI	No of HH	%	HACI	No of HH	%	HACI
users	0 to 3	7	30.4	0.5251	1	100	0.5097	1	100	0.5350	21	38.2	0.4791	11	29.7	0.5010	2	28.6	0.5545	3	27.3	0.5173
	4 to 7	14	60.9	0.5455	0	0	0.0000	0	0	0.0000	33	60.0	0.4831	24	64.9	0.4831	5	71.4	0.4307	7	63.6	0.4805
	8 to 11	2	8.7	0.6167	0	0	0.0000	0	0	0.0000	1	1.8	0.6731	2	5.4	0.7162	0	0.0	0.0000	1	9.1	0.5778
Total/Average		23	100	0.5624	1	100	0.5097	1	100	0.5350	55	100	0.5451	37	100	0.5668	7	100	0.4926	11	100	0.5252
Non-users	0 to 3	55	100	0.1679	2	100	0.1180	4	100	0.1433	19	100	0.2637	35	100	0.1836	10	100	0.1817	0	0	0.0000
	4 to 7	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000
	8 to 11	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000	0	0	0.0000
Total/Average		55	100	0.1679	2	100	0.1180	4	100	0.1433	19	100	0.2637	35	100	0.1836	10	100	0.1817	0	0	0.0000

Source: Field survey 2017/2018

To statistically test the hypothesis that the number of mobile phone based service facilitated network connections increase household adaptive capacity, the Ordinary Least Square (OLS) was conducted. The 125 samples of users were used for this estimation since they use mobile phone based services to connect to the service providers. The HACI of the users is the dependent variable and the independent variables includes; the total number of connections to access the financial and information resources and a set of household head characteristics including; the age of the household head in years, the gender of the household, years of schooling of the household head, main occupation of the household and type of farming systems.

In this estimation the tested hypothesis for the independent variables to the dependent variables is as follows; many mobile phone influenced connections to access financial and information resources contribute to higher adaptive capacity level, the higher age contributes to a higher level of adaptive capacity. For the gender of household head, female-headed households have a lower adaptive capacity level. The higher the years of schooling of the household head the higher the household adaptive capacity level. For the occupation of household head, the occupation of household head as farmer contributes to a lower adaptive capacity level. The type of farming system, the farming system of the household as a mixed farming system contributes to a higher adaptive capacity level. The estimation was computed using equation 7.

OLS: $Y = \beta_0 + \beta_1 N + \beta_2 X + \varepsilon \dots\dots\dots\dots\dots\dots\dots\dots$ (7)

Whereby:

Y= HACI (Household adaptive capacity index)

N= Number of connections to services provers to access financial and information resources

β_0, β_1, β_2, β_3, β_4, β_5, and β_6 = parameters

X= household characteristics (Age, Gender, Years of schooling, Occupation, Farming system)

ε = Error term

As indicated in equation 7 the dependent variable is the estimated HACI of users, the independent variables include; N denoting the number of connections to service providers to access financial and information resources and X denote the set of the household head characteristics indicated as follows; Age, Gender, Years of schooling, Occupation and Farming system. β_0, β_1, β_2, β_3, β_4, β_5, and β_6 are the parameters to be estimated and ε is the error term to cater for the other factors that affect the HACI not included in the model.

The result of the estimation is as indicated in Table 63. The hypothesis of this estimation that the mobile phone based services influence connections that contribute to a higher household adaptive capacity was supported. The estimated F-value is 9.88. The hypothesis of this estimation is supported since the number of connections of the user to service providers is significant with a positive coefficient of 0.0243. This implies that an increase in one link increases the HACI by 0.0243. The gender of the household head is also significant with a negative coefficient of 0.0675, implying that the HACI of the households decreases with the female-headed households compared to the male-headed households. This is due to the resource accessibility of the male-headed households is higher compared to the female-headed households as depicted in this study as shown in Table 61.

The years of schooling of the household are statistically significantly different from zero with a positive coefficient of 0.0148. This depicts that the more educated household head is the higher the probability of being acquainted with knowledge and ability to access the resources to develop the adaptive capacity compared to the less educated household. The Occupation of the household is as well statistically significant with a positive coefficient of 0.0008 as indicated in Table 63. This implies that the HACI of the household increases with farming households.

The type of farming system of the household is also statistically significant with a positive coefficient of 0.0544 as depicted in Table 63. This implies that the HACI of the household increases with households practicing a mixed type of farming compared to a single type of farming which is also portrayed in Table 62. The age of the household head is not statistically significant on the household adaptive capacity index. The gender of the household head is statistically significant to the HACI.

Table 63 OLS result for the impact of the number of connections on HACI for the users

Variable	HACI
Constant	0.3240 (0.0053)
Age (years)	-0.0004 (0.0006)
Gender (female=1, male=0)	-0.0675*** (0.0230)
Years of schooling	0.0148*** (0.0047)
Number of connections	0.0243*** (0.0062)
Occupation (farmer=1, non-farmer=0)	0.0008 (0.0168)
Farming system (1=Mixed type of farming, 0=Single type of farming)	0.0544*** (0.0162)
Total Observation Adjusted R-Squared F-Value	125 0.3861 9.88***

Note: Standard error in Parentheses, ***p<0.01, **p<0.05, *P<0.1 representing 1%, 5% and 10% level of significance.

Source: Field survey 2017/2018

8.5   Summary

This chapter highlights two important issues. First and foremost, the networks for the users and non-users to service providers to access information and financial resource are assessed. Through social network analysis, the users and non-users' information and financial network are created. The users' networks are mobile phone based initiated in both information and financial resource. The result of this study depicts that the users have a wider network compared to the non-users. Through mobile phone based services, the users are able to connect to more service providers to receive information thus expanding their networks and increasing information resources due to the accessibility of different information from different service providers. As a result, the information resource of the users is higher compared to the non-users. On the other hand, the non-users have a lesser connected network to access information from other service providers since the non-users utilize the face to face method to reach the service providers.

Secondly, the impact of the number of connections to service providers on household adaptive capacity is assessed. The result proves that the higher the number of connections to access information and financial resource from the service providers higher the HACI of the households. The number of connections to the service providers of the users is more compared to the non-users as well as the level of HACI. Furthermore, the result proves that most of the female-headed households in the users and non-users have fewer connections compared to the male-headed households as well as the level of HACI. Also, the number of connections for the users practicing the

single type of farming and mixed farming systems is more compared to the non-users. Also, the level of HACI for the users in both a single type of farming and mixed type of farming is higher compared to the non-users.

Furthermore, the OLS statistical analysis proves that the number of connections the household has to access information or financial resource from the service providers the higher the household's adaptive capacity (HACI). As evident in the previous chapters, the household adaptive capacity is determined by the resources and the higher the resource accessibility the higher the household adaptive capacity. Also, the OLS result depicts that the gender of household head, years of schooling, occupation of household head and the type of farming system being statistically significant to HACI. The HACI increases with male-headed households, the number of years of schooling of household head, the occupation of the households being a farmer and households practicing a mixed type of farming.

Generally, this chapter proves that the number of connections to other services providers contributes to increased access to information, financial resource and adaptive capacity which facilitate adaptive capacity development. This chapter suggests that for purpose of adaptive capacity development there is a need to encourage household's utilization of mobile phone based services in order to expand their social networks to access resources thus facilitating adaptive capacity development. Also, this chapter suggests consideration of gender of the household head and the type of farming systems practiced by households in resource distribution and rural adaptive capacity development interventions.

CHAPTER 9

CONCLUSIONS AND IMPLICATIONS

9.1   Summary of key findings

The aim of this study was to assess the influence of mobile phone based services, one of the ICTs on household adaptive capacity with a purpose to aid adaptive capacity development in order to ensure achievement and sustainability of household development outcomes. To accomplish this aim, this study was divided into two parts; first, the adaptive capacity of households was assessed based on five resources (financial, information, physical, human, and diversity of livelihood) and the resources that need to be developed were identified (Chapter 5). Secondly, the study focused on increasing accessibility and scale of the identified resources through mobile phone based services, one of the ICTs and the impact on household adaptive capacity (Chapter 6 and 7). Furthermore, the study examined the influence of mobile phone based services on household networks to access and exchange resources that facilitate adaptive capacity development (Chapter 8).

The study utilized primary and secondary data from 250 households in Makueni County, in Kenya to achieve the aim of this study. The results of this study reveal that over 63.2% of the surveyed households in Makueni County rely on farming for livelihood and as the main source of food. The farming is mainly rain fed with 72% of the households relying on rainfall as the main source of water. The households are therefore vulnerable to several climates related challenges including; increased droughts (88.3%), changing rainfall timings (87.7%), increased crop diseases (75.4%) and high water shortages with over 74.3% affected. The households revealed that the frequency and intensity of these shocks have been increasing and more severe thus contributing to total crop failure, death of livestock, increase in crop diseases and water scarcity. The key areas the households are experiencing a decline due to the shocks include crop production with 93.6% of households affected, income generation with 76% of households affected and livestock production with 73.1% of the households affected. Although the households depicted that they apply strategies like changing crop variety, changing planting dates, diversification from farming to non-farming activities as well as disposal of livestock/assets, the impacts outweigh their adaptive strategies plugging the households to higher risks such as food insecurity and poverty. This is evident in Kenya Vision 2030 (2013) in which Makueni County is ranked as one of the food insecure counties in Kenya and highly relies on government and NGOs support during the crisis. Therefore, adaptive capacity development is highly imperative to help the rural households to cope and adjust to the short and long term shocks

and also endure their standards of living by achieving and maintaining development outcomes such as increased income, increased livelihood diversification, and increased risk management.

The resource-based adaptive capacity assessment reveals that the average household adaptive capacity index of rural Makueni County is 0.3529 which is relatively low given the range of 0 to 1 of the index. The average resource accessibility was low on the assessed five resources as follows; financial resource (0.0944), human resource (0.0784), information resource (0.0642), physical resource (0.0613) and diversity of livelihood (0.0546). Most of the households were categorized in low (48%) and moderate (50%) HACI levels with only 2% categorized in high HACI level. Given the frequency of the shocks identified and experienced by most of the households, reliance on rain fed agriculture for food and livelihood and limited resources to counteract the impacts the rural households are vulnerable to high rates of food insecurity and advanced risks and this describes a need to develop the adaptive capacities of these households.

The resource accessibility and level of household adaptive capacity differ with the household gender with the male-headed households registering higher accessibility to resources and higher household adaptive capacity compared to female-headed households. The categorization of HACI based on the farming system of households depicts that the households practicing singe farming systems have low HACI compared to the mixed farming system. Out of the five resources used to evaluate adaptive capacity, financial resources, information resources, and diversity of livelihood were identified and ranked as the most important resources that need to be developed across the households. These 3 resources registered a big disparity across the low, moderate and high HACI levels indicating that the accessibility of these resources contributed to differences in household adaptive capacity. On the other hand, the human and physical resources were ranked the least important by households and key experts, and there was no significant difference in the accessibility of human and physical resources since the low, moderate and high HACI level households had equal access to these resources. Also, this study reveals that the higher the resource accessibility the higher the household adaptive capacity. In this case, an increase in financial, information and diversity of livelihood facilitated general household adaptive capacity development.

The next step of this study was to assess the impact of utilizing mobile phone based services in increasing accessibility, scale, and exchange of financial, information and diversity of livelihood which will facilitate adaptive capacity development. The mobile phone penetration rate in Makueni County is high (81%) and these phones are commonly owned assets across the surveyed households. Both the user and non-user are able to access financial, information and diversity of livelihood but the accessibility of the user is higher compared to non-user

since mobile phone based services facilitate access to financial, information and diversity of livelihood resources. The user can access credit, savings and remittances through mobile phone based services thus their financial resource score is higher than that of non-users. Since the financial institutions are limited in rural areas and most of the households do not meet bank requirements to obtain credit, most of the households are unbanked. The use of mobile phone based services has facilitated access to credit and savings with minimal formalities compared to financial institutions. For the information, the users are able to access more of the agricultural, climate and market information compared to non-user. The non-user is not able to reach all the service providers due to certain limitations such as time, distance and availability. Therefore, the use of mobile phone based services has seen the user have a number of information sources and can reach the service providers without traveling. Also, it is depicted that the users diversify livelihood more compared to non-users. The utilization of mobile phone based services through voice calls, text messaging and mobile banking transfers provides the user with the ability to manage and monitor different activities thus facilitating diversification of livelihood.

Furthermore, this study identifies the gaps in the information supplied by the service providers to cater to the household's demand. For agricultural information, new methods of crop preservation, food crop disease control and introduction of improved seedlings are not adequately provided as per household demand. Historical and projected climate information on events is also limited and not adequately supplied by the service providers. On the market information, although some information is provided on the price and quality of products, the households indicated that it's not enough and the number of products in the market was not provided at all. The barriers and challenges experienced and limiting the user and non-user from accessing mobile phone based services include; high price to access the services for users (72%) and the information provided through the services is not enough (68.8%) while the non-user depicted that the price of receiving the services is high (76.8%) and most (80%) are not aware of the mobile phone based services provided.

The study reveals that it's due to the disparity in financial, information and diversity of livelihood for the user and non-user that their HACI differs. This is because, through mobile phone based services, the users have higher access to financial, information and diversity of livelihood thus contributing to a higher HACI. Furthermore, the study reveals that the male-headed households have higher resource accessibility compared to the female-headed households and the households practicing singe farming system have lower resource accessibility compared o he mixed farming system. The major barriers and challenges that the users and non-users experience in accessing mobile phone based services as depicted by the study includes; lack of awareness to mobile phone based services, cost, and information provided through the services is not enough. Therefore, mobile

phone based services increase access and scale of resources thus facilitating adaptive capacity development. In addition, developed household adaptive capacity contributes to the achievement of household development outcomes including increased household income, increased livelihood diversification, increased risk management and increased social networks. It is depicted that the users have higher household income compared to non-user household and the level of income increases with the level of HACI. The level of livelihood diversification increases with an increase in HACI and the user diversify more than the non-user. Also, the users have more adaptive strategies and many households apply them compared to the non-users. In addition, the number of adaptive strategies increases with an increase in the HACI level.

Furthermore, the result of a social experiment conducted on the non-users proves that provision of information and training on mobile phone based services to access information, financial resources and diversify livelihood in Makueni County contributes to increased resource accessibility (financial resource, information resource, and diversity of livelihood) and adaptive capacity. This indicates that mobile phone based services have an impact on resources accessibility and scale and generally on HACI of households since it increased after the intervention. Also, the social experiment proves that the information, financial and diversity of livelihood accessibility and average HACI of the treated female-headed households and households practicing the single type of farming increased. The study further reveals that the users have a wider social network to access information and financial resources compared to the non-user. The use of mobile phone based services leads to expansion and increase of these networks that facilitate the accessibility of resources thus encouraging adaptive capacity development.

9.2   Research conclusion

The main conclusion reached in this study for the purposes of the household's adaptive capacity development is that rural households face a lot of shocks that outweigh their limited resources and have a low adaptive capacity. Also, the lack of access to resources contributes to lower adaptive capacity and higher access to resources contributes to higher household adaptive capacity. The household resource-based adaptive capacity assessment approach facilitates adaptive capacity assessment and identification of the resources that need to be developed.

The resource accessibility and adaptive capacity level of female-headed households and households practicing the single type of farming system are lower compared to male-headed households and households practicing mixed farming respectively. Financial resource, information resource and diversity of livelihood are

identified as the most important resources that need to be developed for rural household adaptive capacity development. Increasing accessibility to the information resource, financial resources, and diversity of livelihood will facilitate household adaptive capacity development at the household level in the rural area.

Utilization of mobile phone based services contributes to increased resource accessibility which translates to household adaptive capacity development. Mobile phone based service non-users have lower adaptive capacity and accessibility to financial resources, information and diversity of livelihood compared to users thus need to consider developing the adaptive capacity of non-users. Lack of awareness, high cost and insufficient information which the households seek are the major challenges limiting utilization of the available mobile phone based services that need to be addressed in rural areas.

Moreover, the social experiment conducted to non-users proves that providing information and training on mobile phone based services contributes to an increase in the financial resources, information resource, and diversity of livelihood as well as increased household adaptive capacity. In addition, the social experiment contributed to an increase in resource accessibility and adaptive capacity development for the female-headed household and households practicing single farming systems.

The users have a wider social network to access financial and information resources compared to the non-users and the number of connections to services providers contributes to increased access to information, financial resource, and adaptive capacity. Household's utilization of mobile phone based services contributes to expansion to social networks to access resources thus facilitating adaptive capacity development.

9.3 Research recommendations

The findings of this study outline the implications for policy, practice, and directions for future research. The adaptive capacity assessment is a piece of clear evidence that most of the rural households have a low adaptive capacity and limited resources. Since the households are vulnerable and experience several shocks impacting their livelihood, the household's adaptive capacity level should be increased significantly so that the vulnerable households can be able to cope and adjust to the shocks experienced, sustain and achieve the household development outcomes. This study suggests consideration of the resource-based assessment approach employed in this study in designing and implementing programs, services, and responses to develop a household's adaptive capacity of vulnerable households through identifying the resources that need to be developed.

Through the adaptive capacity assessment, resources availability was assessed based on five resources assessed and among them financial, information and diversity of livelihood are the resources that are limited and

need to be developed across the households. In this case, resource accessibility should be increased significantly across households to ensure adaptive capacity development in rural areas. This could be done through community intervention initiatives by both the national and local governments to ensure that community outreach covers all households.

The findings of this study clearly prove that the female-headed households and households practicing the single type of farming have a low resource availability and level of adaptive capacity compared to male-headed households and mixed farming systems respectively. Therefore, this study recommends consideration of gender of household head and type of farming system in resource distribution and in rural household adaptive capacity development interventions in order to ensure equal distribution of resources across all households and to facilitate household adaptive capacity development.

In Kenya and other SSA countries, the resource distribution to address the rural household's challenges is based on the top-down approach in which the resources are distributed based on national assessment and then generally distributed to the households and mostly what the households have or need is not put into consideration. Through the resource-based adaptive capacity assessment, the resources the households have and need have been identified. Therefore, household resource-based assessment should be considered when policymakers are designing and implementing programs, services, and responses to challenges faced by rural households so that the appropriate services and interventions are delivered to the households.

The study findings reveal that mobile phone based users have higher access to financial, information and diversity of livelihoods compared to non-users. The lack of financial institutions in rural areas means that most rural households are unbanked and unable to access credit. The mobile phone based services have facilitated easy access to saving, credit, and remittances since fewer formalities are required. Also, the users have higher access to agricultural, climate information and climate information compared to non-user, the users are able to access more information and service providers through mobile phone based services compared to non-user. On the diversity of livelihood, the users have a number of livelihoods compared to non-user and they are able to monitor and manage them through the mobile phone. Due to increased accessibility, the household adaptive capacity of the user households is higher. Therefore, the inclusion of mobile phone based services as a potential way to increase household resource accessibility and adaptive capacity should be considered in the current stakeholder adaptive capacity development interventions in rural areas in order to promote household adaptive capacity development, especially to the non-users.

The results of this study show that there are information gaps existing in rural Makueni County with the information supplied is not sufficient and other information is not provided to cater to the information demand of the households. This study recommends that an increase in the provision of agricultural information, climate, and market information provided to households should be considered in the adaptive capacity development interventions in order to improve the household information resource which will facilitate an increase in household adaptive capacity.

The user and non-user experience several challenges and barriers in accessing and utilizing mobile phone based services to access the resource, for instance, high price, unawareness of the services and information provided is not enough. This study recommends that considerations of proper measures to address the cost and information gap challenges to encourage the utilization of mobile phone based services in order to ensure an increase in resource accessibility and adaptive capacity development. Also, the inclusion of programs to provide information and train non-uses on mobile phone based services will ensure the creation of awareness of the services.

The social experiment conducted to the non-users proves that the provision of information and training on mobile phone based services to access the resources to increase the household resource accessibility and household adaptive capacity. Therefore, this study recommends the inclusion of programs providing information and training on mobile phone based services to the non-users in order to encourage utilization of the mobile phone based services available thus increasing household accessibility to resources and adaptive capacity development.

Generally, this study shows that the development of household adaptive capacity ensures achievement of the several development outcomes; increased household income, livelihood diversification, increased risk management, and increased social networks. These outcomes are higher across the mobile phone based users due to increased resource accessibility. Therefore, mobile phone based services should be promoted to increase their usage and to develop the household adaptive capacity that ensures achieving and sustaining household development outcomes.

9.4   Research contribution

The output of this research contributes to academia and society development. Through extensive literature review conducted in this study, it is proven that there are certain gaps that exist in the literature on regards to adaptive capacity assessment and adaptive capacity development as indicated in Table 64.

Table 64 Summary of literature gaps

Detail	Literature gaps
Adaptive capacity assessment	1. Most studies assess adaptive capacity at the National level, limited studies at the household level (Thathsarani et al, 2018)
	2. Limited quantitative studies on resource-based adaptive capacity assessment at the household level in developing countries (Nyamwanza, 2012; UNDP, 2014; Defiesta et al., 2014)
Adaptive capacity development	3. Adaptive capacity development remains one of the least explored areas of ICTs potentials (Ospina and Heeks, 2010) - No existing studies on mobile phone
	4. Limited studies on quantification of how developed range of ICTs are being utilized to develop household adaptive capacity in rural Africa context (Pant et al, 2012) - No existing studies on mobile phone
	5. Limited studies that qualitatively visualize or quantitatively assess how ICTs influence networks that facilitate adaptive capacity development at household level in rural Africa context (Ingold et al., 2010; Luthe et al. 2012; Rotberg 2013; Ingold 2015)

Source: Authors

The objectives of this study focused on narrowing down all these gaps existing in the current literature. This study, therefore, provides an evidence-based study grounded on field-based qualitative and quantitative inquiries composed of selected households, community organizations and government officials as well as relevant secondary materials to provide comprehensive documentation of the mobile phone based services for household adaptive capacity development in rural Africa.

Through the adaptive capacity assessment, this research estimates the level of household adaptive capacity and resources that need to be developed. This approach provides insights that can guide the decision making at the household level and policymakers on delivering the appropriate programs and services to develop household adaptive capacity. Also, through this evidence-based study, the households can be encouraging to utilize available mobile phone based services to facilitate resource accessibility and development of adaptive capacity in order to sustain and achieve household development outcomes such as; increased income, increased livelihood diversification, increased risk management and expansion of social networks that increase resources accessibility. Also, the rural households experience a lot of shock due to reliance on rain fed agriculture, the utilization of mobile phone based services will develop their adaptive capacity thus increased the ability to cope and adjust to both short and long term shocks.

9.5   Research limitation and future research

First and foremost, in this study a comprehensive Household Adaptive Capacity Index (HACI) of the household is computed based on five resources; information, financial, human, physical and diversification of livelihood directly or indirectly and this study proves that the mobile phone based services increase accessibility

to financial, information, diversity of livelihood, the three resources that need to be developed and which contributes to adaptive capacity development of the household in rural Makueni County, the impact of mobile phone based services on human and physical resource accessibility could not be tested in this case. Therefore, this study suggests future work by applying this study approach in a different context to test the impact of mobile phone based services on human and physical resources accessibility.

Secondly, in this study, the resource-based analysis was used to assess the household adaptive capacity using five resources (financial, information, physical, human and diversity of livelihood), other factors such as cultural factors could not be captured in this scope. Therefore, this study suggests future work on considering other external factors such as cultural factors that can impact the resource accessibility of the household and the utilization of mobile phone based services which could influence the household adaptive capacity development. Also, one of the challenges in social sciences on impact evaluations is the selection of good variables and other external factors in order to eliminate selection biases. For the statistical estimations, this study recommends consideration and inclusion of other variables affecting the adaptive capacity to such as the actual distance to the service providers in order to increase the precision of estimations.

Thirdly, this study utilized the social experiment to provide and train the non-user on mobile phone based services to access financial, information and diversify livelihood, baseline data (before intervention) was first conducted and a follow-up survey then conducted 6 months later. Although an intervention could be short or long term according to UNDP (2014) to evaluate an impact or change on some of the resource accessibility such as human and physical resources, future work is suggested on applicability of this research approach on a different context and the monitoring/evaluation after intervention conducted in more than a year in order to capture other factors not applied in this study that could impact the outcomes. Also, consideration is recommended in choosing the social experiment participants to moderate bias.

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APPENDIX A: Household questionnaire for Makueni County

HOUSEHOLD QUESTIONNAIRE, MAKUENI COUNTY

My name is _____from The University of Tokyo, Japan. I am carrying out a study in this area on implication of mobile phone based services on household adaptive capacity development. You have been selected randomly to participate in the study. All the information given will be treated with confidentiality and be used for the purpose of the study only. Do you wish to participate in the study?

☐

Yes

No

Thank you very much

Note to the interviewer:

This questionnaire MUST be administered ONLY to households meeting the following criteria.

- Live in the selected areas
- Fits within BOP segment

Respondent must be the head, husband or wife of the family

1.	Serial no	
2.	Date	Day: Month: Year:
3.	Name of the respondent	
4.	Head of household	
5.	Number of household members	Male: Female:
6.	Location	
7.	Village	

1. Social demographic information

	Question			Answer
1.	Gender *(Please don't ask directly. Observe and record)* 0= Male 1= Female			
2.	Age of respondent *(If the respondent doesn't give exact age ask age range in question 3)*			
3.	Age Range of respondent 1) 18-25yrs 2) 26-30 yrs. 3) 31-35 yrs. 4) 36-40 yrs 5) 41-45 yrs 6) 46-50 yrs 7) 51-55 yrs 8) 56-60 yrs 9) Above 60 years			
4.	Respondents marital status 1. Single 2. Married 3. Single parent 4. Divorced 5. Window/ widower 6. Separated 7. Others Please (specify)……………….			
4.	What is your highest education level (Respondent)? 1. College/University 2. polytechnic 3. Completed Secondary school 4. Bit of secondary 5. Completed Primary School 6. Bit of primary 7. Informal schooling (e.g. Ngumbaru) 8. None			
5.	What is your religion? 1. Christian 2. Muslim 3. None 4. Other (Specify………….)			
6.	Who is the head of the household? 1. Husband 2. Wife 3. Single parent 4. Other (Specify…………………)			
7.	What is the household heads' highest education level? 1. College/University 2. polytechnic 3. Completed Secondary school 4. Bit of secondary 5. Completed Primary School 6. Bit of primary 7. The informal school (e.g Ngumbaru) 8. None			
8.	What is the occupation of the household head? 1. Housewife 2. Farmer 3. Daily wage labor 4. Government employee 5. Private business employee 6. Self-employed 7. Student 8. Others (specify………………………)			
9.	Household size	Males	Females	
	a. Number of members aged below 16 years			
	b. Number of member 16 to 30 years			
	c. Number of members 31 to 45 years			
	d. Number of members 46 to 60 years			
	e. Number of members above 60 years			

2. Household monthly Income details

	Question	Answer
1.	What is the total monthly income received in this household *(If the exact amount is unknown or unwilling to say, ask for an income range in the next question 2)*	
2.	Please indicate the total monthly income range received in this household 1. 1000 and below 2. 1001-5000 3. 5001-10,000 4. 10001-20000 5. 20,001-50000 6. Above 50,000 7. None	
3.	In the last year, did you receive any support for the family? *(It can be money, material or service provided) If yes move proceed to the next question* 1.Yes 2.No	
4.	If yes, from whom did you receive the support from? 1. Family 2. Relative 3. Government 4. N.G.O 5. Volunteer/well-wishers 6. Neighbor/s 7. Others(specify…………….)	

5.	What kind of support did you receive?				
	1. Material (e.g food, farm inputs, etc) 2. Money 3. Service (e.g training)				
6.	Please Specify a range of how much you receive in Ksh in a year?				
	1. 1000 and below 2. 1001-5000 3. 5001-10,000 4. 10001-20000 5. 20,001-50000 6. Above 50,000				
	7. None				

3.   Land and assets ownership

	Question				Answer
1.	How many plots do you have? (*Please indicate the number*)				
2.	a. Type of land *(Tick the applicable)*	b. Size of the land in Hectares	c. Location of the land *(Tick the applicable)*		
			Homeland	Land outside the homeland but within Makueni County	Outside Makueni County
	1. Inherited				
	2. Owned				
	3. Rented				
	4. Borrowed				
	5. Other (Specify)				
3	Cropped Area				
	a. The area under cultivation in this season in hectares *(In all the type of plots indicated in question 2)*				
	b. The area under cultivation in the previous season in hectares *(in all the type of plots indicated in question 2)*				
4.	For how many years have you been farming? *(Farming experience)*				
5.	What type of farming do you practice? 1= Subsistence farming (Own consumption) 2= Commercial farming (Selling) 3= Both Subsistence farming and Commercial farming 4= Other (specify)				
6.	Please specify the type of food crops you planted in the last season? 1. Maize 2. Beans 3. Vegetables 4. Cowpeas 5. Cassava 6. Arrowroots 7. Yam 8. Sweet potato 9. Ndegu 10. French beans (Minji) 11. Other (Specify………….)				
7.	Please specify the type of cash crops grown in the last season? 1. Mangoes 2. Oranges 3. Avocadoes 4. Coffee 5. Sugar cane 6. Coffee 7. Other (Specify……..)				

6.   Household perception in precipitation and temperature

	Question		Answer
1.	a) Have you observed any long term changes in temperature and rainfall over the last 5 years? 1.Yes 2.No		
	b) If yes please indicate the changes √ in the table below		
	Perceived changes	Selected factor √	
	1. Increased temperature		
	2. Decreased temperature		
	3. Increased number of rain events		
	4. Decreased number of rain events		

	5. Increased rainfall intensity		
	6. Decreased rainfall intensity		
	7. Increased rainfall durations		
	8. Decreased rainfall durations		
2	On a scale of 0 - 5, how has the long term changes affected your routine? Rank code: 0 = No Impact 1 = Somewhat significant 2 = Significant 3 = Severe 4 = Very severe 5 = Extremely severe 6 = I don't know		
	Impact	Selected factor √	Rank Severity
	1. Changed rainfall timings		
	2. Changes in the growing season		
	3. Shorter growing seasons		
	4. Increased droughts		
	5. Increased drought intensity		
	6. Increased floods		
	7. Increased flood intensity		

	Please, rate the impact of variation of rainfall and temperature on the following areas in the last 5 years (please tick (√) the appropriate)					
3.	Impact	Extremely low	Low	Moderate	High	Very low
	Crop Production					
	Income generation					
	Livestock production					
	Water sources					
	Vegetation cover					
	Others (specify)………………					

7. Farmer's adaptation options

	Question	Answer
1.	Have you made any changes in your farming ways to adapt to changes in temperature and rainfall over the last 5 years? (*If yes proceed, If No go to question 3*) 1=Yes 2=No	

2.	If yes in 1, what adjustments have you made in your farming practices to these long-term shifts in temperature and rainfall in the last 5 years?
	
	   1. Change crop variety
	   2. By increasing number of plots/sacks
	   3. Rainwater harvesting
	   4. irrigation
	   5. Implement soil conservation in the plot
	   6. diversify from farming to non-farming activities
	   7. Diversification of crop varieties/cultivars
	   8. Changing planting dates
	   9. Planting trees
	   10. Others (specify) …………………………. (*Multiple choices*)	

| 3. | If No in 1, why haven't you made adjustments in your farming practices?

    1.   The adjustments are expensive 2. I don't know which adjustments to apply 3. I think it's not necessary to apply the strategies

        4. Others (Specify……….) | |

8. Mobile phone ownership and usage

	Question	Answer
1.	Do you own a mobile phone? *(If No go to question 4)* 1. Yes, 2. No	

2	*a.* If yes, why did you get a mobile phone? *(Multiple choices)*
	
	    1. Communication 2. Money banking (e.g M-pesa, M-kopa, etc) 3. To access internet 4. Facilitate day to day activities
	        5. Other (Specify………..)	

	b. For how long have you used your mobile phone? *(From the time they have been using the mobile phone)* 2. 1-3 years 2. 4-6years 3. 7-9 years 4. Above 10years	
3.	Which of these network operators do you use? *(Multiple choices)* 1. Safaricom 2. Airtel 3. YU 4. Orange 5. Other (specify…..)	

4.	*(If you don't own a mobile phone)*
	
	    a) Please, can you indicate why you don't own a mobile phone
	
	        1. Expensive 2. I don't know how to operate it 3. I don't need a mobile phone 4. other (Specify……)	

	b) When you want to use mobile phone services, what do you normally do?
	        1. Use phone Kiosk (e.g. simu ya jamii, Phone agents) 2. Borrow from a friend/neighbor/family 3. I don't use it at
	        all 4. Other (Specify……………)	

5.	How many family members own a mobile phone? *(Please include the respondent)*	
6.	Please indicate who owns the mobile phone *(Please select all that apply)* 1. Husband 2. Wife 3. Son 4. Daughter 5. Other (Specify………)	
7.	Which of these applications do you use *(Please tick)* and indicate how often you use them per day *(Please tick)*	

Are you able to use the following using a mobile phone?	(Please tick used)	How often is used per day *Code: 1= very rarely (once a month) 2= Rarely (2-3 times a month)* *3= Occasionally (2-3 times a week)* *4= Frequently (1-2 times a day) 5= Very frequently (More than 2 times a day)*
1.Voice application (calls)		
2. Text Messaging (SMS)		
3. Internet		
4. Mobile banking services		
5. Others (Specify……)		

| 8. | Please indicate other purposes of the mobile phone beside the above named? *(Multiple choices)*

    1.   Mobile phone radio 2. Camera 3. Communicate with family/ friends 4. Data storage 5. Social networking   4. Obtain
        credit   5. Extension services   6. Receive agricultural information 7. Receive weather forecast 8. Receive market
        information 9. Farming training 10. Other (Specify……) | |

9. Household access to agricultural information, climate information and market information (*Information resource*)

A. Access to agricultural information	
Question	Answer

1.	Do you receive agricultural information *(Information which helps your farming and productivity on crops, livestock, etc)*	
	1. Yes, 2. No	
2.	Do you generally receive the following agricultural information? *(Read all to the respondent and choose the applicable)*	
	1. Introduction of new pesticides/herbicides and uses	
	2. Better crop rotation practices and fertilizer application	
	3. Type of soils and best soil types for planting	
	4. Introduction of improved seedlings	
	5. Crop diseases treatment and control	
	6. Livestock diseases treatment and control	
	7. Use of Artificial Insemination (Ai on local sheep, cows, and goats)	
	8. New methods of crop preservation	
	9. Introduction of new animal vaccines and drugs	
	10. New crop varieties	
	11. I don't receive any of the above information	
	12. Other (Specify…………)	
3.	From whom do you receive agricultural information*? (Multiple choices)*	
	1. Government extension officer 2. Research agent 3. N.G.O 4. Community-based organization (CBO) 5. Other farmers 6. Chief Barazas 7. Private firms e.g Safaricom 8. Farmers organization 9. Other (Specify………)	
4.	How do you receive agricultural information?	
	1. Posters 2. Exhibitions 3. Leaflets 4. Radio 5. Mobile phone 6. Mobile phone radio 7. Television	
	8. Government Extension officers 9. Veterinary officers 10. Other (Specify………….)	
5.	Do you use the mobile phone to get agricultural information? *(If No proceed to question 6)*	
	1. Yes, 2. No	
6.	Please specify the agricultural information you receive using a mobile phone? *(Read all to the respondent and choose the applicable)*	
	2. Introduction of new pesticides/herbicides and uses	
	3. Better crop rotation practices and fertilizer application	
	4. Type of soils and best soil types for planting	
	5. Introduction of improved seedlings	
	6. Crop diseases treatment and control	
	7. Livestock diseases treatment and control	
	8. Use of Artificial Insemination (Ai on local sheep, cows, and goats)	
	9. New methods of crop preservation	
	10. Introduction of new animal vaccines and drugs	
	11. New crop varieties	
	12. I don't receive any of the above information	
	13. Other (Specify…………)	
7.	a. How do you get the agricultural information using the mobile phone?	
	1. Voice application (Calling) 2. Text messaging (Sms) 3. Internet 4. Installed mobile application (e.g M-Kilimo, Kilimo Salama) 5. Mobile phone radio programs 6. Other (Specify……)	
	b. Whom do you contact for agricultural information using the mobile phone?	
	1. Government extension officer 2. Research agent 3. N.G.O 4. Community-based organization (C.BO) 5. Other farmers 6. Chief Barazas 7. Private firms e.g Safaricom 8. Farmers organization 9. Other (Specify………)	
8.	Where did you learn about this agricultural-based use for the mobile phone?	

	1.Self-knowledge 2. Friends 2. Neighbors 3. Government extension officer 4. Farmers organization 5. Social groups/networks (e.g Chama) 6. Media (radio/TV) 7. Chief Barazas 8. N.G.O 8. Other (specify……)	
9.	Did you teach anyone else this agricultural-based use for the mobile phone? 1. Yes, 2. No	

10.	What kind of agricultural information do you seek using a mobile phone?
	
	    1. Cash crops 2. About Livestock 3. Food crops 4. Vegetable crops 5. Crop pests and diseases 6. Livestock pests and diseases
	       7. Others (specify…)	

11.	Is the agricultural information received through your mobile phone beneficial to your farming? 1. Yes, 2. No	
12.	How is the received agricultural information beneficial to your farming production? *Rank code: 1= Increased significantly 2= increased slightly 3= remained the same 4= decreased significantly 5= decreased slightly* <table><tr><td>Production</td><td>Rank code</td></tr><tr><td>1. Cash production</td><td></td></tr><tr><td>2. Food production</td><td></td></tr><tr><td>3. Animal production</td><td></td></tr><tr><td>4. Other (Specify……..)</td><td></td></tr></table>	
13.	How has mobile phone influenced your access to agricultural information? 1. Increased significantly 2. Increased slightly 3. Remained the same 4. Decreased significantly 5. Decreased slightly 6. I don't know	
14.	a. Have you attained any farming training through a mobile phone in the last 5 years? *(It could be through call, text message or mobile application)* 1. Yes, 2. No	
	b.if yes, what kind of training did you attain? *(Please specify, Multiple answers are allowed)* 1. Gain new experience in Fishkeeping, 2. New agricultural technology e.g farm machines 3. Gain new experience in livestock keeping 4. Field crops 5. About beekeeping 6. Other (Specify……….)	
15.	a. Do you participate in a farmer's organization or does any member of the household participate in farmer's organization? 1. Yes, 2. No	
	b. If Yes, do you use a mobile phone to access/follow the activities of the farmer's organization? 1. Yes, 2. No	
	c. Please indicate which kind of activities of the farmer's organization you access through mobile phones? 1. Receive information on main discussions of the meetings 2. Receive/send money 3. Others (specify..)	
	B. Access to Weather, Seasonal rainfall & temperature conditions and Long term projections of future rainfall and temperature information	
14.	Do you receive any climate generally receive any climate/weather information *(e.g on temperature, rainfall)* 1. Yes, 2. No 3. I don't have any access to climate/weather information	
15.	Which channels do you use to get the information? 1. Radio 2. Mobile phone radio 3. Friends 4. Government extension agents 5. Mobile phone application 6. Newspaper 7. Television 8. Chief meetings 9. Workshops with experts/researchers 10. Farmers organization 11. Other (specify…..)	
16.	Do you use a mobile phone to get the following information? <table><tr><td>a. Information</td><td>Answer Code: 1= Yes 2= No</td><td>b. How do you receive the information on the mobile phone? Code:</td></tr></table>	

			1= Inbound calling (a call initiated by the farmer) 2=Outbound calling (a call initiated by the call centers or extension officers) 3=Text messaging (Sms) 4=Internet 5=Installed application in the phone (Specify……………) 6=Other (Specify……..)	
	1. Weather information *(Observed rainfall and temperature over a short period of time e.g days to weeks)*			
	2. Seasonal rainfall and temperature conditions *(Observed rainfall and temperature in months or years)*			
	3. Long term projections of rainfall and temperature *(observed rainfall and temperature information in more than 10 years)*			
17.	Please specify how frequently do you receive the weather information? 1. Very rarely (Once a year) 2. Rarely (2 times a year) 3. Occasionally (3times a year) 4. Frequently (4 times a year) 5. Very frequently (More than 4 times a year)			
18.	Please specify how often do you receive the seasonal rainfall and temperature conditions? 1. Very rarely (Once a year) 2. Rarely (2 times a year) 3. Occasionally (3times a year) 4. Frequently (4 times a year) 5. Very frequently (More than 4 times a year)			
19.	What kind of weather/climate variability and climate change information do you receive through the mobile phone? *(please read one by one to the respondent and choose appropriate)* 1. Rainy season start dates 2. Early warnings on droughts 3. Early warnings on floods 4. Change in temperatures 5. Change in rainfall intensity (quantity of rainfall) 6. Daily weather forecast 7. Projections of future rainfall and temperature 8. Historical trends in rainfall and temperature 9. Historical changes in extreme events (Droughts and floods) 10. Other (Specify)			
18.	Is the weather/ seasonal and long term projections on temperature and rainfall beneficial to your farming activities? 1. Yes, 2. No 3. I don't Know			
19.	If yes, how has mobile phone influenced your access to weather/seasonal and long term projections on rainfall information? 1. Increased significantly 2. Increased slightly 3. Remained the same 4. Decreased significantly 5. Decreased slightly 6. I don't know			

10. Household access to financial resource

	Question	Answer
1	a. Do you generally receive any remittances (money assistance)? 1. Yes, 2. No	
	b. If yes, from who? 1. Family 2. Friends 3. Relatives 4. Neighbors 5.Others (Specify ……….)	
	c. Please give a range received per month? 1. 1000 and below 2. 1001-5000 3. 5001-10,000 4. 10001-20000 5. 20,001-50000 6. Above 50,000 7. None	
2.	a. Does the mobile phone help you receive the remittances received? 1. Yes, 2. No	
	b. From whom do you receive the remittances on the mobile phone? 1. Family 2. Friends 3. Relatives 4. Neighbors 5.Others (Specify ……….)	
3.	a. Do you generally access credit? 1. Yes, 2. No	
	If yes, where do you get the credit from? 1. Bank institution 2. Social organizations (Chamas) 3. Table banking 4. Farmers organization 5. Mobile banking services (e.g. Safaricom Mkopa) 6. Other (Specify…….)	
4.	Does the mobile phone help you access credit? 1. Yes, 2. No	
	If yes, how do you access credit using your mobile phone? 1. Access from bank agent using a mobile phone (coop agent, equity agent) 2. Safaricom applications (Mkopa, Mshwari) 3. Other (Specify……..)	
	b. Do you use the credit received on the mobile phone for your farming activities? 1. Yes No	
	c. If Yes, what kind of farming activities? 1. Purchase farm inputs (eg seeds, fertilizer, etc) 2. Pay farm labor 3. Purchase new livestock 4. Other (Specify……)	
5.	Do you save? 1. Yes, 2. No	
	Has a mobile phone helped you in doing the saving? 1. Yes, 2. No	
6.	a. Generally, has the mobile phone helped you access finances in your household for farming activities? 1. Yes, 2. No 3. I don't know	
	b.Please rank how the mobile phone has enhanced your access to finances in your household? 1. Increased significantly 2. Increased slightly 3. Remained the same 4. Decreased significantly 5. Decreased slightly 6. I don't know	

11. Access to Livelihood activities and Market information

	Question			Answer
1	What is the main source of income of this household? *(Just select the main one)* 1. Farming 2. Business 3. Wages (daily casual labor) 4. Salary (employed permanently) 5. Mining 6. Other (specify……)			
2	*a.* Does your household engage in other income-generating activities which contribute to the income in this household? *(state other income-generating activity apart from the main source income for the household)* 1. Yes, 2. No			
	b. If Yes, please specify which other income-generating activities the household is engaged in, 1. Farming 2. Business 3. Wages (daily casual labor) 4. Salary (employed permanently) 5. Mining 6. Other (specify……)			
3.	How do you manage to operate all the income-generating activities of this household? 1. Support from family members 2. Employees 3. Self-management 4. Others (specify……)			
4.	How does the mobile phone help in managing the income-generating activities? 1. Communicating with the employees (Both calling and text messaging) 2. Mobile banking activities (Send and receive money) 3. Get Market information (Get prices) 4. Other (Specify…..)			
5.	Do you get income from agricultural activities? 1. Yes, 2. No			
4	If Yes in (5), do you do the following?	Code: *1.* *Yes* *2.* *NO*	c. If yes, please indicate the level of market participation Code: *1. Partial market participation (Sell small excess produce)* *2. Strong market participation (sell a large amount)* *3. Other (Specify…….)*	

	i. Sale of crops
	    1. Horticultural crops eg vegetables
	    2. Field crops e.g Maize,
	    3. Cash crops e.g Mangoes			

	ii. Sale of livestock			
	iii. Hiring out agricultural labor			
	iv. Other (Specify…….._)			
5	If yes in 4 (i) and 4 (ii) How do you access market information e.g Prices on (can indicate more than one)			

	i. Sale of crops
	    1. Horticultural crops e.g vegetables
	    2. Field crops e.g maize,
	    3. Cash crops
			1= Print media (newspaper, Magazines, Newsletters)
			2= Radio,
			3= Television
			3= Mobile phone radio	

	ii. Sale of livestock		4= Mobile phone SMS 5= Government extension services 6= other farmers 7= own decisions 8= Mobile phone applications 9= Other (Specify……………._)	

12. Awareness and usage of mobile phone applications to access information, financial and livelihood activities

	Question	Answer
1.	Which of these mobile phone applications do you Know? 1. M-Pesa 2. M-Kopa 3. Kilimo Salama 4. E-Soko 5. M-farm 6. Kenya agricultural commodity exchange (KACE) 7. I-cow 8. None of the above	
2.	Please rank your awareness on the above mobile phone application? 1. Not at all aware 2. Slightly aware 3. Somewhat aware 4. Moderately aware 5. Extremely aware	
3.	Which of these mobile phone applications do you use? 1.M-Pesa 2. Kilimo Salama 4. E-Soko 5. M-farm 6. Kenya agricultural commodity exchange (KACE) 7. I-cow 8. None of the above	
4.	Please rank your knowledge to use the above named mobile phone application? 1. Low 2. Moderate 3. High 4. Advanced	
5.	Where did you learn about these mobile phone applications? 1. Safaricom 2. Government extension officer 3. Other farmers 4. Farmers organization 5. Radio 6. Mobile phone radio 7. Internet 8. Newspaper 9. Posters 10. Television 11. Other (Specify….)	
6.	How have these mobile applications benefit you as a farmer? *Multiple choices (read all the respondents and choose appropriate)* 1. Timing of planting and harvest 2. Timing of fertilizer, pesticides and irrigation application 3. Protecting lives and property from extreme events 4. Selecting crops and varieties 5. Livestock stocking and feeding strategies 6. The intensity of input use (Fertilizer and pesticides) 7. Diversifying sources of income 8. Major capital investments (Buying or expanding land holding, irrigation systems, farm equipment, etc)	
7.	What are some of the challenges you experience to access the above mobile applications? 1. Expensive 2. Complicated to use 3. Poor network 4. The information provided is not enough 5. Other (Specify……….)	
8.	Would you be interested in mobile phone applications that provide access to agricultural, weather, seasonal and long-term projections of rainfall and temperature information? 1. Yes, 2. No	
9.	Would you be interested in mobile phone applications that provide access to finances and livelihood activities? 1. Yes, 2. No	
10.	Would you be willing to pay some money in order to access these mobile phone applications? 1. Yes, 2. No	

13. Extension services and training

	Question	Answer
1	Do you have access to the extension services? 1. Yes, 2. No	
2	What type of extension service do you access? 1= Agricultural 2= Non-agricultural (e.g. health, business etc) 3=Both agricultural and non-agricultural 4= Other (Specify…………._)	
3	If the answer in 1 is yes, how frequently do you access extension services within a year? 1= 5 times and below 2= 6 to 10 times 3= 11 times and above	

4	If the answer in 1 is yes, how do you access the extension services? 1= only the extension agents visit us 2= only us visit the extension agents 3= both us and the extension agents visit us each other 4= Use mobile phone to access the extension services 5= Media services (Radio or TV) 6= Other (Specify……..)	
5	From the extension services do you get information on the following? *Code: 1= Yes 2= No*	
	a. Fertilizer use	
	b. Use of improved crop varieties	
	c. Pest and disease management	
	d. Soil management	
	e. Marketing advice	
	f. Credit	
	g. Livestock management	
	h. Natural resources management	
	i. Weather information	
	j. Other (Specify……………)	
6	Are the extension services adequate? 1= Yes 2=No	
7	Do you get information relating to climate change from extension services? 1= Yes 2= No	
8	Have you or any member of the household attended/ have some agricultural training? 1= Yes 2= No	
9	If yes indicate the level of training? 1= ordinary farmer training (e.g. Master farmer) 2= Advanced training (certificate level) 3= Advanced training (diploma level) 4= Advanced training (degree level) 5= other	

14.   Ownership of Information and Communication Technologies (ICTs)

	Question	a. Do you know the following or have heard about it? 1=Yes 2=No	b. If yes in (a) Does anyone who stays at this household own the following? 1=Yes 2=No	c. If yes, How many?	d. Indicate who owns these? 1=HH head 2=Spouse 3=Son 4=Daughter 5=Joint 6=Other (Specify……)	Answer
1	ICT asset					
	1. Radio					
	2. Television					
	3. Satellite Decoder					
	4. Mobile phone					
	5. Computer/ laptop					
	6. Other (Specify…..)					

2.	Are you able to read and write?	

15. Adaptive capacity to climate change resource estimation details *(details to estimate the adaptive capacity of household)*

	Information resources	Answer
1	Did any of the family members receive any training for the last 1 year 1) Yes 2) No	
2	Did any family member participate in any member's organization 1) Yes 2) No	
3	How do you get weather information? 1) Radio 2) Mobile phone 3) Extension services 4)Chief Baraza 5) Television 6) Others	
4	Did any family member receive any technical assistance? 1) Yes 2) No	
	Physical resource	Answer
1	Land size in acres	
2	Type of land ownership 1=Inherited 2= Owned 3= rented 4= borrowed 5= Lent out	
3	Source of water for irrigation 1= Canal 2= Well 3=Pond 4=Dam 5=Rainfed 6=River 7=other (Specify……..)	
4	System of farming 1=Agriculture 2)Livestock 3) Horticulture 4) Others	
5	Please indicate the number of farming machines owned in this household? *(Write total number)*	
	Human resource	Answer
1	Respondents highest education level 1. College/University 2. polytechnic 3. Completed Secondary school4. Bit of secondary 5. completed Primary school 6. Bit of primary 7. None	
2	Number of adults living in the household	
3	Number of adults with primary education living in this household	
	Financial resource	Answer
1	Total number of animals	
2.	Do you access to credit? 1. Yes, 2. No	
4.	Receives support from the government? 1) Yes 2) No	
	Diversity of livelihood	Answer
1	Number of sources of livelihoods	
2	% of the land with crops	
3	Number of crops planted	

16. Role of mobile phone on development outcomes

	Question	Answer
1.	a. Has mobile phone use influenced your agricultural productivity? 1= Yes 2=No	
	b. please rate how the mobile has influenced your agricultural productivity? 1= increased significantly 2= increased slightly 3= Decreased significantly 4= Decreased slightly 5= Remained the same	
2.	a. Has mobile phone use influenced your knowledge and understanding of changes in rainfall and temperature? 1= Yes 2. No	
	b.please rate how the mobile has influenced your knowledge and understanding of changes in rainfall and temperature? 1= increased significantly 2= increased slightly 3= Decreased significantly 4= Decreased slightly 5= Remained the same	
3.	a. Has the use of mobile phone influence on preparedness on projected climate change impacts e.g drought 1= Yes 2=No	
	b.Please rate how the mobile has influenced your preparedness on projected climate change impacts e.g drought? 1= increased significantly 2= increased slightly 3= Decreased significantly 4= Decreased slightly 5= Remained the same	
4.	Has the use of mobile phone influenced your ability to adapt to climate change impacts e.g drought, declines in rainfall, etc 1= Yes 2=No	
	b.Please rate how the mobile has influenced your ability to adapt to climate change impacts e.g drought, declines in rainfall, etc? 1= increased significantly 2= increased slightly 3= Decreased significantly 4= Decreased slightly 5= Remained the same	

17. Social networking of the household to access information, financial services, and livelihood activities

In the next set of questions, I would like to ask you information on people you contact about your farming activities, e.g. about weather information, about farming practices, about market prices, people you get support from like farm inputs and about your livestock Note: Ask for people whom the respondent contacts/reaches his/her for his/her farming activities e.g. extension officers, another farmer, CBO, etc.

1. Please identify up to 10 people and where they work who are important/contact on your farming activities e.g. provide you with information on adaptation, weather, farming practices, etc. in one season (Please enter at least one name) *Those people who provide you with information to help your farming, provide solutions to problems you experience, support you financially on your farming) e.g. Mutua- farmer*		
1.1 Name of the person *E.g. Mutua*	1.2 Position *e.g. Farmer, extension officer, etc.*	1.3 Where they work *E.g., Government office*
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Person	2.1 How are they contacted? *(Use Code 1)*		2.2 How is the process of contacting the identified person?		2.3 Rank the most contacted to the least contacted *(Note: Rank the identified individuals from the most contacted to the least contacted)*		2.4 How frequent do you contact them *in one season?*		2.5 What kind of benefit do you get from the identified persons *(Use code 6)*		2.6 How beneficial is the information received? *(Use code 7)*	
	Face to face	Mobile phone	Face to face *(Use code 2)*	Mobile phone *(Use code 3)*	Face to face	Mobile phone	Face to face *(Use code 4)*	Mobile phone *(Use code 5)*	Face to face	Mobile phone	Face to face	Mobile phone
1.												
2.												
3.												
4.												
5.												
6.												
7.												
8.												
9.												
10.												

2. Please indicate how the above-identified persons are contacted in the last 6 months (face to face or mobile phone) and the process of contacting them, rank the most contacted person to the least, indicate how frequently you contact them, the benefit obtained from them and how beneficial is the information received?

Note: for questions 2.1, 2.2, 2.4, 2.5 and 2.6 follow the order of the persons mentioned in question a

Code 1:

1= Yes   0= No

Code 2:

1= only him/her visits   2= only me visits him/her   3= both of us visit us each other 4= Other (Specify………)

Code 3:

1= Inbound calling (a call initiated by the farmer)   2=Outbound calling (a call initiated by the call centers or extension officers)

3=Text messaging (Sms)   4=Internet   5= other (Specify……..)

Code 4:

1= Never 2= rarely (1-2 time per season) 2= occasionally (3- 4 times per season)   3=frequently (5-6 times per season)   4= Very frequently (More than 6 times per season)

Code 5:

1= Never 2= rarely (1-2 time per season) 2= occasionally (3- 4 times per season)   3=frequently (5-6 times per season)   4= Very frequently (More than 6 times per season)

Code 6

    a.   *Weather information:*

1= Start and end of rainfall seasons   2= Early warning in droughts/floods 3= Rainfall intensity (quantity of rainfall) 4= Change in Temperature 5= future rainfall/temperature projections

  b.   Agricultural information

6= Introduction of new pesticides/herbicides and uses 7= Better crop rotation practices and fertilizer application 8= Type of soils and best soil types for planting 9= Introduction of improved seedlings   10= Crop diseases treatment and control 11=Livestock diseases treatment and control 12= Use of Artificial Insemination (Ai on local sheep, cows, and goats)   13= New methods of crop preservation 14= Introduction of new animal vaccines and drugs   15= New crop varieties 16= New adaptive strategies   17= Seed varieties to plant on certain season

  c.   Market information

18= Information on price farm inputs (e.g seeds, pesticides.) 19= information on the quality and variety of the farm inputs (variety of available products) 20= information on market prices of farm produce (e.g maize, beans, mangoes.)

  d.   Financial services

 21= Receive financial support e.g. money for farming activities   22= Obtain credit/short loans

Code 7

1= Not beneficial   2= somehow beneficial   3= very beneficial

18. Simple household poverty estimation details

	Question	Answer
1.	Have all the household members aged 7 to 17 years been to school in the last 12 months? 1= Yes 2= N0 3= No one in that age range	
2.	What type of fuel does the household mainly use for cooking? 1= Firewood 2= Agricultural residues e.g Maize cobs 3= Charcoal 4= Paraffin 5= Biogas 6= Electricity, solar or lp gas	
3.	What is the main source of lighting used in this household? 1= Burning wood 2= Hand help paraffin lamp 3= Candles 4= Solar 5= Electricity 6= Biogas 7= Torch	
4.	What Kind of toilet facility does the family have? 1= Open-pit latrine 2= Closed pit 3= Flashed toilet (WC) 4= None (Shared with neighbors) 5= Other (Specify)	
5.	The floor of the main dwelling is predominately made of what material? 1. Earth/ sand 2= wood 3= Cement/tiles	
6.	How many habitable rooms does this household occupy in its main dwelling (do not count bathrooms, toilets, storerooms or garage) 1. one 2. Two or three 3. Four 4. Five 5. Six or more	
7.	What is the highest school grade that the female head/spouse has completed? 1. None or pre-school 2= Primary standards 1 to 6 3= Primary standard 7 4= Primary standard 8 or secondary 1 to 3 5= Secondary form 4 or higher 6= No female head/spouse	
8.	What Kind of business (the type of industry) is the main occupation of the male head/spouse connected with? 1= Does not work 2= Agriculture, hunting, forestry, fishing miming 3= No male head/ spouse 4= Any other	
9.	Do you own a radio or a cassette player in this household? 1=Yes 2=No	
10.	How many television sets does the household have? 1= none 2=one 3= Two 4=Three or more	

Thank you very much for your participation! Asante Sana

APPENDIX B: Questionnaire for Makueni County, Key expert's questionnaire

1. With respect to Physical resources
Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate (X) the relative importance of options A (left column) to options B (right column).

A Options	Extremely		Very strong		Strongly		Moderately		Equally		Moderately		Strongly		Very strong		Extremely	B Options
Farm size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Farm ownership
Farm size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Irrigation
Farm size	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of machine owned
Farm ownership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Irrigation
Farm ownership	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of machine owned
Number of farm machines	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Irrigation

2. With respect to Human resources
Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate (X) the relative importance of options A (left column) to options B (right column).

A Options	Extremely		Very strong		Strongly		Moderately		Equally		Moderately		Strongly		Very strong		Extremely	B Options
Farm experience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Education of household head
Farm experience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of adults with primary education
Farm experience	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of adults in household
Education of household head	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of adults with primary education
Education of household head	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of adults in household
% of adults with primary education	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of adults in households

3. With respect to Diversity in livelihood

Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate (X) the relative importance of options A (left column) to options B (right column).

A Options	Extremely		Very strong		Strongly		Moderately		Equally		Moderately		Strongly		Very strong		Extremely	B Options
Number of livelihoods	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	% of land not in crops
Number of livelihoods	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of crops planted
% of land not in crops	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of crops planted

4. With respect to Information resource

Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate (X) the relative importance of options A (left column) to options B (right column).

A Options	Extremely		Very strong		Strongly		Moderately		Equally		Moderately		Strongly		Very strong		Extremely	B Options
Training on farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Receives technical assistance
Training on farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Participates in farm organization
Training on farming	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of sources of climate information
Receives technical assistance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Participates in farm organization
Receives technical assistance	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of sources of climate information
Participates in farm organization	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Number of sources of climate information

5. With respect to analyzing adaptive capacity

Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate (X) the relative importance of options A (left column) to options B (right column).

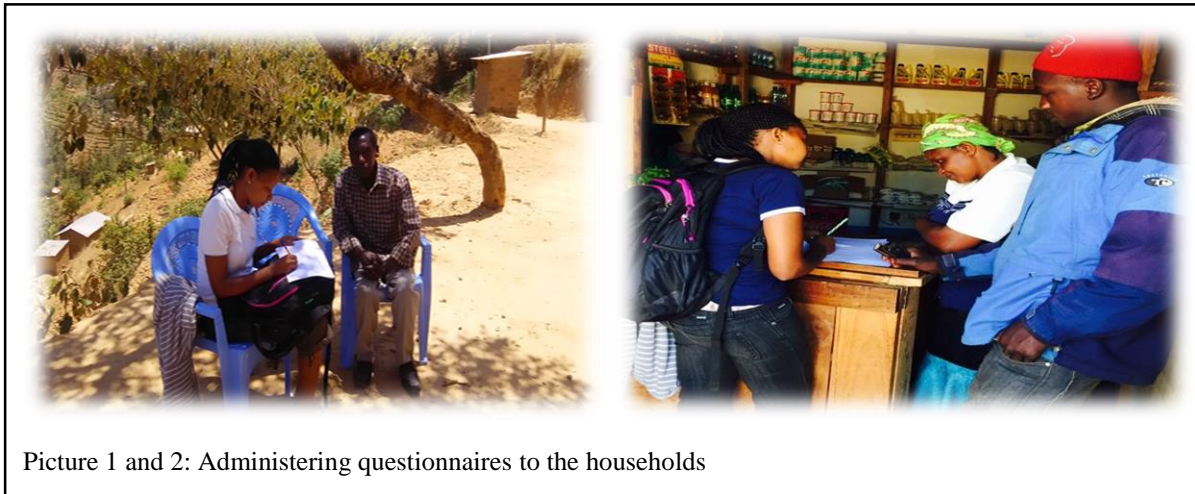| A Options	Extremely		Very strong		Strongly		Moderately		Equally		Moderately		Strongly		Very strong		Extremely	B Options
Financial resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Physical resource
Financial resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Human resource
Financial resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Information resources
Financial resources	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Livelihood diversity
Physical resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Human resource
Physical resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Information resource
Physical resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Livelihood diversity
Human resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Information resource
Human resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Livelihood diversity
Information resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Livelihood diversity

Thank you very much for your participation! Asante Sana!

Name:

Mobile phone: Email address:

APPENDIX C: Field survey pictures

Picture 1 and 2: Administering questionnaires to the households

Picture 3 and 4: Conducting Key expert's interviews and questionnaire

Picture 5 and 6: Focus group discussions

APPENDIX D: Descriptive statistics for SNA measures for Financial and Information

resources

1. Descriptive statistics for each measure for users Information resource

	Detail	1 Degree	2 Closeness	3 Betweenness	4 Eigenvector
1	Observations	125	125	125	125
2	Minimum	0.016	0.504	0.026	0
3	Maximum	1	1	0.412	0.444
4	Mean	0.075	0.523	0.072	0.008
5	Standard Deviation	0.131	0.056	0.052	0.044
6	Sum	9.419	65.415	9.053	0.940
7	Variance	0.017	0.003	0.003	0.002
8	SSQ	2.868	34.624	1	0.246
9	MCSSQ	2.158	0.392	0.344	0.239
10	Euclidean norm	1.694	5.884	1	0.496

Field survey 2017/2018

2. Descriptive statistics for each measure for Non-users Information resource

	Details	1 Degree	2 Closeness	3 Betweenness	4 Eigenvector
1	Observations	125	125	125	125
2	Minimum	0	0.200	-0.000	0
3	Maximum	0.403	0.464	0.426	0.303
4	Mean	0.028	0.320	0.062	0.008
5	Standard Deviation	0.059	0.061	0.065	0.038
6	Sum	3.484	40.050	7.701	1.053
7	Variance	0.004	0.004	0.004	0.001
8	SSQ	0.535	13.296	1	0.189
9	MCSSQ	0.438	0.464	0.526	0.180
10	Euclidean norm	0.731	3.646	1	0.435

Field survey 2017/2018

3. Descriptive Statistics of each measure for Users Financial resource

	Details	1 Degree	2 Closeness	3 Betweenness	4 Eigenvector
1	Observations	125	125	125	125
2	Minimum	0.016	0.504	0.026	0
3	Maximum	1	1	0.412	0.444
4	Mean	0.075	0.523	0.072	0.008
5	Standard Deviation	0.131	0.056	0.052	0.044
6	Sum	9.419	65.415	9.953	0.940
7	Variance	0.017	0.003	0.003	0.002
8	SSQ	2.868	34.624	1	0.246
9	MCSSQ	2.158	0.392	0.344	0.239
10	Euclidean norm	1.694	5.884	1	0.496

Field survey 2017/2018